STATE OF MICHIGAN

STATE OFFICE OF ADMINISTRATIVE HEARINGS AND RULES

In the matter of:	File Nos.:	GW1810162 and MP 01 2007
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. _____/	Part:	31, Groundwater Discharge 632, Nonferrous Metallic Mineral Mining
	Agency:	Department of Environmental Quality
	Case Type:	Water Bureau and Office of Geological Survey

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

HEARING - VOLUME NO. X

BEFORE RICHARD A. PATTERSON, ADMINISTRATIVE LAW JUDGE

Constitution Hall, 525 West Allegan, Lansing, Michigan

Friday, May 9, 2008, 8:30 a.m.

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Lansing, Michigan

Friday, May 9, 2008 - 8:39 a.m.

MR. HAYNES: Good morning, Dr. Maest.

THE WITNESS: Good morning.

ANN S. MAEST, Ph.D.

having been called by the Petitioner and previously sworn:

DIRECT EXAMINATION

BY MR. HAYNES: (continued)

Q When one is doing geochemical tests at a site like the proposed Eagle Mine, is it important to have representative samples of the rock to be tested?

A Yes, it is.

Q And is it important to have samples that are representative of the sulfide percentages in the rock in order to test them accurately?

A Yes.

Q And you've reviewed the samples that we -- we went through some samples yesterday and you describe in one of the slides the percentage of sulfide in the various types of rock, didn't you?

A Right. That was the table that we looked at yesterday.

Q And do you recall what the percentage of sulfide was in the peridotite, for instance?

A The sulfide in the peridotite, according to Kennecott, ranges up to 30 percent sulfide.

Q And what were the -- what was the percentage of sulfide in the peridotite in the samples that were used for testing?
A That was expressed as percent sulfur, and I believe the highest was 2.44 percent sulfur. And if it's a 30 percent sulfide content in the peridotite, that would be equivalent to about a 10 percent sulfur content. So the test samples that were run underestimate the possible amount of sulfide -- sulfur in the peridotite itself.
Q Thank you. And is the leachate that is derived from the development rock dependent on the type of -- on the amount of sulfide that's present in the rock?
A Yes. That's one of the main controls.
MR. HAYNES: For the record, we're looking for DEQ Exhibit 76, page 11 of that exhibit, Table 3-1.
Q Now, Dr. Maest, you reviewed what has been marked -- or proposed as a DEQ Exhibit 76 which is the -- which is a document prepared by Ted *??8:36:33Eerie?? of the DEQ, have you not?
A Yes, I have.
Q And we've pulled up from page 11 of that document Table 3-1 which is entitled "Summary of Numbers of Samples Selected for Testing by Major Rock Type." Have you reviewed this table?
A Yes, I have.
Q And can you tell us what the table says to you?

A Okay. Let's see. First of all, this column here (indicating) says the type of geochemical test. ABA stands for acid-base accounting. This is a whole rock test that tells you the total concentrations of metals and other contaminants in the rock. Short-term leaching is just, you know, a day-long test. And this (indicating) is the long-term column leaching that I show the results from that go up and down over time, and then the mineralogy. And then this is the ore, which together includes the massive and the semi-massive sulfide units. And then this is the intrusive or the peridotite, and then this is the sedimentary rocks. These he's characterized as being development rock and this as ore.

Q When you say "these," you mean the intrusives and the metasediments?

A Oh, I'm sorry. Yes, the intrusives and the metasediments have been characterized as development rock by Mr. Eary's table and then ores in the second column here.

Q All right. And then at the last we have the column that says "Tonnes per Sample."

A This is -- right.

Q And just for the record, explain what "tonnes" means, t-o-n-n-e-s.

A It's a metric ton, so it's 1,000 kilograms rather than --

Q Okay. If you could, translate that into pounds.

A It's 2200 pounds, something like that.
Q Okay. Thank you.
A So it's a little more than a regular ton that we know about. So what he's done in this column, "Tonnes per Sample" is how many tonnes does each sample represent if you look at the whole mass that is represented by these different rock types. And what Mr. Eary is using is EPA 1994 guidelines for the number of samples -- geochemical samples that should be used per amount of rock that you're trying to characterize.
Q And is that an appropriate guideline to use?
A It's a fine guideline. It's one that is used in the United States. There are some other guidelines as well. And what Mr. Eary has listed here is the number of samples for the different types of geochemical tests that were conducted on this material. So for acid-base accounting in the ore there were 11 samples. For the peridotite for acid-base accounting there were 58 samples. There were more samples, et cetera. And for -- what he did here was, say, "All right. How much rock are we trying to characterize, and how many samples were there?" And for that he used 675,000 metric tonnes of development rock. So that's how much development rock is planned to be taken out of the mine as it develops. And he divided that by the number of samples here to come up with the tonnes per sample.

Q And is the 675,925 tonnes of development rock an appropriate figure to use?
A I don't think that it is, no.
Q Why is that?
A Because that's just the amount of rock that's going to be taken out. That isn't how much rock there is there to characterize. The other issue I have with it is, that has nothing to do with how much ore is there. The amount of ore is 4.05 million tons.
Q So the "Tonnes per Sample" column on this chart -- on the right-hand column on this chart measuring samples only in the development rock and not in the ore?
A That's right. That's right. And we don't have a number here for ore, but if you use that number, 4.05 million tonnes of ore, then it's more like, instead of 6,000 tonnes per sample, it's 380-, 370,000 tonnes per sample.
Q And in your view, based on your experience, is that an appropriate sampling amount?
A That's too low. That's not enough samples per amount of rock.
Q To determine the representative leachate that would be coming from the ore in the development rock?
A Well, to determine how acid generating the rock is or what the whole rock composition in going to be. Also down here (indicating), you note that he doesn't come up with the

tonnes per sample for the leach tests.

Q And is that appropriate?

A Well, you know, there are no set numbers, but you want to make sure that there are enough samples to be representative. And if you used this here (indicating) there are only three samples from the ore, five samples from the peridotite, seven samples from the sedimentary rocks for a total of 15 leachate samples.

Q And is that an adequate amount?

A That's a low -- that's a relatively low number for that much rock.

Q Now, Dr. Maest, I've had brought up from Petitioner's Exhibit 68 which has already been admitted into evidence which is your report dealing with the -- not the predictions report but the characterization report, the sampling of mines. And we have a table on page 22 of that report. And on page 22 of your report you have an example of a recommended minimum number of samples. This is listed on Table 2 -- adapted from Price and Errington, 1994. Who are Price and Errington?

A Price and Errington are regulators in Canada in British Columbia, and they've done a lot of work on looking at testing methods for mine materials, probably more than any group in the United States.

Q And they list in this table -- or the table that you list

from their 1994 study a minimum number of samples for certain amounts of massive rock of each separate rock type. And how does this table relate to what Mr. Eary was reporting?

A Well, we know that there is 4.05 million tonnes of ore. So that would be between a million and 10 million tonnes. And their recommendation for the minimum number of samples is between 26 and 80 samples for that much rock. And if we recall back to the other table, there were 11 samples for acid-base accounting in the ore and lower numbers there were three samples for long-term leachate testing. So that would pretty severely underestimate the number of samples that they recommend.

Q And underestimating the samples recommended would have what effect on the ability to predict leachate coming out of the development rock?

A It means that you don't know the range of possible contaminant leaching concentrations.

Q Now, Dr. Maest, we've had put up the table that we talked about yesterday which lists the number of kinetic tests that were taken by Kennecott for its sampling here.

A Yes.

Q Why are these kinetic tests to important?

A They're important for two reasons: One is that it's the only type of test that is intended to simulate the long-term

weathering of these rocks as that would occur in the mine environment. And the second reason is that that's the only one of these tests that is used as input to water quality predictions. It's not the acid-base accounting or any -- you know, the percent sulfide or the mineralogy. It's only the results from the leachate, the long-term leachate tests. And you can see there that the massive sulfide has only one test, semi-massive two tests, and there are more in the sedimentary rocks and peridotite but only, you know, a total of seven in the sedimentary rocks and five in the peridotite.

Q And based on your training and experience, how do the number of geochemical tests that were perform here compare to others that you reviewed in your experience?

A The -- we don't have it on this slide, but the acid-base accounting numbers are low. There are mines in Nevada that I've looked at that have literally thousands of acid-base accounting tests. And these have 11 for the ore and I can't remember. I think it was 58 for the peridotite. So many more acid-basing accounting tests could have been done to figure what the range of acid production -- possible acid production would be. Now, I think it's -- for the ore I think it's fair to say that all the tests that were conducted for acid-base accounting showed that they would be acid generating. So it think it's less important so that we

know -- everyone knows that those are going to be acid generating. But for the peridotite, there's a range of possible outcomes, and we don't know what that range is.

Q You say that many more tests could have been done. Is it your view that many more tests should have been done?

A Yes, definitely.

Q And without those tests, what is the likely predictive result?

A The problem with having fewer tests is that we don't know the possible high range of contaminant leaching potential, and that's what's important in terms of designing protective mine waste units.

Q Dr. Maest, you have reviewed the Sainsbury reports in this proceeding, haven't you?

A Yes.

Q And the Sainsbury reports talk about the proposed crown pillar as it was initially proposed as being about 32 meters thick. Do you remember that?

A Yes.

Q And the later Sainsbury report in November 2006 recommended that the crown pillar be -- the thickness be increased to about 88 meters. Do you remember that?

A Yes.

MR. LEWIS: Objection to form, your Honor. I think, Mr. Haynes, we've got Sainsbury confused with the

Golder folks.

MR. HAYNES: Actually they both did it.

MR. LEWIS: Maybe I've got them confused.

MR. HAYNES: I think Counsel has them confused.

MR. LEWIS: And I guess the -- that's fine. What he said is fine. I withdraw that objection.

Q Anyway we're at the point where the crown pillar is recommended to be about 88 meters thick, Dr. Maest.

A Okay.

Q Did you observe in any of your review of these documents in this case that anybody proposed to test the water coming through the crown pillar?

A No. There were no tests conducted on the material that would become the crown pillar. And for that there were no -- what I mean by that is that there were no humidity cell leachate tests on that.

Q Now, the next slide in Exhibit 66 is a slide you prepared based upon cross-sections appearing in the Kennecott reports, is it not?

A Yes. That was from Appendix C of the mine permit application.

Q All right. Thank you. And we have -- we've actually seen these figures before with other witnesses. These are cross-sections going through the orebody -- correct? -- and crown pillar?

A Yes.
Q And you have on these cross-sections superimposed several lines. Can you explain what those are, please?
A Okay. The dashed line here (indicating) is what was originally proposed as the top of mining limit. In other words, they would take out the ore and development rock up to this level right here (indicating). Then after the Sainsbury report came out, the mining level has just been okayed to this (indicating) level here. So that less ore and development rock would come out.
Q Just was the record, when you say "this level," what does your chart say that level is?
A All right. 327.5 meters is the new approved level.
Q And that's the elevation above sea; correct?
A That's about sea level. That's right. And 383 meters or a higher elevation above sea level was the former level which the mine permit application addresses.
Q And what is the implication of lowering the height of the crown -- lowering the bottom of the crown; that is, increasing the thickness, what implication does that have for purposes of acid-generating rock in the crown pillar?
A It allows less of the ore to be taken out. And you can see here that what is left -- well, let's look at the top line first. Previously very little of the ore -- the massive sulfide is shown in red, by the way, and the semi-massive

sulfide is shown in this kind of yellow-ish, tan-ish color here (indicating), and the peridotite is in purple, and the sedimentary rocks are in green. And the dash line which was the former higher line that was allowed for mining left very little of the ore behind in the underground mine. When that level was lowered to allow for a thicker, more stable crown pillar, that allows -- that allows more ore to be left in. So you see massive sulfide and semi-massive sulfide ore, quite a bit of semi-massive sulfide ore, semi-massive sulfide, semi-massive sulfide ore to be left in the roof of the mine.

Q And is the semi-massive and the massive ore potentially acid generating?

A They are -- yes, they're very potentially acid generating. Every sample showed that -- there were only six, but all of them consistently showed that both of those units are acid generating.

Q Now, in your review of the documents have you determined -- and based upon your experience, have you determined whether the -- whether these semi-massive and massive ore portions would be alternative wetted and dried during the mining process?

A Yes, they would.

Q And what is the implication of that?

A Well, during mining this cavity would be extracted. There

would be a hole here (indicating). And the water level would have to be decreased through pumping and drawdown in order to allow access for mining. So there would be a cone of depression of the water table around here, and there would be no groundwater allowed in the mine. But when it rains and when the snow melts, it will infiltrate through this crown pillar and allow leaching of that material to bring contaminated water into the underground line.

And the thing that makes alternating wet and dry samples the most -- like the best environment for producing acid mine drainage is that when it's dry it has a chance for the sulfides to oxidize and form these very soluble metal sulfate salts. Then when it gets wet again, so sulfate salts are kind of like sugar or salt, and they dissolve very readily in inflowing infiltration.

Q Then these acid-generating ores that are wetted and dried that create more acid will then filter into the water that's going to be pumped out of the mine; is that right?

A That's correct.

Q And has that fact been taken into account in the modeling that you've reviewed by Kennecott?

A No, it has not.

Q Should it have been?

A Yes, it would have been.

Q Now, Dr. Maest, we've had put on the screen another slide

that you prepared that entitled "Geochimica's General Approach to Modeling."

A Uh-huh (affirmative).

Q Can you summarize for Judge Patterson your view of the approach to modeling that Kennecott's consultants took?

A Yes. You know, the humidity cell test results that I showed yesterday where the concentrations were going up and the pH was going down, Kennecott selected a certain range of weeks, the concentrations from those weeks, and put those into a spreadsheet model. Then they knew the amount of surface area that was represented by that leaching and how much time that took. And they created a concentration per unit surface area per time. Then they asked the question, "Well, how much surface area is in the mine?" And that would include the exposed rock in the mine on the walls of the mine and also the surfaces of the development rock. And the reason that's important to do is because the surface area is really what controls the leaching rate and how much contaminants you get. The more surface area, the worse the water is if the rock will generate acid.

Q And then what did they do?

A And then they divided the mass -- the amount of leach contaminants by how much water was going to be inflowing to the mine in terms of groundwater and came up with a concentration in the underground mine of contaminants after

mining and backfilling.

Q Now, overall is this method of modeling appropriate for this site?

A I believe it is, yes.

Q Okay. And did it, however, contain some assumptions that you think ought to be adjusted for purposes of their model?

A Yes.

Q All right. Dr. Maest, you have -- based upon your knowledge, training and experience you have looked at the model inputs and adjusted some of them. Can you explain what those are for Judge Patterson, please?

A Okay. First of all, an assumption was made by Kennecott that the mining was going to take out pretty all of the ore.

Q Is that assumption, in your view, valid?

A No, it's not. It's just not possible with this large scale of an operation in mining to do that.

Q I see. And so how did you adjust that assumption?

A There are two things -- you know, areas where that's important. That's in the development rock, so how much ore would potentially be in the development rock, and how much ore would be in the mine wall rock. Now, Kennecott did put some ore in the mine rock, but they didn't put any in the development rock. So we added five percent of the semi-massive sulfide to the development rock assuming that you could not possibly keep all of it out of there. And then we

split the remaining 45 percent each for intrusives and country rock for the development rock. For the mine wall we used a higher percentage of semi-massive and massive sulfide ore, assuming that, again, not all of it could be removed. Kennecott used 8 percent for the semi-massive. We used 12. For the massive they used 2; we used 3. And then we split the remaining between the intrusives and the country rock, putting more for the intrusives; 64 percent for intrusives and 20 percent for the country rock.

Q Based upon your knowledge, training and experience and the number of mines that you have reviewed and the geochemistry of those mines, are your assumptions in your view more valid than the assumptions used by Kennecott?

A I believe that they are, yes.

Q Now, did you also adjust the assumptions for the particle size?

A Yes.

Q And explain for Judge Patterson what you mean by particle sizing.

A Particle size is just, what are the size of the rock in the development rock or the waste rock pile? And these rocks were assumed to be 10 centimeters in diameter, so all -- every rock piece would be 10 centimeters in diameter by Kennecott. And waste rock is fairly large in size, but there are a lot of very small particles, and those have a

higher surface area per unit volume than the big pieces.

Q What is the implication of having a higher surface area per unit volume?

A That means that those smaller rocks will leach faster and have higher concentrations of contaminants.

Q I see.

A And so we adjusted that and used 90 percent of the -- we said 90 percent of the rocks would be 10 centimeters and 10 percent would be 1 centimeters.

Q And based upon your knowledge, training and experience, is time assumption more valid than the assumption used by Kennecott?

A It is, and we also looked at a jaw crusher and the type -- the sizes of particles that would be produced by the jaw crusher that is similar to the one that is proposed to be used for this operation and found that there were much smaller particles present than 10 centimeters. So we added in 10 percent at 1 centimeter.

Q And is that a conservative assumption?

A It doesn't include the very smaller particles, so I believe that it's conservative.

Q Now, you also adjusted an assumption that deals with the amount of development rock in the pile. Can you explain that?

A Yes. So this is, you know, essentially the weight or how

much in tonnes development rock will be in the stockpile. Maybe I should back up a minute. There was a prediction made about the water quality coming off of the stockpile in year three 'cause that's when there will be the most waste rock on that pile. And Kennecott in that prediction used an assumption that the amount of development rock in the pile would be 126,000 tonnes.

Q And that's in year 3; correct?

A That's in year 3.

Q And how did you adjust that assumption?

A Well, I looked at the Kennecott materials, and in year 3 the plan is to have 379,000 tonnes. So that's the number we used.

Q And how do you account for the difference?

A I'm not really sure. You know, it's too --

Q That is, the 379,000 tonnes that you used is from their documents.

A You mean why did Kennecott use 126,000?

Q No. Let me ask the question.

A Okay.

Q Is the 379,000 tonnes from the Kennecott figures?

A Yes. Yes, it is.

Q And then you also in this slide talk about the amount of development rock that's backfilled?

A Yes.

Q And can you explain that for us, please?
A The plan for the mine is to store the development rock on a pad for the first three years of mining operation and then to start backfilling or in other words putting it back into the mine. And the amount of development rock backfilled overall throughout the whole course of the mine is expected to be 647,000 tons.
Q And what did Kennecott use for their assumption here?
A Kennecott, instead of using that higher number for the end of mining calculation used what was there during your 3 of mining, and that's how much would be on the pad as a maximum, but it's not how much would be in the mine as a maximum. They used 379,000 tonnes.
Q And in your view, based upon your knowledge, training and experience, the higher figure of 647,000 tons and change is a more representative figure of what will actually be backfilled into the mine?
A That's what Kennecott says, and that's for predicting. At the end of mining we need to put all of that development rock back in there and figure out what the leachate concentrations will be.
Q Now, Dr. Maest, we've gone to the next slide in this exhibit, and we have another series of assumptions. The first one talks about water infiltrating through the crown pillar. Can you explain that assumption for us, please?

A Yes. During mine operation the plan is to lower the water table, as I described. And that means that water from snow melt and rain infiltration will be going through the crown pillar and leaching contaminants. And that will -- that's known to contain high concentrations of contaminants based on the humidity cell leach tests and also other mines that have been studied.

Q Now, the humidity cell leach tests are those charts that we went through yesterday with the nickel and the pH and the sulfate; correct?

A Yes, that's right.

Q Now, we also have the next assumption which deals with the leachate concentrations for the end of mining. Can you explain that was us, please?

A Yes. I think I talked about this yesterday a little bit. At the end of mining leachate concentrations should be represented by later humidity cell tests, like later weeks. And these weeks were available to use, but Kennecott used results from weeks 20 through 50, and we use results from weeks 50 through 70 where they were available.

Q And what generally is the result of using earlier weeks for the humidity cell testing results?

A For most of the rocks it will underestimate potential leachate concentrations.

Q Now, the last assumption that was adjusted is the assumption

dealing with the groundwater infiltration. Can you explain that for us, please?

A This is -- the way that the model calculates water quality, it calculates how much leachate will be produced by the leaching of the walls and the development rock in the mine. And then it dilutes that by inflowing groundwater. And the infiltration to the mine based on Kennecott's water balance, the expected case is 75 gallons per minute.

Q And what did they use for an expected inflow rate?

A Kennecott used 180 gallons per minute. And that will cause more dilution by the way this is calculated and is not the expected case or the highest case according to their own water balance.

Q Now, Dr. Maest, having adjusted these assumptions to the model inputs, did you then go through the model to predict water quality from the stock- -- development rock stockpile?

A Yes.

Q And we have here the next slide in Exhibit 66 which is a comparison of the Geochimica model results and your model results. Now, just for the record, the Geochimica mining results are from the mining permit application Appendix D-3; correct?

A I believe that's correct.

Q And can you explain for Judge Patterson the results of -- or the comparison between the model results from the Geochimica

model and your model based upon the more realistic assumptions that you used?

A Okay. Well, this first column here is the contaminant of interest: sulfate, nickel -- TDS is total dissolved solids. And then there are metal below that: aluminum, beryllium, cadmium, cobalt, copper, iron, lead and zinc. And I selected these because these are the ones that have water quality standards, and most of these are known to be toxic either to humans or to aquatic life or both. And the second column is Geochimica's predictions of the leachate that would be coming out of the development rock stockpile during year three. And the last column here is our predictions of the leachate that will be coming out of the development rock stockpile in year 3. And you can see that our numbers are, I think uniformly higher, often by an order of magnitude or 10 times higher. And the reason for that is because Kennecott underestimated the amount of development rock on that pile, and they also, in my opinion, didn't include enough ore. Some ore would have to be present in that development rock stockpile. So you can see that, for instance, for sulfate, 575 milligrams per liter is predicted by Kennecott. And we predict almost 6,000 milligrams per liter.

Q All right. I note that on this slide there is a note that says, "Does not include limestone." Why did you not include

limestone here?

A As I mentioned yesterday, I didn't include limestone because -- for a couple of reasons: One is that there is a lot of iron in this deposit. You can see that we're predicting -- well, both of us actually are predicting pretty high concentrations of iron, 26 milligrams per liter and almost 400 milligrams per liter of iron.

Q What is the implication of having high amounts of iron in the stockpile?

A High amounts of iron will -- iron will precipitate and form this rust, iron hydroxide precipitate, that will coat anything that, you know, it comes in contact -- especially limestone. So the effectiveness of the limestone is diminished if it has crust on it. And I believe that a fair bit of that limestone will be coated with an iron precipitate. The other reason I didn't include it is because a number of these constituents that are pretty important to our analysis, especially sulfate and nickel and some of the metalloids like arsenic and antimony are not affected by pH. In other words, you can raise the pH and they don't precipitate out of solution.

Q And you raised the pH by adding limestone?

A By adding -- yes, by adding limestone. That's right.

Q Now, Dr. Maest, based upon the modeling that you performed for the development rock stockpile -- strike that. We've

just gone over the model for the development rock stockpile.

A Yes.

Q Now we're going to look at the predicted mine water quality at the end of mining. And is this in the mine itself?

A Yes.

Q All right. And again, based upon your adjusted assumptions you prepared a table showing your results compared to the Geochimica results and also compared to the various regulatory standards; correct?

A Yes.

Q All right. Dr. Maest, could you lead us through this exhibit, please?

A Okay.

MR. LEWIS: Just a minute, your Honor. I'd like to put an objection on the record as to relevance. On this chart is shown various what are represented to be water quality standards, and there's no evidence in the record or otherwise to indicate that those standards that Dr. Maest has on this table will apply by law to this water in the mine.

MR. REICHEL: We join in that objection particularly with respect to the last three columns.

MR. HAYNES: Well, your Honor, the standards are there for a couple of things: One, we believe that they will apply, and that's a legal question. And secondly,

we're using the standards for comparison so that we can determine -- have Dr. Maest testify as to the comparative polluted water that will exist after the mining ends, so we think they're relevant, and if counsel has an objection to there being used in this case, then that's really a legal argument and shouldn't prevent the witness from testifying about them.

JUDGE PATTERSON: I'll let him go ahead and testify to it. We'll sort the legal argument out later.

Q Dr. Maest, we have the -- as long as we're on that topic, we have various standards that you've listed in this table, and can you explain what the standards are and why you included them here?

A These last three columns here, MCL, SMCL and MCLG are all federal drinking water standards under the Safe Drinking Water Act. MCL stands for the Maximum Contaminant Level. SMCL stands for the Secondary Maximum Contaminant Level, and these are generally more for aesthetics reasons, taste and odor. And then the MCLG is the Maximum Contaminant Level Goal, and this is strictly the health-base limit, not taking into consideration any economics or treatment capabilities.

Q All right.

A And then Part 201 standards are Michigan standards, and these are quite similar to the federal maximum contaminant level drinking water standards. And then the Part 22

standards are represented here as halfway between -- or half of -- sorry -- the Part 201 standards. In reality, the part 22 standards are halfway between background groundwater and the Part 201 standards. But this gives an idea of what Part 22 standards might be based on a very clean background.

Q And the Geochimica results that are shown here are the results shown for the various metals and the TDS that you pulled out of their reports; correct?

A Yes. This isn't the whole list. And the results shown here are for what the predicted water quality in the mine would be at the end of mining with all the development rock backfilled, all the cemented aggregate in there and the water level returned to pre-mining conditions. So this is under essentially a closure scenario.

Q All right. And going to the left you have a column that says, "Stratus Consulting," and you have various results there from your modeling based upon the more realistic assumptions that we talked of previously; correct?

A Yes.

Q And can you tell Judge Patterson for the results how your results compare with the Geochimica results?

A Okay. My results are uniformly higher than the Geochimica or Kennecott results for the reasons that we just went through on that previous slide. Kennecott didn't account for enough surface area. The grain size or the particle

size that they had was too high and didn't account for adequate leaching, amount of ore that is left in the underground mine and in development rock was minimized, and that results in quite a big difference between their predicted results and our predicted results. For example, aluminum concentrations -- the metals are in micrograms per liter, and the sulfate and the TDS are in milligrams per liter. For aluminum, Kennecott hash predicted only 4 micrograms per liter, and we predict almost 5 milligrams per liter, so 3 orders of magnitude higher. Cadmium, .08 micrograms per liter which is right on the edge of the detection limit for that metal. And we predict 362 micrograms per liter. Copper, which we saw was present in high leachate concentrations in the country rock, Kennecott predicts 2.1 micrograms per liter, and we predict 11 milligrams per liter. And you can see these other ones. Nickel, Kennecott also predicts a fairly high concentration of nickel in the underground mine at the end of mining that exceeds any of the standards here for Michigan. 1.7 -- or 8 milligrams per liter, but we predict 15-1/2 milligrams per liter of nickel at the end of mining. And sulfate at the end of mining, 28 milligrams per liter, Kennecott predicts, which is a very low number. I mean, that's, you know, background sulfate concentrations for much of groundwater in the United States that I've seen. And then we predict a

concentration of almost 400 milligrams per liter, which exceeds both of the Michigan standards.

Q All right. Thank you, Dr. Maest.

MR. LEWIS: Mr. Haynes?

MR. HAYNES: Yes.

MR. LEWIS: Just for he record, I think that during the course of that description Dr. Maest, just because she had to look back and forth on the cadmium and the cobalt may have confused the numbers. Could I ask that she just review those two sets again, please?

THE WITNESS: Oh, right.

MR. HAYNES: Sure.

THE WITNESS: You're right.

A Okay. Geochimica was .08 micrograms per liter for cadmium and then we predicted 11.9, almost 12 micrograms per liter. Cobalt, Kennecott predicted 18 micrograms per liter. We predicted 362 micrograms per liter.

Q Now, Dr. Maest, as part of your assignment here, you also dealt with the question of the amount of development rock backfilled or placed in the underground mine; correct?

A Yes.

Q And we have a table which is one of the slides in Exhibit 66 which deals with the development rock estimates. Can you explain this table for Judge Patterson, please?

A Okay. This is the amount of development rock or waste rock

that will be produced and placed in the underground mine each year during the mining process. So this first column is the year of development from year 1 through year 7. And then this is how much development rock is taken out of the mine each year. And then this third column is how much is going to be used in road beds on the tunnels that kind of snake down to the underground mine. And this last column is the cumulative amount of development rock backfilled or placed in the underground mine. And if you recall, we talked about the total amount being almost 650,000 tonnes of development rock, so that's what you get at the end of mining. And these are the amounts -- during your 1, 2 and 3, you can see that not very much development rock is in the underground mine. It's really just from the road bed requirements. And then in year 4 it takes a big jump because that's when they start taking the development rock off the pile and start the backfilling operation.

Q And how is this calculation relevant to your testimony today?

A The relevance of this is for the prediction -- there were several different predictions that were made. And the relevance of this is for the development rock stockpile prediction and also for the water quality prediction during mining. The year that you pick to depict the water quality during mining is very important because if you pick a year

up here (indicating), 1, 2 or 3, there's not much development rock that's backfilled into the mine, and that development rock contains a lot of surface area that will leach contaminants.

Q And what years were picked by Kennecott and what years did you pick for your purposes of modeling?

A To predict water quality during mining, Kennecott picked year 3. And that's right here (indicating), but they actually didn't use any development rock in the prediction of water quality during mining.

Q And is that appropriate, Dr. Maest?

A Well, it's representative of what would be in the mine during year 3. It's actually an under representation because there is some rock that will be in there, but it's a gross underestimation of the amount of development rock that would be in there right after that in year 4.

Q And you would expect for modeling purposes that the higher amount of rock would be used for the modeling?

A To get an estimate of what water quality would be during mining, I picked years 4 and 7 because year 4 is the first year that you're getting a lot of development rock backfilled into the mine, and then year 7 would represent all of that rock being in the mine.

Q Now, Dr. Maest, you also performed calculations dealing with the massive sulfide unit in the mine walls and the crown

pillar during operation of the mine.

A Yeah.

Q We have this on the next slide. Could you explain this table for us, please?

A Yes. For predicting water quality during mining, there were a couple of adjustments that we made to the model. One is that we included earlier weeks of weathering for the massive sulfide unit, and Kennecott did the same thing. The reason is that, if you recall from yesterday, the massive sulfide concentrations got high very quickly in terms of nickel and sulfate and then went down. And at the end of mining we picked the lower concentrations kind of at the end of those humidity cell tests. But for predicting concentrations during mining we wanted to capture that big peak of nickel and sulfate to take a look and see what that would do in terms of water quality.

Q Now, just to add some context to this slide, Dr. Maest, we have another slide from Exhibit 66 which is -- which shows the cross- -- excuse me -- the plan view of various levels of the mine and showing the ore types.

A Yes.

Q Can you explain how this relates to your crown pillar modeling?

A Right. This slide is showing kind of slices through the earth horizontally at different levels in the proposed mine.

So 400 meter level is above any planned mining. 350 meter level is below that and is in what would now be called the crown pillar, and 300 meter level is right below what has been accepted as the crown pillar. And we have the same colors here. The magenta is the intrusive or the peridotite. The kind of tan-ish, yellow-ish color is the semi-massive sulfide and the red is the massive sulfide ore.

Q All right.

A So that shows that there will be quite a bit of ore, and I showed it on the other cross-sections going vertically before. There will be quite a lot of ore remaining in the crown pillar.

Q Now, Dr. Maest, you've also reproduced in your -- in this exhibit a figure that shows how the mine is going to be developed. And can you show for purposes of your estimate of crown pillar conditions during mining where those cross-sections are generally on this mine plan? And first I guess we better explain what the mine plan is or your understanding or it.

A Okay. These tunnels that kind of snake down allow access to the orebody here, which is represented in kind of pink and red stripe, vertical stripes here. And that's where the development rock would be extracted from. And these are different levels in the mine from the top to the bottom. And the stripes represent primary and secondary stopes. The

primary stopes are planned to be backfilled with cemented aggregate that is brought in from elsewhere, and the secondary stopes are planned to be backfilled with uncemented limestone amended waste rock.

Q And then we have also going to the left part of the blue tunneling, it says "Mine decline." And where does that end up if you remember?

A I believe that's at Eagle Rock.

Q And the cross- -- or the plan view that we saw in the previous slide, about where would those slices be represented on this figure?

A Well, the top slice would be a little bit above this at 400 meters. And then at 350 meters would be around here (indicating), and then 300 -- I think the other one was 300 meters --

Q Right.

A -- would be in here (indicating) somewhere.

Q And then, as I recall, the crown pillar height above sea level is 327; correct?

A Yes.

Q 327.5.

A 327.5, yeah.

Q And show on this figure where that would be approximately.

A So somewhere in here (indicating).

Q All right. So this mine plan actually is not -- this is one

of the original mine plans that doesn't take into account the current crown pillar configuration; right?

A That's right. Right. This one shows mining above into the -- what would be considered the crown pillar now.

Q Okay. Now, after that brief digression, Dr. Maest, we're back to the table showing the massive sulfide unit and the crown pillar during operational conditions. Can you explain what this table -- what this table shows?

A Okay. Well, the first column -- well, the second column I've already described. This is the "Massive Sulfide Humidity Cell Test Leachate Concentrations for Week 3." And this is what Kennecott used to predict during mining concentrations as well. That would catch the high concentrations of nickel and sulfate and other contaminants early in the leaching process. The last column on the right is my estimate of what would be coming through the crown pillar. Now, we don't have anything on this because there was nothing -- none of the leach tests were conducted in the material that would become the crown pillar.

Q And so how did you arrive at the figures here?

A I used a mix. I used those cross-sections that we were just looking at, you know, that showed the configuration of the orebody and the peridotite. And by using Geographical Information System, GIS, we estimated the percentages of the rocks that would be present at different levels in the crown

pillar. And the estimate shown here is 10 percent country rock, 50 percent intrusives or peridotite, 37 percent semi-massive and 3 percent massive sulfite ore.

Q And what result did you arrive at from the modeling based upon these assumptions?

A Using those assumptions I use humidity cell test leachate concentrations and mixed them in these percentages shown here to arrive at these concentrations and values here. So pH 5.75, aluminum .5 milligrams -- .6 milligrams per liter. Let's see here; copper 1.3 milligrams per liter, nickel 57 milligrams per liter, sulfate 337 milligrams per liter. So that's the input through the crown pillar that would be going into the underground mine during mining operations. That's my estimate.

Q Now, for purposes of modeling, did Kennecott assume anything relating to inflowing groundwater quality compared with background groundwater quality?

A What do you mean exactly?

Q Well, in the Kennecott modeling was there an assumption made by Kennecott or Geochimica relating to the water quality for the inflowing water into the mine as it relates to background groundwater?

A Okay. Well, in the Geochimica models they diluted essentially with distilled water and said that whatever concentrations they came up with for leachate in the mine

needed to be added to the background concentrations. So those were not taken into account in Kennecott's estimates of leachate concentrations during or after mining.

Q Now, Dr. Maest, as a result of the corrected assumptions that you used did you predict then the influent into the wastewater treatment plant during the operation of the mine?

A Yes.

Q And did you compare these predictions with those predicted by Kennecott?

A Yes.

Q All right. We've had -- we now have a slide from Exhibit 66 which shows this comparison; correct?

A Yes.

Q And can you then tell Judge Patterson what the differences are, if any, between your predictions and the predictions used by Kennecott for inflows into the wastewater treatment plant?

A Okay. This first column shows the parameter that -- of interest: aluminum, boron, et cetera, and most of these are -- actually all of them are in milligrams per liter. The far column on the right is Kennecott's prediction for what water quality will be in the mine during mining in year three, and this -- these two columns right before that to the left of it are our predictions for year four and year seven concentrations. And you can see that most of our

concentrations are higher. Boron is essentially the same. Cadmium is about double. Aluminum concentrations by Kennecott, for example, are .14 milligrams per liter, where we predict somewhere between six and seven or so milligrams per liter of aluminum. Cobalt Kennecott predicts about .7 milligrams per liter; we predict between .8 and 2.6 milligrams per liter of cobalt during mining. Copper Kennecott predicts .15 milligrams per liter and we predict 14 to 18 milligrams per liter of copper. And nickel concentrations Kennecott's and ours are similar during year seven and year three, but our concentrations during mining in year four are higher, 126. Our sulfate concentrations are six or so times higher than Kennecott's and our nitrate concentrations are quite a bit higher than Kennecott's.

Q And what implications does that have, in your view, for the operation of the wastewater treatment plant?

MR. LEWIS: Objection; foundation, your Honor.

Q Dr. Maest, have you in your knowledge, training and experience dealt with inflows to wastewater treatment plants for mines?

A Yes, I have.

Q And have you analyzed constituents that are in water that flow into the -- that are treated by wastewater treatment plants for hard rock mines?

A Yes.

Q And is that the purpose of preparing this -- excuse me. Was the purpose of preparing this slide to show those -- the implications of such concentrations going into wastewater treatment plants?

A Right. This is what would go into the treatment plant.

MR. HAYNES: Your Honor, I think we've laid enough foundation for the witness to testify.

MR. LEWIS: Well, I don't agree, your Honor. And I think the question pertained to, again, this table Dr. Maest has testified about seems clearly to me to be within her qualifications to talk about the quality of the water and the various constituents which may be in the water in the mine; however, the last question posed by counsel as I understand it is asking this witness to offer an opinion as to whether the proposed water treatment system for this mine can handle various levels of metals and so forth. And number one, there's no qualifications for this witness to talk about the design, construction, operation of water treatment plants; and number two, even if she was qualified to do that, there's no foundation that she has done the necessary study and analysis of the proposed water treatment plant in this case to offer such an opinion.

MR. HAYNES: All right. I'll lay the foundation as to the last part, your Honor. I think counsel may have an appropriate objection there.

Q Dr. Maest, have you reviewed in your experience wastewater treatment plant operations for hard rock mines?
A Yes, I have.
Q And about how many?
A It's not my main area of expertise, but I would -- I don't know -- probably seven or eight treatment plants at mines.
Q And have you reviewed those operations in view of the various inputs into the wastewater treatment plant for purposes of treating those inputs for discharge into surface or groundwater?
A Yes, I have.
Q And have you reviewed in this case in general the method of operation and the techniques for operating the wastewater treatment plant for the proposed Eagle Mine?
A Yes, I have.
MR. HAYNES: Your Honor, I think I've laid a foundation now.
MR. LEWIS: Same objection, your Honor.
JUDGE PATTERSON: I'll allow her to testify. She's admitted this isn't an area of her particular expertise, but -- so it may go to the weight of her testimony, but I think there's a proper foundation.
Q Dr. Maest, in your view what implications are there for the operation of the wastewater treatment plant based upon your conclusions from the modeling of the inputs into the

wastewater treatment plant?

A Well, as I've said, our predicted concentrations are many times higher than those of Kennecott's, and this would obviously affect the operation of the treatment plant because the -- if the concentrations of metals and other contaminants are, you know, three orders of magnitude higher that needs to be taken into account in design of the operation of the treatment plant.

Q And for the proposed wastewater treatment plant and the design that you've reviewed, have these additional higher concentrations been taken into account in the design?

MR. LEWIS: Objection; qualifications and foundation, your Honor.

MR. HAYNES: I think this is the same issue that we just went over, your Honor.

JUDGE PATTERSON: I'll overrule.

Q Go ahead, Dr. Maest.

A I'm sorry. Could you repeat that?

Q Have these higher amounts been taken into account in the design of the wastewater treatment plant?

A No, they haven't. No, there are, you know, tables in Appendix G to the mine permit application, for example -- actually, it's the groundwater discharge permit, Appendix G that shows the concentrations that have been considered as inputs to the treatment plant and those are based on these

numbers over here (indicating) rather than ours.
Q You mean the Kennecott numbers shown on the slide?
A Yes, Kennecott -- the Kennecott numbers shows on -- to the right of this slide.
Q All right. And finally, Dr. Maest, have you reviewed what has been marked as proposed Kennecott Exhibit 595, which is the new Golder sampling study?
A Yes.
Q And have you compared the -- have you analyzed the work that was done in that study with the prior Kennecott studies relating to the influent concentrations into the wastewater treatment plant?
A Now, this is -- you're referring to the recent Golder 2008 report?
Q Yes; yes.
A Yeah, this is a report that basically is a continuation of the humidity cell test. These tests were conducted for long periods of time, which is quite good. And this goes out to 150 weeks or even higher, 200 weeks. And so it's mostly a compilation of those results. And the results show that the concentrations of the contaminants either increase or stay the same in the vast majority of the cases.
Q And would those results then be consistent with your charts that we've shown before on the humidity cell testing?
A Not entirely; no.

Q And how are they different and how are they the same?
A Several of them are the same, but I think the one that's the most important that's different is the results for peridotite -- for the sample that I show for peridotite. I had a maximum nickel concentration of .8 milligrams per liter there at week 70 -- actually, I think it was week 50. The concentrations that -- in the Golder report were 40 milligrams per liter of nickel coming off of the peridotite. So those concentrations went up dramatically and the pH came down. So in that regard I feel that I may have underestimated the concentrations of contaminants coming off of the peridotite under long-term conditions.
Q And that underestimation would in fact drive the numbers that you've shown here up?
A Yes; that's right.

MR. HAYNES: At this time I'd like to move the admission of Exhibit 66 and for the slides that I've shown. And I apologize, your Honor. I will get the list of those slides to counsel, but I have to cull out some of the slides that we did not show from that exhibit. But I will get that to counsel so that we can make sure that we're all on the same page there.

MR. LEWIS: Which one is 66?

MR. HAYNES: 66 is the -- are the slides that Dr. Maest has been going through.

MR. LEWIS: Oh. And you and I -- you're going to cull them out and talk to me and then we'll present it to the judge?

MR. HAYNES: Yes; right. And with Mr. Reichel.

MR. LEWIS: That's fine. So there's no current offer, as I understand it, and we'll take of it.

MR. REICHEL: Just to be clear, the anticipated offer will be limited to those slides that the witness has -- that have been projected that she's testified to?

MR. HAYNES: Yes; that's correct. That's correct.

MR. REICHEL: I have no objection to that procedure.

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

THE WITNESS: Thank you.

MR. EGGAN: Do you want to take a break, Judge?

JUDGE PATTERSON: I do.

MR. EGGAN: Very good.

JUDGE PATTERSON: You read my mind.

(Off the record)

MR. EGGAN: Are you ready to go back on the record, your Honor?

JUDGE PATTERSON: Yes, I am.

MR. EGGAN: Good morning, your Honor. Eric Eggan, Honigman, Miller, Schwartz and Cohn; I'm here on, as you

know -- well know, here on the Part 31 part of this thing. I'll say for the record that Mr. Haynes covered quite a bit of what I might have otherwise covered, so the hope is that we'll be able to move through this expeditiously.

DIRECT EXAMINATION

BY MR. EGGAN:

Q Dr. Maest, as I just indicated, my questions will focus primarily on the Part 31 permit and many of the issues that you discussed in talking about the mining permit overlap.

A Okay.

Q I want to just make sure that we have an understanding of the materials you covered in terms of the Part 31 permit, the materials that you looked at in advance of coming today.

A Okay.

Q And I think you said you reviewed the groundwater discharge permit?

A Yes.

Q And the comments that were submitted as a part of the process in this matter, the part of the comments to the permit application?

A Yes, I did.

Q Did you review the Department of Environmental Quality's analysis and their comments to the comments?

A Yes, I did.

Q Okay. And did you also review their files -- the file

materials that were provided to the parties that related to groundwater: e-mails and discussions and correspondence memoranda?

A Yes; some.

Q And you also prepared a report I think on the issues surrounding the groundwater discharge permit?

A Yes, I did.

Q Okay. I'm going to show you the first page of that report, which is 081598. This is the front cover of your comments on the -- our comments in opposition to the proposed issuance to the company of the groundwater discharge permit; is that right?

A Yes, it is.

Q Okay. And that document contains numerous pages. Is this a document prepared by you?

A Yes, by Stratus Consulting. Yes.

Q By Stratus Consulting?

A Yes.

Q Okay.

MR. EGGAN: Your Honor, I'm going to offer Petitioner's Exhibit 8-B at this time. That's Dr. Maest's report.

JUDGE PATTERSON: I'm sorry. What was the number again?

MR. EGGAN: It is Petitioner's Part 31 Exhibit 8-

B, Dr. Maest's report.

MR. LEWIS: Give me a moment here, your Honor, to -- on that. I do have an objection to the admission of this report, your Honor. And there's a few parts to it. I believe I have printed the report that petitioners intend to offer as their Part 31 Exhibit 8-B. If I do -- one objection to this report is that it has various attachments to it beyond the report by Dr. Maest. And, for instance, there is a separate report from -- done by another firm, Conestoga-Rovers attached to Dr. Maest's report for which there's been foundation. My version of this that even includes a CV for apparently the author of this Conestoga-Rovers report and a CV of another gentleman who apparently is also employed by Conestoga-Rovers. So that's the first part of my objection; that this is -- includes many things other than the report by Dr. Maest as represented by counsel.

Number two, within the body of the report there are various opinions that I believe are based on these other reports. Well, I guess that's not so much, I don't believe, a concern of mine beyond the attachment of these various reports without foundation, your Honor. There are some conclusions of Dr. Maest's within this report which, again, was prepared as part of the mine opponents' public comments submitted to the DEQ during the public comment period and I

think that's relevant because I think it in part explains why some of these documents are -- do not comply with typical scientific reporting standards. And in fact, sometimes and oftentimes these documents or so-called reports include opinions and conclusions for which there's no data or foundation presented within the body of the report.

So, for instance, your Honor -- and without -- only for the use of demonstrating what I'm talking about, on page 29 of Dr. Maest's report she draws conclusions as to the -- her predictions of mine water quality as to whether they will have impacts on what she calls down-gradient groundwater and there's no foundation in the report or otherwise for her to draw such conclusions. She draws the conclusion, for instance, that such impacts were ignored by Kennecott in the groundwater discharge permit application. Again, there's been no foundation for such opinions.

On page 30 of her report she references a so-called independent analysis of a geographic area affected by dewatering of the mine conducted by another consulting group who also submitted public comments in the part of the anti-mining comments. And again, this demonstrates a reliance on reporting done by others and Dr. Maest's reference to such reporting and her adoption in drawing opinions from such other reporting, and that's another problem with the

foundation for this report, your Honor. And I object on that basis.

MR. EGGAN: A couple of comments, your Honor. The document that I propose to submit is a 32-page document with an attachment that shows jaw crushers as Attachment 1. There's another attachment that shows single toggle-jaw crushers as Attachment 2. And there are only two attachments. My document does not have the CV that you mentioned or the report from Conestoga-Rovers as an attachment.

MR. LEWIS: Well, we can --

MR. EGGAN: We may be able to chat about that and resolve that particular dispute.

MR. LEWIS: Good.

MR. EGGAN: With respect to the other objections, which are apparently no foundation with respect to the water quality issues; I think that's really a hearsay objection. It's the same objection that was raised earlier in these proceedings related to the admissibility of the reports. We would ask that the Court consider admitting this kind of evidence, this report because this Court has the ability to cull out hearsay, it has the ability to cull out issues that it doesn't consider to be necessary for its resolution. The ordinary rules of hearsay, the stringent rules of evidence don't really apply to these kinds of proceedings as

stringently as they might otherwise. In fact, this Court is allowed to consider evidence that might be considered by a reasonably prudent person in Dr. Maest's position.

So we would ask that this report be admitted on that basis just as other reports have been admitted by -- have been admitted for other experts in this case already. In fact, Dr. Maest's earlier reports on the Part 32 permit were admitted by the Court really without objection.

MR. LEWIS: Your Honor, if I may.

JUDGE PATTERSON: Sure.

MR. LEWIS: Just follow up a little bit. Again, my objection is not per se based on hearsay, and I did not use that word here. And I understand that -- at least my understanding from earlier objections and rulings and so forth has been in general if the witness can lay a foundation for a report and perhaps that in general the hearsay rule itself will not keep the reports out; I understand that. But my objection here is as to foundation and I want to add a little bit to what I just said about this witness's reference in this report to reporting and conclusions drawn by others who have not testified in this proceeding for which no foundation has been offered, and specifically this Conestoga-Rovers report. And I agree with Mr. Eggan that if that either is not in their proposed exhibit or we can agree to take it out, we can take care of

that problem this way, but the other problem remains.

On page 30 of Dr. Maest's report she doesn't just make passing reference -- excuse me -- she doesn't just reference now the Conestoga report but she refers to another report done by a company called WHPA and on page 30 of her report she bullet-point by bullet-point sets forth the conclusions stated by this WHPA in their report as to potential drawdown of the groundwater in the aquifer above the mine. And so I think this is a fairly blatant attempt to get through with Dr. Maest and to in effect try to offer with this exhibit evidence that they very much want this Court to have and they very much want this Court to use for the truth of the matter stated herein and that ought not to be allowed in my view, your Honor.

MR. EGGAN: Your Honor, I'll respond briefly to that. Again, this may be an issue that we can discuss with counsel. There is no attempt to try and sneak something in at all and I don't think he's accusing me of that, but we may be able to discuss this issue. But again, I would note for the Court that you certainly have the ability to admit evidence that would be relied upon by a reasonably prudent expert --

JUDGE PATTERSON: Well, if Dr. Maest relied on those facts, whatever they are, in formulating another opinion, that's one thing, but to put in the -- that report

without a foundation for substantive evidence is a different matter. I'm not sure what your purpose is.

Q Dr. Maest, did you rely on -- in considering the drawdown impacts from mine dewatering did you consider the Whitman report of 2007 as part of your analysis and conclusions?

A Yes, I did.

MR. EGGAN: She did, your Honor, and so -- she's indicated that she has and I think it's --

JUDGE PATTERSON: All right. For that purpose I think it's --

MR. LEWIS: If I may?

JUDGE PATTERSON: Oh, sure.

MR. LEWIS: In this report, your Honor, she's not even discussing the WHPA report and the conclusions in the context of any basis for any conclusions by her whatsoever. She was apparently asked this report to just include it as something to submit to the DEQ in the public comment process to say and hear what WHPA said in their report. It's got nothing to do with her opinions; it's separate and apart from that.

MR. EGGAN: Well, we can go through a process of asking her all about this if you wish, your Honor. I'm trying to shorten things up a little bit and move things along.

MR. LEWIS: And she's a geochemist. The WHPA

report she's referring to is groundwater modeling, your Honor. I mean, what -- how fruitful would it be to ask this -- questions of this witness about a topic for which she has no qualifications, for which she's done no analysis or independent study? Again, all this section does is restate the results of that report. It has no relevance to her opinions and it's improper to attempt to offer this through this witness in my view.

MR. EGGAN: Well, I disagree, your Honor. I think we've established the foundation. And again, what we're trying to do is streamline the process and get this document in. This witness is here; she has testified; she's given opinions that related directly to groundwater. She's eminently qualified as an expert in the areas that she's testified on and we would ask that this be admitted. You have the ability to admit this and give it the weight you think it deserves.

JUDGE PATTERSON: Well, the issue I think is whether she factored that into one of her opinions, so it's underlying facts. But if she hasn't done that and this is just another report that was submitted without being part of her analysis, that -- I don't think that's admissible.

MR. EGGAN: All right. Why don't counsel and I talk about this Part 6.2 of her report after Dr. Maest has testified and maybe we can agree on some mechanism for

deciding this issue?

JUDGE PATTERSON: Okay. Yeah, I appreciate that.

MR. EGGAN: Other than page 30, we would offer the rest of report at this time.

MR. LEWIS: Well, I would rather do what counsel suggested and then if he wants to discuss it and present something to the Court later that's fine. But I presented this bit on page 30 about this reference to another report as an example of what's going on in here, so I have the same objection as to other parts of this report and I suggest that Mr. Eggan and I do talk about it and see if we can reach some accommodation later.

MR. EGGAN: Well, I really don't think that we need to go over this page by page and have several hours of analysis on this, Counsel. You indicated you had a problem with page 30 and I'm willing to talk about that, but I -- Judge, I thought we were trying to streamline the process here.

MR. LEWIS: Again, your Honor, I don think the Court --

JUDGE PATTERSON: Well, that's a worthy goal to a point.

MR. LEWIS: -- wants to go through this page by page right now, so that's the alternative. So I suggest we talk about it and see if we can work something out.

JUDGE PATTERSON: Do you want to do that now?

MR. LEWIS: WE can break --

MR. EGGAN: I don't think we need to do it now, Judge. I think we can go ahead with Dr. Maest and perhaps do it afterwards, yeah.

JUDGE PATTERSON: Okay. You can do it over lunch.

MR. EGGAN: Yes.

Q Dr. Maest, you've indicated what you had reviewed as part of your preparation for today. I was especially interested in what you said yesterday when Mr. Haynes was doing the questioning and you talked about the issue of mitigation and how mitigation plays into -- how important mitigation is to mines in terms of the acid mine drainage issue. Can you tell us where mitigation fits into this particular plan for this particular mine?

A Yes. Well, mitigation again is procedures or actions or, you know, structures that are created to prevent pollution of natural resources, especially of water. And I think in this case for the Eagle project everyone agrees that the rock will make bad water. We've showed that the acid drainage potential is high, that the contaminant leaching potential is high. Ted Eary's report from MDEQ echoes that, and the Geochemica reports prepared for Kennecott say the same thing; that the majority -- the vast majority of the materials need to be -- have special handling, and by that

he's referring to mitigation. So we all know it's going to make bad water; the only thing that stands in between those wastes and polluted water is mitigations. So in this project in particular it's very important that the mitigations are very sound and will do their job.

Q They've got to get it done right?

A That's correct.

Q I want to show you the overview of the treatment plan and make -- to make sure that we're -- we have an understanding of what that plan is.

A Okay.

Q And then I'm going to talk to you a little bit about the groundwater quality issues that are associated with the plan. Okay?

A Okay.

(Pause in dialogue)

MR. EGGAN: Your Honor, as I did yesterday I put together a little tab of exhibits that I've given to counsel. Your Honor, this is Tab 2 in your book. Counsel, this is Bates number MDEQ 010716. It is from MDEQ Exhibit 141 which has already been admitted.

Q Dr. Maest, just so we have an orientation and an understanding of -- these are what are called contact water basins. This is where the water is going to flow into the system. I assume that you've reviewed this exhibit; you

have an understanding in what it is?

A Yes, I have. Yes.

Q Okay. And then the treatment plant -- excuse me -- the wastewater treatment plant is here.

A Okay.

Q You've talked a little bit about the TDRSA, the temporary development rock, this storage area?

A Yes.

Q Which is right here (indicating). Okay?

A Yes.

Q And then here in this area which is this large block we have what's called the Treated Water Infiltration System, the TWIS. Okay?

A Yes; right.

Q So that's kind of the framework and I'd like to go through and hit some points that I think are relevant to water inflowing into the system and the water quality issues. Okay?

A Yes.

Q Do you understand what the purpose is of the contact water basins? What are their purpose?

A The purpose of the contact water basins is to collect water that has been in contact with materials that can create pollution. And in this case that would include the underground mine, the development rock storage area, and it

also includes water that comes in from stormwater runoff at the site. And that goes here to the contact water basins and that is the influent to the wastewater treatment plant.

Q Okay. So when you and Mr. Haynes were discussing the influent that is -- and the concentrations levels that are going into the wastewater treatment system they're first going to these contact water basins?

A That's correct.

Q Okay. Now, you talked also about what we've been calling the TDRSA, which is the area -- if you can point that out?

A Yes. (Indicating).

Q Perfect. Thank you. What is -- again, we need to understand what the purpose of that area is. What are we storing there?

A What we're storing is what Kennecott calls "development rock," which more commonly referred to as "waste rock." And this is the rock that they would take out of those tunnels that are snaking around down to the underground mine. That rock consists of country rock and peridotite and also some ore that cannot be excluded 100 percent from the development rock.

Q Do you have an understanding of -- after that rock is placed there, is there going to be some sort of cover over it?

A They do plan to have at least a partial cover this.

Q Well, you're raising your eyebrows. What do you mean by

that?

A Well, it's --

Q What's the concern, if there is any?

A The concern is that -- well, I, first of all, have never heard of that before at a mine, but they are actually covering a waste rock pile. It's a pretty big facility, so it's difficult to do and I think the plan is to cover it as best they can to exclude infiltration from the waste rock pile so that it doesn't get as much water and melted snow on it and doesn't make as much bad leachate.

Q Well, is this development rock that comes out of the mine and is placed here, is it reactive?

A It's very reactive and the results that I showed for the humidity cell tests show how reactive it would be. We saw concentrations of contaminants going up, pH going down for both the country rock and the peridotite and, of course, the ore.

Q Okay. And we have a depiction of the wastewater treatment plant here. It's probably obvious to everyone, but what is the purpose of the wastewater treatment plant?

A The purpose of the plant generally is to clean up the water that comes into it. And the source of the water going into that is the contact water basin which comes from the underground mine, the leachate from the temporary development -- from the waste rock dump and other locations

on the site.

Q Okay. I want to go back briefly to the contact water basins and we'll kind of move up the system as we go. You and Mr. Haynes covered, I think quite nicely, your perspective about what this water is going to look like after mining operations and going in.

MR. EGGAN: Can I get you to call up 100305?

Q This is an exhibit that you utilized with Mr. Haynes.

MR. EGGAN: And I believe it's Exhibit 66?

MR. HAYNES: Correct.

MR. EGGAN: Okay.

Q The one question I had about this, Dr. Maest, is I'm seeing that you used years four and seven to predict the influent going into the wastewater treatment plant, yet Kennecott used year three. And if you can explain to Judge Patterson why you used years four and seven as opposed to year three I think it might be helpful.

A Okay. The reason that we used year four and seven is because that is when development rock really starts going into the mine, the underground mine, and that's year four. And the importance of that, as I said before, is that there's a lot of surface area on that development rock that will produce contaminated leachate. So to exclude it by using year three will dramatically underestimate concentrations that would be present in the leachate from

the waste rock pile. And also obviously going into -- I'm sorry. This isn't the leachate; this is influent to the wastewater treatment plant. In other words, what's going to be in the contact water basins.

Q Okay. What's going to go into those contact water basins?

A yes.

Q Okay. Now, your predictions are different than the company's predictions?

A Yes.

Q What do you attribute that to? Where did the company go wrong?

A There's several different reasons. One is the amount of development rock that it includes; another is the -- this is what we went over earlier -- the surface area was not considered -- not enough surface area was considered. The assumptions about the amount of ore present in the underground workings of the mine and in the development rock I feel was underestimated by Kennecott. And also the inflow to the mine. I used Kennecott's estimate of expected case inflow 75 gallons per minute, and Kennecott used 180 gallons per minute. Those are the major ones.

Q I understand and you did go over that this morning, --

A Yeah.

Q -- and so I won't ask you to repeat those issues. There was a couple of points that I wanted to add to what Mr. Haynes

asked you about. One of them was did you consider the impact -- or actually, did Kennecott consider in their analysis the impact of blasting and the addition of nitrites in the water -- nitrates?

A Nitrates. It appears that they did not. There is some -- they do include a very small amount of nitrate and I believe that there's -- in the estimate of what's going into the wastewater treatment plant they have some more ammonia going in, but at hard rock mines blasting creates high concentrations of nitrite -- nitrate during operations and that's because they use TNT -- the "N" is for "nitrogen" -- and that creates oxidized nitrogen in the form of nitrate in -- usually in groundwater and leachate.

Q Can it have a discernible impact on water going into the wastewater treatment plant?

A Yes. It will have much higher concentrations of nitrate than Kennecott is showing.

Q Very good. Dr. Maest, is this a slide that you prepared?

A Yes, it is.

Q In anticipation of testifying?

A Yes, it is.

Q Okay.

MR. EGGAN: Counsel, this is Tab 9 in the book that -- in the book of Dr. Maest's potential exhibits that I provided to you this morning. Tab number 9.

MR. LEWIS: For the record, your Honor, I'll just mention again my objection as to relevance and lack of similarity and foundation would apply to this slide as well.

JUDGE PATTERSON: Okay. And I'll overrule as I have previously.

MR. EGGAN: Okay.

Q Dr. Maest, could you please tell us what this slide represents and how you created it?

A Okay. This is a slide that shows the concentrations of nitrate and sulfate during mining at the Jamestown Mine in California. Now, I just put this up as an example. There are many other mines that I've looked that show similar trends in concentrations of these two constituents. And this is in groundwater monitoring wells that are down-gradient of tailings and waste rock. So the tailings and the waste rock are made by blasting out the mine. And the waste rock is the larger sized particles that are created by blasting of the mine that are pulled out, and the tailings in this case are what goes into the mine facility but it also has the blasting residue on it.

So you can see that -- right here (indicating) this is time on this axis: 1984, '87, '93, et cetera. And on the left vertical axis is sulfate concentrations going up to 2500 milligrams per liter and just for reference the federal drinking water standard is 250 milligrams per liter

here. On the right vertical axis we have nitrate concentrations in milligrams per liter going up to 700 milligrams per liter, and for reference the water quality standard for nitrate for protection of human health is ten milligrams per liter.

The open circles are nitrate and the closed circles that go up like this (indicating') are sulfate. And the -- you can see that the nitrate concentrations go up and then down again, and this is what I've seen at a lot of hard rock mines. The nitrate concentrations don't stay high forever, but during mining operations when there's active blasting and removal of rock we see concentrations of nitrate generally going up into the hundreds of milligrams per liter as shown here. And the nitrate concentrations peak at about 600 milligrams per liter, and then go down to about 50 or so later on. And this is just tailings and waste rock; it doesn't actually show groundwater down-gradient of the mine itself.

MR. EGGAN: Your Honor, this is Petitioner's Exhibit -- this is the Petitioner's in the ground -- the Part 31 permitting matter, Exhibit 28-R and we would offer it into evidence at this time.

MR. LEWIS: Same objection, your Honor.

MR. REICHEL: I join in that objection.

JUDGE PATTERSON: All right. For reasons

previously stated I will admit it.

(Petitioner's Exhibit 31-28-R received)

MR. EGGAN: Thank you.

Q And, Dr. Maest, based on your experience in mines and on this exhibit, is the company's prediction as to the nitrate level that will be in the water realistic?

A It is not realistic. Kennecott, as indicated on the slide here, has estimated that the nitrate concentration going into the wastewater treatment plant will be .05 milligrams per liter and I believe that it's going to be closer to 100 milligrams per liter.

Q Okay. I want to ask you about inflow into the mine from so-called "utility water."

MR. EGGAN: This is Tab 3, your Honor. Tab 3 in the book. This is Figure 4.2 from the Kennecott application for groundwater discharge permit and essentially it's a schematic that was prepared by Foth and VanDyke. It is MDEQ Bates number 010722.

Q Dr. Maest, what does this -- what does this document show?

A This is called a "water balance." This shows how much water is coming in from different locations at the proposed mine. And it's hard to read this unfortunately, but this shows the amount coming in from groundwater into -- this is the underground mine right here (indicating), this is the contact water basin, and then the wastewater treatment plant

starts over here. I don't know if it's possible to expand that at all or if it would even make any difference.

Q Would it help, Dr. Maest, to expand this part?

A I think if you can just get it -- try it maybe from here to here.

Q Okay.

JAN: Show me again.

THE WITNESS: From here up here, yeah, to -- down to here.

Q It doesn't help much, does it?

A Well, that's maybe a little better. I can see that this (indicating') is contact water basin, this is Eagle Mine, so this is the underground mine. And there's groundwater inflow coming in and then you asked me about utility water?

Q Yes.

A And that's shown right here (indicating). It's shown in a couple of places. Utility water -- here's the underground mine; there's ventilation water coming in, there's groundwater inflow. There's water coming in from the waste rock pile right here. And then that water, a large part of it, goes to the contact water storage basin. Then there's kind of a preliminary treatment step here that involves mostly filtration. And then you can see that there are -- before it goes into the wastewater treatment plant there's a lot of water that is peeled off and then goes to -- for

different uses at the mine facility. And I believe this -- does that say "utility water" right there? I can't see it.

Q It says water for --

A Where is -- is this the utility water right here, or not?

Q Utility water is here.

A Okay. Right there. Sorry. And I believe that says 124 gallons per minute.

Q It does.

A So it comes from the contact water storage basin. There's a filtration process that goes on. And then before it goes into the full-blown waste water treatment plant, it peels off here and then goes back into the underground mine. So that water is only minimally treated and then is sent back into the underground mine. So it can be expected to have high concentrations of metals and sulfate and a low pH.

Q Thank you. I wanted to ask you about some other sources of drainage. And we'll leave that chart up there. There is -- there are two areas depicted on this document. One is the coarse ore storage area, which is there (indicating).

A That's it right there.

Q Yes. And the other are the fine ore bins. Was there any attempt made by the company to consider or to estimate water quality of the drainage from those sources?

A No, there was not.

Q Why are they relevant in terms of -- in terms of drainage?

A The reason that they're important is because this is ore itself that's been, you know, blasted and stored. And there's expected to be some leachate coming off of this. And as we saw with the humidity cell test results, the leachate coming off of ore will be high concentrations of sulfate and metals and other contaminants and low pH. And that then feeds into the temporary development rock storage area. And Kennecott included no number for that.

MR. EGGAN: Your Honor, we would offer figure 4.2, which is MDEQ Bates number 010722 into evidence at this time.

MR. LEWIS: No objection.

MR. REICHEL: No objection. I believe it's already part of the groundwater permit application in evidence.

MR. EGGAN: I think it is too, but I just wanted to be sure that we got it in.

MR. REICHEL: No objection.

JUDGE PATTERSON: Okay.

(Respondent's Exhibit 141, Figure 4.2 received)

Q I want to show you quickly Appendix G1 from the groundwater discharge permit application.

MR. EGGAN: That will be Bates number 100698. Now, this is going to be hard to read. But if you can highlight that for us?

Q Are you familiar with that document?
A Yes, I am.
Q It's actually a two-page document, isn't it?
A It's more than that, because it has -- I think it's at least a three-page. There are little numbers here and then it says on the third page what those mean, what those refer to.

MR. EGGAN: Okay. This is bates numbers from Petitioner's for the Part 31 case, 100698 through 100701. It's tab 12 at your book.

Q Tell the hearing officer specifically what this document is.
A Okay. This is a table that shows pretty much everything that is being considered by Kennecott that will go into the waste water treatment plant. Here we have some background groundwater wells. There's a representation of upper bedrock concentrations, lower bedrock concentrations, and then a total leakage concentration based on different amounts of the groundwater coming into the mine. And then it has a composite mine drainage. There's a column here for the leachate that would be coming out of the temporary development rock storage area and then what would be going into the waste water treatment plant. It also continues to say what the concentrations would be after different steps in the treatment plant.
Q So essentially what we're talking about are influent quality characteristics?

A Yes.
Q Do these influent quality characteristics that were apparently submitted by the company, do they include a characteristic for temperature?
A No, that's not shown here.
Q Is that important?
A It's an important part for knowing how to operate the waste water treatment plant.
Q Does it include total dissolved solids?
A No, it does not.
Q Is that an important characteristic in determination the influent?
A It is, especially for a reverse osmosis.
Q Does it include total suspended solids?
A It does not.
Q Is that an important characteristic?
A That is. And as I mentioned earlier, the humidity cell tests are dissolved concentrations, not total. So we don't have an estimate of the total including particulate concentrations of metals coming into the treatment plant.
Q Does it include a characteristic for alkalinity?
A No, it does not.
Q Is that important?
A That's how much buffering capacity is coming in in the water, and that would be expected to be very low in acidic

water. But it's not included here.
Q If you were doing -- if you were doing this very analysis, would you have included these factors?
A Yes, I would have.
Q Does it include a characteristic for silica?
A No, it does not.
Q Is that important?
A It is. And it also doesn't include pH.
Q Is pH important?
A Yes.
Q Why is pH important?
A Because that shows you how acidic the water will be or how alkaline the water will be. And that's an important part of figuring out how much lime you need to neutralize it.
Q Let me ask you this question, and I'll frame it by saying the Department of Environmental Quality has a rule that requires a discharger to analyze and describe an influent to a waste water treatment plant.
A Okay.
Q Okay?
A Yes.
Q Did the company analyze and describe the influent to the waste water treatment plant? Did they at least attempt to analyze and describe that?
A Yes, they did. And that's what is shown here.

Q Okay. Did they properly analyze it and describe it?
A No, not in my opinion.
Q Why do you say that?
A Because there are -- the main reason is because I believe that they underestimated concentrations leaching from the waste rock in the underground mine. And they also excluded leachate concentrations from other parts of the facility, including the coarse ore storage bin and the fine ore storage bin.
Q I'd like to talk to you for a few minutes now about permit limits, the limits that were established by the Michigan Department of Environmental Quality and which are contained in their permit. Do you have a copy of the permit in front of you?
A Yes, I do.
Q Okay. I'm going to ask you some questions about that permit. And that, I believe, is MDEQ Exhibit 118.
A That's right. That's what it says here.
Q Yes. MDEQ exhibit 118, which is the permit granted to the Kennecott Eagle Mine Mineral Company.

MR. EGGAN: Has this document been admitted into evidence at this point, Mr. Reichel; do you recall?

MR. REICHEL: I'm not certain, Counsel.

MR. EGGAN: Okay. To the extent it hasn't been, I would offer MDEQ Exhibit 118 into evidence at this time. It

is the permit granted by the MDEQ.

JUDGE PATTERSON: I do not have it being entered.

MR. LEWIS: No objection.

MR. REICHEL: No objection.

MR. EGGAN: Very good.

JUDGE PATTERSON: All right. And that's, again, 118. That will be admitted without objection.

(Respondent's Exhibit 188 received)

Q Dr. Maest, have you reviewed the permit yourself?

A Yes, I have.

Q Okay. What I'm interested in asking you about and having you explain to our hearing officer is, are there various types of limits within this permit?

A Yes.

Q Give the hearing officer a description of some of those various types.

A Okay. There are effluent limits, and those are concentration limits that would be applied to the effluent coming out of the waste water treatment plant. And then there are limits for groundwater that would be applied to the groundwater monitoring wells and samples that were taken out of those, which are downgradient of the treatment water infiltration system, the TWIS. And there are a couple different kinds of limitations for both of those. For the effluent limits, there's an initial effluent limitation list

that's on page three of this permit. And this is for the first 90 days of operation. And during that time the frequency of analysis is daily, so it's quite often. And the maximum daily limit you can see for most of these are just report. There are a couple of numeric limits, but not very many. Another type of limit is final effluent limitations, and that's shown starting on page six of the permit. And the frequency of analysis you can see there is generally monthly. And again, most of the maximum daily limits are report. There are a couple -- there are a few that are -- have numeric limits on them for the effluent, but most are just report. So those are what we have for the effluent limitations as part of this permit. And then starting on page nine of the permit, and this applies to the land application portion of the system, which is the TWIS, the Treated Water Infiltration System. And these are groundwater monitoring limitations. And there are a couple of different limits set for groundwater. One is there are a series of wells that are located hydraulically upgradient and side gradient. I'm not really sure what that means. But side gradient of the treated water infiltration system. And on page nine you can see that that's quarterly monitoring and there are no numeric limits set for upgradient or side gradient groundwater. And then on the following page ten, that's where we get into the

downgradient groundwater monitoring wells that are in this glacial-alluvial material. And you can see that the frequency of analysis is again quarterly. And that has the most number of numeric limits set. And you can see the numeric limits for maximum daily limits set on pages ten and 11. And I believe that's it.

Q Thank you. A couple of questions about some of the -- some of the substances that are included in the permit. Is there a -- is there a limitation in this permit for total inorganic nitrogen?

A Yes, there is.

Q What is total inorganic nitrogen?

A Total inorganic nitrogen includes ammonia, nitrate and nitrite.

Q Okay. And what is the limitation established in the permit for total inorganic nitrogen?

A Well, it's broken down into the different components. And if you look on page ten of the permit, I believe the only numeric limit set for that -- let me check this -- yeah -- is in downgradient groundwater monitoring wells. And you can see that the numeric limit for nitrate -- and this would come from blasting and possibly some other sources -- is ten milligrams per liter. The limit for ammonia is also ten milligrams per liter. And there is no limit set for nitrate -- nitrite -- sorry -- nitrite nitrogen. So

together the ammonia and nitrate will allow a total inorganic nitrogen concentration of 20 milligrams per liter. But since there's no limit set for nitrite, we don't really -- can't really tell what the limit is for total inorganic nitrogen.

Q Okay. Does the limitation in the MDEQ permit for total inorganic nitrogen, is the limitation consistent with the MDEQ's rules?

A No, it's not.

Q Why do you say that?

A I believe that the limit in the Part 22 rules for total inorganic nitrogen is five milligrams per liter.

Q Is there a numeric limitation in this permit for nitrite?

A No, there is not.

Q Is there one required?

A According to the Part 22 rules, I believe the standard for nitrite is 500 micrograms per liter.

Q Okay. Are there numeric limitations in this permit for beryllium, boron and lead?

A Yes, there are.

Q And what are those limitations, if you know?

A And again, in the permit; right?

Q In the permit.

A There is a limit in the initial effluent monitoring for boron and also in the final effluent, and that is 285

micrograms per liter. And that's the same in the groundwater limitation. For beryllium, there is nothing numeric, and lead the same thing; nothing numeric for the effluent. And in groundwater, the concentration limits in downgradient wells are three micrograms per liter for beryllium and also three micrograms per liter for lead.

Q Do the limitations established in the permit exceed the allowable limits established in Rule -- in the Part 22 rules?

A I believe they do by a small amount.

Q Okay. Now, up to this point -- and I'm going to switch gears now. We're going to talk about -- we're going to talk about some other issues. We've been talking about permit limits and their impacts on groundwater. But I want to turn your attention to the potential impact of these permitted levels on surface water. I believe the company has indicated that this discharge will eventually surface at seeps?

A Yes.

Q You know what seeps are, I take it?

A Those are -- I guess they'd be more accurately called springs. These are headwater regions of the East Branch of the Salmon Trout River and other locations where groundwater comes into a stream as a spring.

Q Is there any indication in the materials that you have

reviewed to suggest that the Michigan Department of Environmental Quality considered the effect of this particular discharge on surface waters?

A Yes.

Q What did you read and what leads you to believe that that was considered?

A There's correspondence from MDEQ showing that certain employees were concerned about the concentration limits for the effluent and whether or not they were protective of surface water.

Q And what conclusion was reached based on that correspondence? What did you understand the analysis to have been on that issue?

MR. REICHEL: I'm going to interpose an objection here. First of all, there's no specification as to what correspondence in question the witness is being asked to testify about. So I don't -- I don't think it's appropriate to simply ask an open-ended question about -- I don't think it's appropriate to ask such a vague question as to what this witness' understanding is of certain statements allegedly made or reduced to writing by DEQ employees.

MR. EGGAN: I'll respond. Let's go to MDEQ Bates number 011789, which is tab 19 at people's books.

Q Do you know what this is, Dr. Maest?

A Yes. I've seen this.

Q And what is this document?
A This is an e-mail from Sarah Wolf, who is an MDEQ employee, to Jeanette Bailey about --
Q Is Jeanette Bailey an employee of the MDEQ?
A I believe so.
Q Okay.
A And this is about the effect of the proposed Kennecott discharge on surface water.
Q And what does it -- what does this particular document tell you about the MDEQ's consideration of the issue of the impact of this discharge on surface waters?
MR. LEWIS: Objection, Your Honor; calling for this witness' interpretation of the letter. I guess if they want to read the letter, I would have no objection. But I don't know what relevance this witness' interpretation of the letter has for this court
Q Is there a section of the letter that talks about the issue of the impact of this discharge on surface waters?
A Yes, there is.
Q Where is it, if you can use your pointer?
A Well, I can't really see this very well.
MR. EGGAN: There we go. Very good.
Q Okay. And what do you understand this e-mail to say that leads you to believe there was some consideration of the impact of this particular discharge on surface water?

A Okay. This -- it's the handwritten material that was from December 19th, 2006. And it says,

"Conversation with Jim J. wanted to know what the surface water value is for these six metals and compare to groundwater number. Will use more restrictive number. They will also consider a basis memo for limits."

And she said that she picked these six metals because they were sampled for in the effluent of the treatment plant, but not in the groundwater wells. And here she has composite effluent concentrations for a number of metals, the groundwater number and then the surface water number.

MR. LEWIS: Your Honor, if we could, the witness left off the end of the sentence there on the left, and I wonder if we might add that for completeness?

THE WITNESS: Right here (indicating)?

MR. LEWIS: Yes.

A Okay. "Picked these six metals because sampled for in the effluent but not in groundwater wells. Now will add these to number three part one downgradient wells." And I believe that's referring to the permit, the limits that were set for monitoring of downgradient groundwater.

Q And what does -- what does this mean?

A What this means -- my understanding of what this means is that there are groundwater limitations set for these metals.

And then this column here (indicating) is what the surface water standards should be for protection of aquatic life for these metals. And then she's comparing. And the ones that are circled are ones that where she believes that the groundwater monitoring limits -- permit limits that are set are not protective enough to protect surface water. For instance, nickel concentration she estimates the surface water standard would be 32 micrograms per liter, and in the permit it's 50. And for barium the surface water standard would be 210 micrograms per liter, and in the permit it's 1,000. Chromium looks like it's okay. And then zinc, the surface water standard should be 140, but the permit limit is 1200, which is three times -- well, several times that, almost ten times that.

Q Okay. Recap what this means, then, so that we have an understanding of what this means.

A Okay. What this means is the effluent from the waste water treatment plant, the plan for that is to be put into the ground at the treated water infiltration system, at the TWIS. It will then flow downgradient toward the headwaters of the East Branch of the Salmon Trout River. So the concentrations that are allowed in the effluent are very important because if those are higher than what would be protective of surface water, that's a concern, because there's no dilution or attenuation or, you know,

modification that is planned in between the TWIS and the surface water.

Q And what did you -- what do you understand the conclusion that MDEQ reached with respect to this groundwater standard versus surface water standards?

MR. REICHEL: Object to lack of foundation. Is this -- is the question directed to the author of the handwritten notes that appear on this, or is it directed to this witness' understanding of the actual permit that was issued?

MR. EGGAN: It is directed to the witness' understanding of the permit that was actually issued.

MR. REICHEL: Well --

JUDGE PATTERSON: Does that alleviate your objection?

MR. REICHEL: I guess it does, yes. I'll withdraw the objection.

JUDGE PATTERSON: Okay. All right.

MR. EGGAN: Okay.

Q Dr. Maest, what does -- did the permit actually apply the surface water standards?

A No, it did not. And for some of these, it really doesn't make a difference, because the groundwater -- allowable limits in groundwater are protective of surface water. But what we see here is that for some of the other metals that

are known aquatic toxins, the allowable limits in groundwater are not protective of surface water.

Q Okay.

MR. EGGAN: Your Honor, could we take a short break right now?

JUDGE PATTERSON: Sure.

MR. EGGAN: And we'll come back to this issue briefly upon our return.

(Off the record)

MR. EGGAN: Thank you, Judge.

JUDGE PATTERSON: You're welcome.

Q Dr. Maest, I want to focus your attention to this e-mail that we have and that we've been talking about. Down here in the handwritten section -- okay? --

"Conversation with Jim J. wanted to know what the surface water value is for these six metals and compare the groundwater number. Will use more restrictive number."

What does that -- what does that indicate to you?

A What that --

MR. LEWIS: Objection; relevance, Your Honor.

MR. EGGAN: It is extremely relevant. The company is claiming that the issue is or that this groundwater discharge is going to be released at some point into springs. And we want to at least bring to the hearing

officer's, to your attention, that there are some surface water standards that may be applicable here. What has apparently occurred is that the MDEQ has decided that it's going to apply these standards, it's going to apply the more restrictive of the two standards; the surface water standard compared to the groundwater standard; and whichever one is more restrictive, that's the number they're going to use. That's what this e-mail says. And so it is extremely relevant to these proceedings.

MR. LEWIS: Well, again, that may be what Counsel says in closing briefs. But my objection is to the relevance of this witness' interpretation of written notes on this document. And the question was posed as to her interpretation of those notes.

MR. REICHEL: And I would join in that objection. While the issue of the appropriateness of the standards is certainly relevant, this witness' understanding of or interpretation of handwritten notes on a DEQ e-mail I don't think is relevant.

MR. EGGAN: Your Honor, I think it is relevant. And --

JUDGE PATTERSON: Well, I don't --

MR. EGGAN: -- I think that -- I think that this handwriting speaks for itself. It says that very thing.

JUDGE PATTERSON: Well, that's the essence in the

objection, I think.

MR. EGGAN: I'm sorry?

JUDGE PATTERSON: If it speaks for itself, she doesn't need to interpret it.

MR. EGGAN: Okay. Very good. Then we'll -- as long as -- as long as it's in the record that the groundwater number that they're going from here --

MR. LEWIS: Objection. Your Honor, what's in the record is what's on e-mail. Counsel's trying to recast it as if he's asking the question he posed to the witness.

MR. EGGAN: Your Honor, what it says is this:

"Jim J. wanted to know what the surface water value is for these six metals and compare it to the groundwater number. Will use more restrictive number."

JUDGE PATTERSON: That's what it says.

MR. EGGAN: That's what it says.

Q Let's take a look -- let's take a look at whether or not the MDEQ in this permit really did apply the more restrictive number.

A Okay.

Q Did you prepare a document on this, Dr. Maest?

A Yes, I did.

MR. EGGAN: Can I get some assistance with --

Q Dr. Maest, did you prepare a chart that analyzes whether or not the MDEQ in granting this groundwater permit applied the

more stringent of the groundwater standards versus the surface water standards?

A Yes.

Q And how did you create this chart? Where did the information come from?

A Okay. There are two sources for this table; one, the second column here, the middle column, is what the surface water standard would be at 50 milligrams per liter hardness. And that -- the source for those numbers is a Foth and Van Dyke memorandum from September 2006.

Q Okay.

A And that was a Kennecott document. And then this last column here is the downgradient groundwater permit limit, and that's from the permit that we were talking about earlier, the groundwater discharge permit for downgradient groundwater.

Q All right. And the far left-hand column where it is described as parameter?

A Those are metals, barium --

Q And the reason why we selected those particular metals?

A Because these are metals that may have a more stringent standard in surface water than the groundwater permit has allowed.

Q What does this chart tel us about whether the Department of Environmental Quality actually did apply the more stringent

of the two standards?

A Okay. Well, we look at what has been applied, and that's in the third column here, the downgradient groundwater permit limit.

Q So these are the actual numbers that come from the permit itself?

A Yes; that's right.

Q Okay.

A And then we can compare that to the concentrations that are allowable in surface water. And for almost every one of them, the more restrictive number is in surface water. And we see that this (indicating) number is higher, for example, barium, the number that's protective of surface water is 210 micrograms per liter. I'm sorry I don't have the units on here. These are all in micrograms per liter. For barium, the permit limit that's allowed is 1,000. So that's about five times higher. Beryllium the standard to protect aquatic biota should be .41 micrograms per liter. Three micrograms per liter is allowed, and so on. Cadmium 1.34 micrograms per liter, and the allowable limit is three. The only one that doesn't fit that description is lead. The limit allowed in the groundwater permit is protective of surface water. For every single other one, and copper in particular, the groundwater permit is twice as high as what is protective of aquatic biota in streams.

Q Okay. And would you mind mentioning -- you've mentioned the other ones. You might as well mention zinc.
A Okay. All right. Nickel, the allowable permit limit for groundwater is 57. The surface water standard is 28.9, I think that says. For zinc the allowable limit is 200 micrograms per liter and in surface water it should be 65.7 micrograms per liter to be protective of aquatic biota.
Q So if the goal of the MDEQ was to apply the more stringent of the two standards, surface water versus groundwater, did they do that?
A No, they did not.

MR. EGGAN: Your Honor, I would offer this document as Petitioner's Groundwater Exhibit Number 45.

MR. REICHEL: May I voir dire, Your Honor?

JUDGE PATTERSON: Sure.

VOIR DIRE EXAMINATION

BY MR. REICHEL:
Q Did you prepare this document, Dr. Maest?
A Yes, I did.
Q When did you prepare it?
A Last night.
Q Did you have access to the information contained in this document prior to last night?
A Yes, I did.
Q Did you have access to this information at the time, say,

prior to March 1st of this year?

A I don't recall. I'm not sure.

MR. REICHEL: I have no further questions on voir dire.

JUDGE PATTERSON: Okay.

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

JUDGE PATTERSON: Sure.

MR. REICHEL: Your Honor, if I may request an opportunity for limited further voir dire on this?

JUDGE PATTERSON: Sure. Go ahead.

Q Dr. Maest, the values -- the surface water standard values in the middle column on this proposed exhibit, it's your testimony that you believe that those are representative of the standards imposed by the DEQ?

A Yes.

Q And you base that upon what?

A I base that upon the e-mails that I've reviewed and also the Foth and Van Dyke memo that was prepared of Kennecott.

MR. REICHEL: Well, Your Honor, I have an objection to this, a two-fold objection. First of all, the underlying information of this is readily available apparently to Petitioner's some time ago. This wasn't on their exhibit list. It was just prepared last night. Secondly, it is not by any means clear that the surface

water standard at 50 micro milligrams per liter hardness necessarily represents the standards that would be imposed by the DEQ under applicable regulations or its application of those regulations. So I don't believe there's an adequate foundation.

MR. LEWIS: Join in that, Your Honor. I don't -- she has not provided us with the source of the numbers up there as to their relevance to actual regulatory level.

MR. EGGAN: I think that -- I think that she has given us that source. The source is a report prepared by the company's own experts, Foth and Van Dyke. It's Table 2 of a report that they prepared for the groundwater discharge permit in 2006. They don't -- I think they don't want this exhibit admitted into evidence, and I understand why. But the witness has certainly laid a proper foundation for its admission, and it ought that be admitted and considered by this court.

MR. REICHEL: If I may respond briefly?

JUDGE PATTERSON: Sure.

MR. REICHEL: First of all, it's not a matter of not wanting it in because of its contents. I think the issue is if it's being offered to prove the truth of the matter asserted that the regulatory standard in the middle column is in fact the DEQ's regulatory standard. I don't think that has been established. The fact that one of

Kennecott's consultants may have put those numbers in the permit application is by no means dispositive of what the actual regulatory standards are.

MR. EGGAN: I think that's an issue that can be handled on cross-examination. And I also think it's an issue that can be handled through witnesses that the MDEQ can bring in.

MR. REICHEL: Well, I mean, we certainly will address this. But that doesn't necessarily resolve the concern that I have that an inadequate foundation has been laid and it may actually misrepresent what it purports to say.

MR. EGGAN: I think a proper foundation has been laid. The witness has indicated where this information came from. It's evidence that is probably already in this record from the application. So she indicated that. It's from the company's own experts.

JUDGE PATTERSON: I think this is a compilation of underlying --

MR. EGGAN: It is.

JUDGE PATTERSON: -- preexisting exhibits. I'm going to admit it for what it's worth. Obviously, if the analysis is flawed, it can be pursued on cross-examination or the department's case in chief or whatever.

MR. eGGAN: Thank you.

(Petitioner's Exhibit 31-45 received)

DIRECT EXAMINATION

BY MR. EGGAN: (continued)

Q Dr. Maest, what is the hardness predicted to be in the treated water infiltration system discharge?

A The hardness is predicted to be very, very low, somewhere between one and five milligrams per liter.

Q Do you see any issue related to hardness as it has been specified in the permit?

A Well, I do. The hardness that is predicted to be coming out of the waste water treatment plant and going into groundwater at the TWIS is predicted to be very, very low. And as that treated discharge moves through the soil and goes to the springs, no addition of hardness can be contemplated in that.

Q When you say that, how do you know that's the case?

A Because this is considered a rapid infiltration basin.

Q The TWIS is called a --

A Yes.

Q It's considered a rapid infiltration basin under whose rules?

A In the Part 22 rules there's a section on land application, and there's several types of land application that are permissible under the Part 22 rules. And the rapid infiltration basin is one that allows a large amount of

water to go into an aquifer. And one of the conditions is that there can only be minimal treatment of that discharge in the soil. So in other words, as the treated discharge water moves through the soil, they can't consider that it's going to get better before it gets to the venting point at surface water.

Q And what is the -- how does that relate to hardness with respect to this specific discharge?

A The relationship to hardness is that the assumption made in the surface water standards is that the discharge is going to gain hardness as it goes through the soil. And hardness is calcium and magnesium. And the importance of hardness for aquatic biota is that it protects fish and aquatic insects from the impacts -- the adverse impacts of metals. And in fact, the standards that I just showed on the table there are a function of hardness for a number of those metals. The higher the hardness, the higher the metal content is allowed to be and still be protective of fish. If the hardness is lower, the standard has to be set at a lower number for those hardness dependent metals in order for it to be protective of fish.

Q And so what is it about the hardness in this discharge that is causing you a concern with respect to the Part 22 rules?

A The concern is that the hardness is actually, like, one to five milligrams per liter. It's not 50 milligrams per

liter. So if you just looked at the hardness of the discharge, the standards should actually be a whole lot lower for surface water than they are on that table that I produced.

Q I see. I want to ask you a question or two about the requirements in the permits themselves. You mentioned earlier that, as you looked through the permit, there are daily and monthly reporting requirements. Do you have any comment on that?

A There are for the initial period for the effluent there are daily reporting limits. And that's a more protective approach, because you're doing very frequent analyses of the effluent to see what its quality is. Then as you step out to weekly, monthly, quarterly, obviously that's less often that you're sampling and figuring out what -- what the water quality is of the discharge and groundwater.

Q And with respect to daily and monthly reporting and its protection, are there specific concerns you have within the permit on those issues?

A Yes. The daily -- the only time the daily monitoring is required for the contaminants is during the initial period, and that's only on the effluent. And then as I went through the permit before, most of the limits are not numeric. They're just report, report, report. And when you get into groundwater, there are some numeric limits set. But in

order to be protective, you should set those limits at the effluent, too. Because by the time it gets into groundwater, it's already in a natural resource and it's much more difficult to adjust if there are problems.

Q I want to switch gears now and talk a little bit about operational closure and then ultimate closure.

A Okay.

Q Are you familiar with the company's plan for backfilling the mine as mine operations actually continue?

A Yes, I am.

Q What are your observations with respect to backfilling the mine during mining operations? What will be the impact on water quality?

A Well, the -- what the backfilling proposes to do is to have waste rock put in the underground mine, mix with limestone but not cement it. So that waste rock will be there in the underground mine and actively leeching for some unknown period of time. So those -- when it's stored in the waste rock pile, it's going to oxide for metal-rich salts. When it's put back into the mine, those salts will be on the waste rock, and then the water level will rise, and that'll dissolve all those metals and put them into groundwater.

Q What can you tell the hearing officer about the water quality at closure? And I know you've discussed this previously. But tell the hearing officer a little bit about

what the water quality is going to be when they're closing the mine itself.

A Okay. Well, we've made a prediction about what the water quality will be at the end of mining, and then I compared it to Kennecott's predictions. And our predictions are that the water quality is going to be a lot worse. It's going to have higher -- substantially higher concentrations of metals and sulfate at a lower pH value.

Q Now, it's my understanding -- and I -- you tell me if it's your understanding -- that the company is going to keep the wastewater treatment plant open and is going to recirculate this water; run it -- run the water -- even after closure it's going to run it through the wastewater treatment plant and then back into the system.

A Right.

Q Will that resolve this issue of water quality?

MR. LEWIS: Objection to the form of the question, your Honor. It misstates the contents of the permit and the requirement. And specifically I understand the -- what Mr. Eggan just described to be a requirement in the event it is deemed by the DEQ to be necessary, dependant upon, in fact, what the mine water quality turns out to be and some other parameters. So he has not properly characterized the permit application or the permit requirement.

MR. EGGAN: Let me ask it a different way.

A Okay.
Q Do you see any indication, any evidence that the Department of Environmental Quality or Kennecott considered the effect of the treatment of water through the wastewater treatment plant post closure on the water quality in the mine itself?
A Yes.
Q What?
A There is a contingency for that. If the water quality is -- requires it because it's poor, there's a contingency to send the -- just the upper part of the water in the closed underground mine to the wastewater treatment plant and then put it back into the underground mine kind of in a circle -- loop.
Q Okay. And do you have an opinion as to the viability of that system and what the impact is going to be on water quality?

MR. LEWIS: Objection; foundation and qualifications, your Honor.

MR. EGGAN: I think this witness is eminently qualified to testify about what the water quality will be post closure and what the impact of this treatment plan -- this treatment will be on the water.

MR. LEWIS: It's similar to the objection posed before, your Honor. This question posed to the witness presumes that she has the necessary qualification and

foundation to offer opinions as to the efficacy of the water treatment system.

MR. EGGAN: That's an objection that I believe that you overruled previously.

JUDGE PATTERSON: I'm not sure I did. She's already testified as to what she feels things, say, the condition of the water will be. But I think, if you're asking her if the treatment plan will be effective, I'm not sure she has the expertise to answer that --

MR. EGGAN: Okay.

JUDGE PATTERSON: -- as an operational --

MR. EGGAN: As an operational issue?

JUDGE PATTERSON: Yeah.

MR. EGGAN: I understand.

Q Let me ask you this: Let's talk for a mine about the aquifers that are surrounding the mine. Are -- the aquifers that will be impacted by water that would escape the mine post closure, are they of a quality that are sufficient to serve human uses?

MR. LEWIS: Objection, your Honor, to the form of the question and to foundation. As to the form, the term "aquifer" has a defined use, as I understand it, amongst people who use that term, and there's been no definition or foundation for how Mr. Eggan is using that term as to whether it's potable well supply or as to whether it's just

any water in the earth no matter where it appears. And secondly, there's been no foundation that this witness again has either the qualifications or has done the proper analysis to offer an opinion as to how and whether the water in the mine after closure may move around the environment. And again, that takes us back to Petitioners earlier had an expert up here on groundwater movement and so forth. That's not this witness.

Q Let me respond to that by this: Dr. Robert Prucha was here yesterday.

A Right.

Q And he testified that, in his expert opinion, there was a possibility -- in fact, I think he said a likelihood that water from this closed mine operation is going to escape through faults and other openings into the groundwater system.

A Uh-huh (affirmative).

Q Okay?

A Okay. Surrounding groundwater.

Q All right. So use that as an assumption.

A Uh-huh (affirmative).

Q And that water is going to go into certain aquifers. Okay?

A Uh-huh (affirmative).

Q Do you have an opinion as to whether the aquifers that we are talking about are of a sufficient quality -- water

quality -- before they are subjected to this water, are of a sufficient quality to serve human uses?

MR. LEWIS: Objection; foundation, your Honor.

MR. EGGAN: Your Honor, I am simply asking her whether the water surrounding the mine that she has studied and understands the -- what the quality of is -- I'm asking her whether or not she has an opinion as to whether or not that water is usable by humans before it is subjected to this contamination.

MR. LEWIS: I've heard no foundation that this witness has studied all of the various wells and all the various background groundwater quality testing that's been done.

JUDGE PATTERSON: That's my concern. I don't recall her testifying to the --

THE WITNESS: Yes, I have.

JUDGE PATTERSON: -- water in the surrounding aquifers.

Q Do you have any information that would support that issue, that -- of what the other uses are of these aquifers?

A Yes. I mean, I have definitely looked at the background water quality in the unconsolidated aquifer, which is the glacial alluvium, and also the upper bedrock and the lower bedrock. And that's part of what goes into predicting what the water quality will be and also part of what is relevant

for calculating Part 22 standards as part of the permit. So I have, in fact, looked at all the water quality results for background groundwater in those three aquifers.

MR. EGGAN: I thinks established that she has a foundation to answer this question, your Honor.

JUDGE PATTERSON: Dr. Maest, where did you get that information?

THE WITNESS: It's in the appendices to the groundwater discharge permit application. There's a -- in fact, it was one that we showed -- an exhibit that we showed earlier that had the yellow and white stripes on it. That shows groundwater wells in the glacial alluvium around the TWIS and also a composite upper bedrock quality and also lower bedrock quality. And they kind of combined those in certain proportions to come up with the background groundwater quality that is expected to go into the mine as inflow.

JUDGE PATTERSON: Okay. I think there's a proper foundation.

THE WITNESS: Yeah. You're welcome.

MR. EGGAN: Thank you, your Honor.

Q Do you have an opinion on this issue? Will -- are the aquifers that are impacted by -- that will be impacted by this water currently of sufficient quality to serve human uses?

A Yes, they are.

MR. LEWIS: Again, just objection to the form again. Mr. Eggan, earlier in response to that objection, asked Dr. Maest to assume certain things that Dr. Prucha said --

JUDGE PATTERSON: Right.

MR. LEWIS: -- or suggested are true. And he's the question --

MR. EGGAN: I apologize. That's built into the question.

JUDGE PATTERSON: That's obviously predicated on the assumption that Dr. Prucha's right.

THE WITNESS: Right.

MR. EGGAN: It is; it is, of course; yes.

MR. LEWIS: That's fine.

MR. EGGAN: Yes.

JUDGE PATTERSON: I understand that.

THE WITNESS: Yeah.

A But this -- I think you were just asking me just is that water suitable for human uses right now --

Q Yes.

A -- right now, which -- yes. And the answer is "yes."

Q Are they suitable for domestic, commercial, industrial, agricultural and recreational uses?

A Yes, they are.

Q Wildlife, aquatic life?
A Yes.
Q Thank you. I want to ask you a little bit about your experience with post-closure issues in hard rock mines.
A Okay.
MR. EGGAN: Jan, can you please call up 100306?
Q And I'm interested, Dr. Maest -- again, this is the issue -- the issue we're talking about now is post-closure issues in hard rock mining and even --
MR. LEWIS: Let me just note my objection again for the record, your Honor.
JUDGE PATTERSON: You may.
Q You've indicated that you have a pretty broad range of experience in this area.
A Uh-huh (affirmative).
Q What does this exhibit show us?
A Okay. This is concentrations of copper and sulfate in the underground mine workings in Butte, Montana, which is one of the largest underground and also open-pit copper mines in the United States. And this shows how concentrations of sulfate and copper changed as water was allowed to fill up in the underground mine workings. And on the vertical axis here, I have the concentration of copper in micrograms per liter and sulfate in milligrams per liter. Copper is shown as the black circles, and sulfate is shown as the magenta

circles. And you can see that this is every -- you know, a factor of 10 in between these lines here. It's called a semi-log plot.

So up here we have a million micrograms per liter of copper or milligrams per liter of sulfate. And what happened -- and this is a mine that is not backfilled. It's just underground workings. There's a lot of unconsolidated material down there, but it's not officially backfilled. But this is what happens when the water was allowed -- the pumps were turned off and the water was allowed to rise in the underground mine. And this is in -- going from about 1984 to about 1999 as the water level was rising.

And you can see that the copper concentrations started off very high; you know, over 100 milligrams per liter. And they dropped pretty dramatically as the water level was allowed to rise and -- but they stayed around 100 micrograms per liter. They dropped down here (indicating) to very low micrograms per liter then but then jumped up again to 100 micrograms per liter. And just for comparison, the surface water standard for copper at a hardness of 50 milligrams per liter is about 5 micrograms per liter so the --

Q The surface water standard where?

A This would be, you know, the Clean Water Act surface water standard at hardness, because these standards are hardness

dependent for certain metals so -- and the drinking water standard for copper would be here (indicating). Okay?

Q Which is -- you're pointing to the --

A 1 -- I'm sorry -- 1 milligram -- about 1 milligram per liter -- 1.3 milligrams per liter. So initially it exceeded drinking water standards dramatically and aquatic life standards, and then it when down below drinking water standards but still exceeded aquatic life standards. And then, in the magenta circles, we see sulfate. And it's hard to tell on this plot. The sulfate was quite high and went down, but you see that it still stayed around 5,000 milligrams per liter even after water was allowed to rise into the underground workings.

Q Thank you, Dr. Maest. I want to ask you now about your primary conclusions.

A Okay.

MR. REICHEL: Excuse me. Counsel --

MR. EGGAN: Oh, I need to offer that as an exhibit.

MR. REICHEL: No. You need to identify it first, please.

MR. EGGAN: Okay.

MR. REICHEL: And just not by a Bates number, please.

MR. EGGAN: All right.

Q What's the title of this document?
A The title is "Behavior of dissolved copper and sulfate in Kelley underground workings after filling, Butte, Montana, 1983 to 1998.
Q And what is the data source for this?
A The data source is Metesh and Duaime 2000 from the Montana Bureau of Mines and Geology. It's an open file report.
Q And this is a document that you prepared?
A I prepared -- I was working with the Montana Bureau of Mines and Geology for the State of Montana, and I had this data available to me on a spreadsheet.
Q All right.

MR. EGGAN: And this is Petitioner's Groundwater Permit Exhibit 28-U. We would offer that into evidence.

MR. LEWIS: Same objection as to foundation and relevancy, for the record, your Honor.

JUDGE PATTERSON: Okay.

MR. REICHEL: The same objection.

JUDGE PATTERSON: Same ruling. It'll be admitted.

MR. EGGAN: Okay. Very good.

(Petitioner's Exhibit 31-28-U received)

Q I want to talk to you about your main -- can I get -- for just a moment -- your main conclusions factor. Okay, Dr. Maest. Let's talk about your primary conclusions in this case.

A Okay.
Q Talk about your primary conclusion number one.
A Okay. The first conclusion is that the rock at the proposed mine is inherently the type that is going to generate acid and produce high concentrations of metals and other contaminants, and everyone agrees with that, and that's why the importance of the mitigations is so high.
Q What about number two?
A The second conclusion is that Kennecott's estimate -- estimates of water quality that they predicted severely underestimate the concentrations that I believe will be present in water related to the mine.
Q And your third conclusion?
A The third conclusion is that the permit limits in the permit itself are not designed to be protective of groundwater or surface water resources.
Q And then your fourth conclusion?
A And the last conclusion is that, under post-closure conditions, water in the mine will be contaminated and exceed the standards even if it is diluted many times in downgradient groundwater.

MR. EGGAN: Thank you, Dr. Maest. I have nothing further.

MR. HAYNES: Your Honor, just one bit of housekeeping before Dr. Maest has cross-examination, if I

may?

JUDGE PATTERSON: Uh-huh (affirmative).

MR. HAYNES: Dr. Maest, earlier, when you were testifying with me, we talked about your report that you submitted and the comments submitted in October 2007 in relation to this mine permit application. Do you remember that?

THE WITNESS: Yes, I do.

MR. HAYNES: And I identified for the record, your Honor, that that was Petitioner's Exhibit 3, Appendix 7. And, Dr. Maest, does your testimony from yesterday and today -- is your testimony from yesterday and today included in that report that was submitted in October of 2007?

THE WITNESS: Yes, a largest part of it is.

MR. HAYNES: I will move the admission of Petitioner's Exhibit 3, Appendix 7. And I have furnished copies of that report to counsel just for their -- to refresh their recollection on the report.

MR. LEWIS: Give me a moment, your Honor, to find that one, if I could.

JUDGE PATTERSON: Sure.

MR. LEWIS: I'm sorry, Mr. Haynes. Exhibit 3 again is that --

MR. HAYNES: Is the combined comments.

MR. LEWIS: -- the large collective exhibit of

combined comments?

MR. HAYNES: Right.

MR. LEWIS: And within that collection, the reference would be Appendix 7?

MR. HAYNES: Correct.

MR. LEWIS: And is that KBIC, Mr. Haynes?

MR. HAYNES: No. That would be NWF comments, volume I.

MR. REICHEL: For the record, Mr. Haynes, that's entitled, "Geochemical Review of the Eagle Project Mine permit application" prepared for Michelle Halley and submitted as part of the comments last October; is that correct?

MR. HAYNES: That's correct.

(Counsel review document)

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

MR. REICHEL: No objection.

(Petitioner's Exhibit 632-3, Appendix 7 received)

MR. EGGAN: Can I add one more -- were you done?

MR. HAYNES: Yes.

MR. EGGAN: Can I add one more housekeeping duty? I need to just clear up one minor point with the witness.

JUDGE PATTERSON: Sure.

Q Yeah. During your testimony when we were talking about the contact water basins, you indicated that storm water is

going to go into a contact water basin. Can you correct --

A Yes.

Q I think you made a misstatement. Would you mind correcting it?

A I did. There are two types of storm water, in fact. I just said generically "storm water." The -- there's contact storm water and noncontact storm water. The contact storm water is going into the contact water storage basins, as I said. The noncontact storm water is not going into there. It's going into a noncontact storage area or basin that is then allowed to directly infiltrate to groundwater. And there are no estimates of the composition of this noncontact storm water.

MR. EGGAN: Thank you.

THE WITNESS: Okay.

JUDGE PATTERSON: It's just a few minutes before noon. Do you want to break for lunch now?

MR. LEWIS: All right.

JUDGE PATTERSON: Come back at 1:00 o'clock.

(Off the record)

MR. LEWIS: Hello, again, Dr. Maest. Rod Lewis on behalf of Kennecott Eagle Minerals Company.

THE WITNESS: Okay. Hello.

CROSS-EXAMINATION

BY MR. LEWIS:

Q A couple things I just wanted to clarify for the court, Dr. Maest.

MR. EGGAN: Your Honor, we have one minor problem, and that is --

JUDGE PATTERSON: Oh, yes. Poor, Mr. Reichel. We keep forgetting him.

MR. REICHEL: That's all right. I saw it was pretty late and --

JUDGE PATTERSON: You're not that late.

MR. REICHEL: I am still part of this case.

MR. EGGAN: We just started 20 minutes ago, so --

JUDGE PATTERSON: You didn't issue a thing.

Q All right. One thing I wanted to clarify for the court is about the -- what we called the ore in the mine, the materials that will actually be mined, and characterized it and others have characterized it as the massive sulfide unit and the semi-massive sulfide unit. And I know you've offered some testimony about it's your belief that some of that will be left remaining in the mine walls; that it cannot all be removed, is your view; and that some of it -- I think it's your view as well that some of it may necessarily end up in the TDRSA. But as to the plan for the mining -- and again, so we make that clear, you do understand, don't you, Dr. Maest, that the ore itself, the semi-massive sulfides and the massive sulfides, are going to

be shipped offsite for processing?

A The ones that are extracted from the underground mine --

Q Yes.

A -- are planned to be shipped offsite. Yes, I understand that.

Q Okay. I wanted also to look at with you a moment -- it was one of your papers that counsel asked you about earlier, Dr. Maest. It was the Part 632 Exhibit 68 paper titled "Predicting Water Quality at Hard-Rock Mines." And you were asked to look at a table on that page and asked to read what it said, and I just wanted to -- if we could, this is the section that I believe counsel referred you to earlier, Dr. Maest. And you read the first part of that above the table which says, "Examples of recommended minimum number of samples of each rock type," and I believe that was pertinent to your discussion and opinions as to whether you felt the number of sampling here was sufficient or not. And in that context I wanted to see what the rest of this says, and it says, does it not, that:

> "Runnell's et al, however, argue against this approach and emphasize the importance of site-specific variability in dictating the number of samples collected and analyzed. Using this approach, more homogeneous materials such as tailings would require fewer samples than the more heterogeneous waste rock at

any given site. This approach reflects the fact that fundamental error which results from the compositional heterogeneity of particles is often the main source of sampling error," with another citation to Pitard. That's what that says?

A That's correct. And at this site there are no tailings. As you just mentioned, the ore is planned to be taken offsite that they can extract from --

Q Just wait for a question. Okay, Dr. Maest?

A Okay. Sure.

Q Now, I wanted to refer also, Dr. Maest, back to one of your papers, I believe, Petitioner's Part 632 Exhibit 68, I guess the same paper we just looked at. Again, the paper on predicting water quality at hard-rock mines. And I wanted to ask you, Dr. Maest, it's -- I believe it's part of your position as reflected in your testimony is that this kind of predictions, these predictions are calculations of water quality, geochemical water quality associated with mining, inherently have some substantial degree of uncertainty. Would you generally agree with that?

A Yes, I do.

Q And, in fact, you've said as much I think in some of your reports on the subject. For instance, in this paper I just referred to on page 56, you say that:

"Considering the difficulty in representing

physical and chemical properties of mined materials, the meaning of 'accuracy' in water quality modeling must be reconsidered in the regulatory process." Does that sound right?

A Yes.

Q And you said, for instance, that:

"Regulatory decisions using models should recognize these limitations and be based on a conservative approach that takes into account the likelihood and consequences of all reasonably foreseeable outcomes."

A That's right.

Q And again in another paper on which you're an author titled "Evaluation of Methods and Models Used to Predict Water Quality at Hard-Rock Mine Sites, Sources of Uncertainty and Recommendations for Improvement," I believe you say on page 15 or you do say, Dr. Maest --

MR. EGGAN: Your Honor, I'm going to object to him reading from documents that have not been offered into evidence. Is this going to be -- maybe it's going to be offered.

MR. LEWIS: I don't have to offer this. I'm asking the witness about prior statements she's made and asking her questions based on those statements, your Honor.

MR. EGGAN: I just want to make sure the witness

has an understanding of precisely where this is coming from.

MR. HAYNES: And also, your Honor --

JUDGE PATTERSON: I assume if she wrote it she knows that, but I'll overrule.

MR. HAYNES: Your Honor, I have a similar objection, however, and that is if Counsel is going to read a statement that the witness supposedly authored, perhaps Counsel could show the statement to the witness including the report it comes from so it can be put in context rather than trying to have her remember every word that she's ever written in the past 20 years.

MR. LEWIS: I have no problem doing that if necessary. If the witness tells me that doesn't sound right or wants to look at it. If the witness is comfortable it's her report and she remembers --

A I would like to see it.

Q Okay. That's fine.

A Yeah, that would be much better.

MR. LEWIS: Again, I think I read the title, Dr. Maest. I'll show it to you here.

A Okay. Thank you.

Q That's (indicating) the paper.

A Okay.

Q Do you recognize that as your paper?

A Yes.

Q Now, all I wanted to do is ask you about your reference on page 15. You've got a heading here that says, "Sources of Uncertainty in Hydrogeologic and Geochemical Modeling and Recommendations for Improvement"; right?

A Uh-huh (affirmative).

Q And you say:

> "The ability of today's models and advanced computers to predict an outcome may exceed the ability of hydrogeologists and geochemists to accurately characterize all of the complex and heterogeneous physical and chemical processes occurring at the site. The degree of confidence in the models is severely limited in part because the models are so complex that they cannot be easily reviewed by regulatory staff and the public."

A Uh-huh (affirmative).

Q That's what you say in this report.

A That is. That's why it's so important that they're conservative in terms of protection of the environment.

Q And that's why also it's important -- I believe it's position that because of that level of uncertainty, it's also important that proper mitigation be planned for these projects.

A That's correct.

Q And I assume that based on, again, your views on this

subject and the inherent uncertainty that other -- it would be -- you would, I guess, recommend that other mitigation be used, and those would include, would they not, for instance, the fact that in this project the development rock is going to be stored on this temporary development rock storage area which has a lined bottom, has a sump pump, and so it's designed to send the water to the treatment plant. That would be a proper mitigation method, would it not?

A Yes. I mean, that's one that's already -- I don't know what you mean by other mitigations. That's one that's already planned; right?

Q Yes. And in general the use of limestone to amend rock which may have the potential to develop ARD is a good idea, is it not?

A Well, I think there's been a lot of failure with that approach actually, and that's in the other report that I talked about. That was one of the failure modes.

Q But you're not suggesting that it not be used, are you, Dr. Maest?

A I think it's worth a try, yeah.

Q And I take it you would agree that re-flooding the mine after mining is a good thing to do?

A That's a pretty general statement. I think the thing with re-flooding backfilled mines that I've seen is the water quality gets worse before it gets better.

Q Okay. I understand the intent of the re-flooding to be that to either slow down or cut off this process by which ARD can develop because you remove the aerobic conditions in the mine; is that --
A That's the hope. That's the hope.
Q And as you testified earlier, one of the necessary ingredients for the development of ARD in your reactions is the presence of oxygen?
A Yes, although there has been some -- there have been some studies done in Canada showing that acid drainage can form without the presence of oxygen if ferric iron is present.
Q Nevertheless, though, in general, as you described earlier, oxygen is driving this reaction?
A That's the most important driver, yes
Q And the purpose of re-flooding the mine is to deprive --
A Take that out of the equation if -- as best you can.
Q And I know you offered some -- perhaps you had some questions in your mind as to the ability here to actually use a cover on this TDRSA development rock pile, however, you would not disagree with using a cover to help reduce the inflow of water to the rock and therefore help reduce the potential for ARD development?
A I mean, I understand the concept of it. I have never heard of it being applied, ever.
Q And I take it you would also be favor of requirements for

continual monitoring of this water that's going to be developing in the mine?

A Yes.

Q And you're aware that we have such continuing monitoring requirements in the permit here?

A Yes.

Q And I take it or I would assume, Dr. Maest, that you'd also be in favor of reclamation requirements for these types of mines in the event there is some damage?

A Could you clarify what you mean by "reclamation"?

Q That they reclaim the area when they're done mining.

A You mean the surface, --

Q Yes, ma'am.

A -- just the surface? Yes, but I have to say that I'm not familiar with any reclamation plans. I'm just not familiar with them.

Q And you would be in favor, I assume, of bonding requirements for these kinds of mines?

A Yes.

Q Now, you talked some earlier today about -- you presented some evidence that pertains to other mines around the country. You referenced an article that you wrote earlier where you reviewed some other mines around the country. It's true, is it not, Dr. Maest, that you've never had any experience with any other mine that's been permitted under

Michigan's Part 632 Mining Statute and Regulations?
A No, I have not. Isn't this the first sulfide mine, in fact, --
Q It is.
A -- under those rules?
Q It is. And you're probably aware of how our governor has characterized this new Michigan law which was discussed earlier in Petitioner's Part 31 Exhibit 25 in which the governor says that, "The standards you have developed are the strongest and most protective in the Nation and fulfill our promise and responsibility as the current stewards of the environment." Have you seen that letter?
A I have not seen that, no.
Q Now, Dr. Maest, you've testified in litigation before in opposition to mining projects, have you not?
A Yes, I have.
Q You've never testified in litigation in support of a mining project, have you, Dr. Maest?
A No, I have not.
Q Some of your papers, including the paper you referenced earlier where you did a review of some historical mines in the nation, were funded, were they not, by a group called Earthworks?
A Yes, let me clarify something. Those are not historical mines. That's a mix of historical and active mines. And,

yes, Earthworks was the funder of that report and the other one.

Q Earthworks is a politically active organization in Washington, D.C. with an anti-mining agenda, is it not?

A I wouldn't describe them as anti-mining agenda, but they're -- they are an environmental group.

Q The report you referred to earlier, your comparison of predicted and actual water quality at hard-rock mines was not -- did not have any independent peer review. Is that also true, Dr. Maest?

A No, that's not true. It was reviewed by the Environmental Protection Agency, Bureau of Land Management, state agencies and a number of other entities, as was the other one. In fact, the main reviewer of the other report was --

Q I'm talking about this report right now.

A Okay. We can take them one at a time.

Q Okay, Dr. Maest?

A Sure.

Q Again, Part --

A So, no, it's not true.

Q Okay. It does say in the report, does it not, Dr. Maest, that:

> "Various versions of the database report and sections of the report were sent to state and federal regulators and industry consultants for review and

comment. Because of the nature of this report with many site-specific examples, it was difficult to obtain peer review for every example and for the report as a whole." That's what it says.

A Right, but we had many peer reviews of that report including EPA and state agencies.

Q And what you list is project advice, input and internal peer review provided by some named individuals. Is that what the report says?

A I don't recall that part, if you could just show it me?

MR. HAYNES: Just for the record, Counsel, which exhibit are we talking about here?

MR. LEWIS: Part 632 Number 65.

MR. HAYNES: Thank you. And what page are we on?

MR. LEWIS: Page ii.

Q Right here (indicating).

A Uh-huh (affirmative); right.

Q That's what it says?

A Yes; uh-huh.

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

MR. REICHEL: Good afternoon, Dr. Maest. My name is Bob Reichel and I represent the Department of Environmental Quality. I just want to follow up on a few items, primarily some things that Mr. Eggan asked you this morning with respect to the groundwater discharge permit

issue.

THE WITNESS: Okay.

CROSS-EXAMINATION

BY MR. REICHEL:

Q I believe you testified on direct examination on a couple of instances about your understanding of how the permit, as issued to date by the Department, comports with what you understand to be the requirements of the administrative rules promulgated by the DEQ with respect to groundwater discharge. Do you recall being asked about that?

A Yes.

Q And more specifically I believe you were asked or the phrase "Part 22 Rules" was used. Do you understand what those rules are in general?

A I've read those rules, yes; yes.

Q And would you agree with me, based upon your review, that those are rules promulgated by the DEQ that regulate groundwater discharges?

A Yes.

Q And just to be clear, prior to your involvement in this case, have you ever had an occasion to consult on or do an analysis of a mine project or any project involving proposed groundwater discharge in the state of Michigan?

A In the state of Michigan? No.

Q So, again, apart from your involvement in this project have

you ever had occasion to review the administrative rules promulgated by the Michigan DEQ under Part 22?

A No, I have not.

Q So if I understand your testimony, you've read the rules in connection with your work on this project?

A That's correct.

Q I believe one of the things that you testified to on direct examination have to do with your belief that the permit as issued did not comport with requirements of the rules as they relate to total -- with respect to nitrogen. Do you recall that?

A Right. Total inorganic nitrogen?

Q Yes.

A Yes.

Q And just so I'm clear, it is your contention that the rules require under the circumstances of this case, a limit -- what was your testimony? I believe you testified that the limit should be 5- -- excuse me -- 500 micrograms for liter?

A That's just for nitrite. That's my recollection.

Q Okay. In offering that testimony, were you basing that, if you recall, on a particular provision of the rules?

A You mean do I recall what the provision number is or --

Q No, I'm not asking you -- I'm not trying to plug you in here. Am I correct in assuming that in forming that opinion you read the rules, and you saw a rule -- I'm not asking you

tell me by memory what that was, a rule that led you to believe that that was the appropriate standard?

A Yes.

Q If I were to tell you that it appears that one of the rules that you may have read is Rule 323.2222 headed, "Discharge Standards" -- and what I'll do, I'll project this up here so you can see what I'm talking about.

MR. REICHEL: Okay. For the record, I'll represent to the tribunal that this is a copy of the Part 22 Rules. And I'm specifically going to direct the witnesses' attention to R323.2222 with the heading "Discharge Standards."

Q Again, does this rule or its heading look familiar to you, Dr. Maest?

A Yes, it does.

Q Okay. Thank you. And now specifically I'd like to direct your attention to sub rule 2 of that rule. I'm just moving it up here. Do you see that?

A Okay.

Q Okay. And then sub rule (2)(a) -- I'm sorry if this is -- can you read the rule up there?

A Yes.

Q Okay. And my first question is -- take a moment to look at that, is, if you recall, Dr. Maest, is that the rule upon which you based your previously stated opinion?

A Yes, it is.
Q Okay. I'd like to direct your attention to the beginning of that rule. You're with me here? Sub rule 2, I'll just read it and tell me if this -- so the record is clear. It says: "A discharge that contains a substance that is capable of being treated by the actions of soil, soil microorganisms or plants shall be limited as follows:" -- and there's an "a," and it goes on to include the text including (a)(1). Do you see that?
A Yes.
Q So this rule by its terms or the part that you're referring to states that this rule applies to a discharge that contains a substance that's capable of being treated by the actions of soil, soil microorganisms or plants.
A Yes.
Q Now, is it your testimony, Dr. Maest, that as you understand how the TWIS system; that is, the treated water infiltration system; is going to be set up and operated here, that the nitrogen-containing compounds in this instance are capable of being treated by the soil, soil microorganisms or plants?
A They are capable of being treated by -- yes, they --
Q Do you believe that they will be treated by those?
A I believe that they will be to some extent, yes. They --
Q On what do you --
A Go ahead.

Q On what do you base that opinion?
A Because microbes are capable of oxidizing and reducing nitrogen compounds and mineralizing them, it's called, into the soils.
Q I believe you testified earlier that it's your understanding that what is being proposed here is what's called a rapid infiltration system?
A Yes.
Q And so -- I just want to be clear about this. It's your testimony that you would expect there to be significant treatment of nitrogen-containing compounds between the point where it exits the infiltration gallery and before it gets to the groundwater?
A Before it gets to the groundwater?
Q Yes.
A You know, I haven't done an analysis of that. I really don't know. You're asking me if I think there will be significant treatment?
Q Yes.
A I really can't say. I really can't say. But it's my understanding that that's not allowed if it's a rapid infiltration basin.
Q Again, your understanding of what is or is not allowed, just to the record is clear, is it, upon your review, your reading of the rules in connection with this project?

A That's correct.
Q You don't hold yourself out as an expert in the interpretation or application of these rules, do you?
A No, I don't.
MR. REICHEL: Can I have just a moment, Judge?
JUDGE PATTERSON: Sure.
(Counsel reviews notes)
MR. REICHEL: I have nothing further at this time.
MR. HAYNES: Dr. Maest, --
THE WITNESS: Yes.
MR. HAYNES: -- a few questions on redirect.

REDIRECT EXAMINATION

BY MR. HAYNES:
Q Mr. Lewis asked you about a funding source for your two reports, the predictions report and the comparisons report.
A Uh-huh; yes.
Q Do you remember those questions?
A Yes, I do.
Q And you testified that those reports were funded by an organization called Earthworks. Do you remember that?
A Yes.
Q Did Earthworks in funding these reports direct you to any particular conclusion?
A They very much did not.
Q And so it's your testimony that the conclusions that you

arrived at in both of the reports, Petitioner's Exhibit 65 and 68, were independent of any funding source?

A Yes.

Q Mr. Lewis also directed you to Petitioner's Exhibit 25 which is a letter from Governor Granholm dated February 23, 2006, and he read a portion of that letter to you, and I'd like to go over a portion of that with you also. The third paragraph of that letter says in the third sentence -- and this is a letter directed to Stephen Chester, director of the Michigan Department of Environmental Quality, from Jennifer Granholm. The third sentence of the third paragraph says, "The standards you have developed are the strongest and most protective in the Nation." That's part of the sentence. Do you remember Mr. Lewis asking you about that?

A Yes, I do.

Q In your experience in evaluating hard-rock mines around the country and, in particular, in the four states in which you've worked, Montana, Colorado, New Mexico and California, would you have a basis for comparing the regulations that you've been involved with there with the regulations concerning the proposed Eagle Mine in Michigan?

A Yes, to some extent.

Q All right. And to that extent, Dr. Maest, can you tell us whether or not the regulations that you've reviewed for the

Michigan -- under the Michigan statute are comparable to, worse than or better than; that is, more protective than; the regulations that you've reviewed for other states?

A I think it's hard to say. You know, overall generally I'd say that they're comparable to. I think there are some good provisions in the rules, but they don't stand out, you know, as substantially better than the other states.

Q So that you would, in fact, disagree with Governor Granholm's assertion in this letter that the standards you have developed are the strongest and most protective in the Nation based upon your knowledge of the regulations that you've reviewed?

A I wouldn't agree with that.

MR. HAYNES: I have nothing further.

MR. EGGAN: I have no questions on redirect.

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

MR. LEWIS: Nothing further, your Honor.

JUDGE PATTERSON: You're done. You're excused.

MR. HAYNES: Your Honor, could we have a short break to handle the next witness?

JUDGE PATTERSON: Sure.

MR. HAYNES: Thank you.

(Off the record)

MR. DYKEMA: Your Honor, I call Mack Strand.

JUDGE PATTERSON: Are you going to go ahead

without Mr. Eggan or --

MR. DYKEMA: Yes.

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

DR. STRAND: I do.

ROGER M. STRAND, PH.D.

having been called by the Petitioner's and sworn:

DIRECT EXAMINATION

BY MR. DYKEMA:

Q Dr. Strand, will you please state your full name for the record?

A It's Roger Malcolm Strand.

Q And please spell your last name?

A S-t-r-a-n-d.

Q And where are you currently employed?

A North Michigan University.

Q And what is your field?

A Aquatic ecology.

Q Can you please recite for the court your post-secondary education?

A Yes. I have a bachelor of arts at Gustavas Adolphus College, a master of science from the University of Minnesota and a Ph.D. from Michigan State University.

Q And what was the subject matter of your dissertation?

A It was sedimentation impacts on Upper Peninsula stream

communities.
Q Has most of your research been in the Upper Peninsula of Michigan?
A No, about half, I suppose.
Q And what teaching positions have you had prior to your current position at Northern Michigan?
A I was a visiting assistant professor at Dartmouth College just prior to this.
Q In what subjects?
A Aquatic ecology.
Q And what subjects do you teach at Northern Michigan and what subjects have you taught as well?
A I teach stream ecology, sort of a comprehensive aquatic ecology course call Ecology of the Great Lakes, aquatic insect ecology, entomology, invertebrate zoology as well as general biology, research and seminars as well.
Q I'd like to go through with you quickly some of your other professional activities beside teaching and research at Northern Michigan. Have you done any consulting work as an aquatic ecologist for private companies?
A Yes.
Q Can you please describe some of that work?
A Well, I have -- as a -- at Michigan State I worked with a consultant to identify and alleviate mosquito pest problems for BASF, the client in this case, midge aquatic insect

problems for Dow, a sort of community ecology study for Upjohn. I've also done a little bit of endangered species work in this case for -- this consultant was hired by Kennecott in the Flambeau Mine in Wisconsin case. We did a consult there.

Q What was the work you did for Kennecott?

A We were looking for the presence of a threatened dragonfly in the Flambeau River.

Q Did you find it?

A Yes. Someone did, Ken Tennison, but the group did, yes.

Q Are you familiar with a group called the Central Lake Superior Watershed Partnership?

A Yes.

Q Have you done work for them?

A Indeed. I did a survey of the river mouths of Marquette County into Lake Superior, 13 different streams and did habitat evaluations and certain aquatic macroinvertebrate surveys for them. It was a DEQ grant that they had gotten to do this, so the report went to the DEQ.

Q And do you serve or sit on any societies or boards relevant to your field of aquatic ecology?

A I'm in societies. I've been part of the North American Benthological Society, the Ecological Society of America the Entomological Society of America and I'm a past member of the board of directors of the Yellow Dog Watershed Preserve.

Q And do you serve on any advisory committees?
A Not -- oh, yes. Excuse me. I'm on the State of Michigan Insect Technical Advisory Committee which oversees the listing and reviewing periodically the status of threatened and endangered insect species in Michigan.
Q So the function of that committee is to advise the state authorities on the status of threatened populations?
A That's correct.
Q How many publications do you have?
A Somewhere around ten I suppose, peer-reviewed publications.
Q And how many of those approximately have to do with aquatic ecology?
A Directly eight.
Q What is aquatic ecology?
A It is a very broad field obviously and refers to fresh water as opposed to marine ecology and it incorporates the study of fresh water environments, the environment and the organisms within those ecosystems and the interactions of the organisms with each other and with the environment.
Q Is it a so-called multi-disciplinary field?
A Yes.
Q What are the disciplines encompassed by aquatic ecology?
A Well, we have -- I guess we could start with the base -- biogeochemistry, limnology, ichthyology, entomology.
Q The first you mentioned was biogeochemistry. I could take a

guess at that by splitting it up into its roots, but perhaps you could put it into English instead of Latin. What is biogeochemistry?

A It's the study of the nutrients and intoxicants in ecosystems; their movements, their cycling. It's the biochemistry and the physical geological processes that drive nutrient cycles in ecosystems.

Q As part of being a biogeochemist as an aquatic ecologist do you have to have some command of the field of toxicology as it relates to aquatic organisms?

A Yes.

Q Is that a subject that you teach?

A Yes; not as a specific course, but yes, in parts of courses.

Q In what courses is -- does toxicology come up.

A Well, nearly all of them. The biggest part would be a designated part of the ecology of the Great Lakes course where -- its, of course, a quite relevant part of that course matter, but also in all the aquatic ecology courses: stream ecology, insect ecology. Even at the level of introductory biology you introduce that.

Q Did you study toxicology when you were a PhD candidate?

A Yes.

Q With whom did you study the subject?

A I took Dr. John Geeze's aquatic ecology course at Michigan State.

Q What is Dr. Geeze's standing in the field?
A He's one of the world's foremost authorities in aquatic ecology -- excuse me -- aquatic toxicology.
Q You also mentioned ichthyology; that's the study of fish?
A Uh-huh (affirmative).
Q How much research of -- well, backing up to toxicology. For purposes of teaching aquatic ecology do you keep yourself current on the literature related to aquatic toxicology?
A Yes, particularly when it refers to the Great Lakes and local streams and --
Q As an ichthyologist are you familiar with brook trout biology?
A As an ecologist I'm familiar with brook trout biology; I'm not a trained ichthyologist, although I have considerable experience with fish as a stream ecologist and a general aquatic ecologist.
Q And aquatic ecologist has to have substantial command of the principles of ichthyology; is that correct?
A Particularly if you're going to teach it, yes.
Q Do you serve on master's thesis research committees at Northern Michigan?
A Yes, I do.
Q In that capacity have you reviewed brook trout research proposals and studies?
A Yes. One of my students was part of habitat assessment for

a Coaster Brook Trout rehabilitation study -- or excuse me -- introduction study in rehabilitating the population. So I was the director of that. And I've also sat as a member on -- well, now four master's theses research that -- projects that are specifically on the biology of Coaster Brook Trout in the Pictured Rocks National Lakeshore. One of these has been completed; the other three are active.

Q What is a Coaster Brook Trout?

A The definition is typically a brook trout that utilizes in the sort of evolutionary sense the ocean as a foraging habitat as in the Lake Superior sense utilizing the lake as a foraging habitat and then a habitat that can be used to move from stream to stream. So it's a brook trout that leaves the stream and feeds in the lake, returns to the stream to spawn. In some cases though in Isle Royale the Coaster Brook Trout spawn on the shoals around the island; they don't spawn in streams. And so they're always on the coast. But the term comes from the propensity, particularly in the Atlantic Ocean, to stay very near the coast because the salt wedge water is very cold and thus they hang around the estuaries. And so the coast is -- they're close to the coast and that's where that comes from.

Q Have you studied brook trout elsewhere in the country?

A Yes. I've studied brook trout in a forest called the Second College Grant in Northern New Hampshire bordering Maine and

Canada and there was several research programs there on -- directly on brook trout. And one of my main position -- my main roles there other than teaching was to establish a stream ecology study center in this 30,000-acre forest with the goal of combining sustainable yield sylvaculture with brook trout production and managing for brook trout.

Q Is limnology one of the fields that an aquatic ecologist has to have substantial command of?

A Absolutely.

Q That's the study of lakes?

A Uh-huh (affirmative).

Q I think you also mentioned entomology; that's the study of insects?

A Yes.

Q Are you familiar with the term "hydroecology"?

A Yes, I am.

Q What's that?

A This is a relatively new subdiscipline that combines hydrology with ecology, as it suggests. My role as -- in hydroecology research has been a collaborative one with USGS, the United States Geological Survey scientists from -- in this case the Wisconsin office in Middleton. We work collaboratively, hydrologists with ecologists to study the -- in this case the role of groundwater on influencing productivity of stream systems.

Q Does the fact that there is a field called "hydroecology" reflect the fact that an aquatic ecologist has to have substantial command of the principles of hydrology insofar as they affect rivers and lakes?

A I think that that would be overstating it, a "substantial command" as a collaborative field -- and perhaps why it is starting this way is because these are disparate disciplines and training is very different, and so communication with hydrologists is very important in being able to sort of put together research projects that joins the expertise of the hydrologist and the ecologist. And so familiarity, ability to lecture about it and -- is required in my job, but --

Q Dr. Strand, in a little while we're going to talk about your opinions regarding the likely impact of the Eagle Mine on aquatic resources in the area, but before we get to that I would like you to share with the court your understanding of the resources at risk.

MR. DYKEMA: Can we have the first slide, please?

Q Does this picture, which I'll identify as the Part 632 Exhibit 11, photo number 14 -- is this the upper Salmon Trout River?

A Yes, it is.

Q And right by the orebody?

A Right above it.

Q In your view is the Salmon Trout River one of the aquatic

resources that is -- will be jeopardized by the Eagle Mine?
A Yes.
MR. DYKEMA: The next slide.
Q We're now looking at slide number two --
MR. DYKEMA: And before we proceed further, your Honor, let me hand out my demonstratives so everyone will have them in front of them if they want. The package of demonstratives has been marked as Exhibit 146.
Q Dr. Strand, is slide number two one that you prepared?
A Yes.
Q And why did -- what are we looking at and why do you think we should look at it?
A What we're looking at here is three snapshots of the Salmon Trout River from -- moving from headwaters through one mid-reach stretch -- section to the mouth and the point being made here is that when we -- a stream ecologist and aquatic ecologist looks at a stream we the watershed and the connectivity between the headwaters and the mouth both through the water, obviously, but energetically and through organism movements is very important, so we see this as one system.
Q Does what happens to the headwaters of a stream impact the entire stream?
A Yes.
Q Does what happens to the Salmon Trout River also affect the

inshore region of Lake Superior near the mouth?
A Yes.
Q Are there energy connections between the river and the inshore lake area?
A Yes, there certainly are.
Q Now I'd like to explore with you a little bit the quality of the Salmon Trout River in terms of aquatic ecology.
MR. DYKEMA: Can we have slide three, please?
Q What are we looking at, Dr. Strand, in slide number three of your demonstratives?
A We are looking at some data from a GLEAS Procedure 51 study that was done to provide baseline information about the habitat quality of the streams near the proposed mine site and a couple streams that are somewhat more distant. But these are all streams close to the region that we're discussing. This particular --
Q First of all, who did this study?
A This was done through the DEQ with DEQ personnel and also some DNR personnel and also some private consultants that were, I believe, hired by the DEQ to conduct some of the analyses that we're looking at here.
Q And was this done in connection with the mining proposal?
A I believe so, yes. Providing baseline information, yes.
Q And have you reviewed -- generally reviewed this survey work, baseline stream study work that was done by this group

of organizations?
A Yes; yes.
Q Did they do a good job?
A Excellent I think.
Q Slide number three shows us what in particular about the Salmon Trout River?
A Well, it makes the point that overall the habitat quality -- and this is what we're looking at -- the physical habitat part of the procedure is excellent.
Q You mentioned a GLEAS 51?
A Yes.
Q What's that?
A It's a protocol on the Great Lakes Environmental Assessment Schedule protocol -- Schedule 51 protocol for evaluating the habitat quality and the biotic communities of wadeable streams in Michigan.
Q And is GLEAS 51 a protocol that you yourself use from time to time?
A Yes; yeah, I do.
Q And what does the application of GLEAS 51 tell you about a river?
A It gives you a general snapshot in time of the habitat quality and the community that's there and allows you to compare streams in the region and it gives you a comparative basis for the -- all the other surveys done. So it's a

standard protocol for Michigan streams.

Q And what results did they get for the Salmon Trout River?

A That the habitat quality was -- is excellent, was excellent at the time and the biotic community intact, excellent.

Q Does the GLEAS 51 look at the biotic community?

A Indeed.

Q And we have -- they had two sites here for the Salmon Trout?

A Yes.

Q Station 3 and station 4?

A Uh-huh (affirmative).

Q 4 is on the AAA road?

A Okay. Yeah.

Q And that's where -- where is that in relation to the mine site?

A Very near the mine site, just to the west.

Q And then station 3 is at the northwestern road?

A Uh-huh (affirmative).

Q Where is that in relation to the mine site?

A That's another half a mile north.

Q So downstream?

A Downstream, yes; that's correct.

MR. DYKEMA: Can we flip to demonstrative number four?

Q Dr. Strand, is demonstrative number four an excerpt from the text portion of the DEQ baseline survey that summarizes the

GLEAS 51 results?

A Yes.

Q And what does it say?

A It says what I have just mentioned, that the macroinvertebrate results were like those of the habitat survey -- study results; that the quality is excellent.

Q Is there a higher category than excellent in GLEAS 51?

A No.

MR. DYKEMA: The next one.

Q Dr. Strand, let's take a look at your slide number five. What specifically -- is this from the same report?

A Yes.

Q And what specifically does this tell us?

A This, again, suggests that in this case the macroinvertebrate community is -- indicates excellent quality habitat. It's in all cases but one the top score, "excellent."

Q Now, second from the right is a river called "Cedar Creek," station five?

A Yes.

Q Is that one that the surveyors used as a control?

A I would say a reference place outside of the potential area of impact as it was determined at the onset of this study. Similarly with Big Pup Creek.

Q Is Cedar Creek on the Huron Mountain Club property?

A Yes.
Q And that's got a score of "excellent"?
A Yes.
Q Now, station four for the Salmon Trout got a score of "acceptable." Do you see that?
A Yes.
Q Is that right?
A Uh-huh (affirmative).
Q How is "acceptable" as a rank in relation to "excellent"?
A Well, it's just under "excellent" as a rank.
Q And did the authors of this report comment on that particular score?
A Yes, they did.
MR. DYKEMA: Go to number six.
Q We're now looking at slide number six, Dr. Strand. Is this an excerpt from the text of the DEQ baseline study?
A Yes; yes.
Q What does it say about that acceptable rating?
A Well, the last sentence suggests that it was a "very high acceptable"; in other words, the total metric score obtained at this station was very near the five threshold which would score as excellent, so it was a high four. So it was close to excellent.
Q How close is the Yellow Dog River to the mine -- proposed mine site?

A It's quite close.
Q In your view is the Yellow Dog an aquatic resource that is at risk if the mine is approved?
A Yes.
Q What did the baseline study by the DEQ show us about the quality of the Yellow Dog?
A Another excellent quality cold water fishery.
Q Is "cold water fishery" a term of art in Michigan?
A Yeah.
Q Does Michigan classify streams?
A Yes.
Q And is "cold water fishery" one classification?
A The DNR would classify a stream as a cold water fishery, yes.
Q How does a cold water fishery rank in terms of its value?
A I suppose it depends on the angler you're thinking about, but as -- overall, these are the high quality streams.
Q Dr. Strand, have you yourself done a comparative survey of rivers in -- cold water rivers in the Upper Peninsula?
A Yes. Some of those were cold water rivers and others were --
Q Approximately how many rivers were involved in the comparative study that you did?
A Thirteen.
Q And how did the Salmon Trout rank?

A Top.

MR. DYKEMA: Can we look at slide seven, please?

Q Dr. Strand, is slide number seven a demonstrative that you have prepared?

A Yes.

Q What does it show?

A Well, it shows on X axis along the bottom the physical totals, those habitat scores, the habitat quality of these streams and you can see it's moving left to right from relatively low habitat quality to the right relatively high habitat quality with the Salmon Trout having the top quality there. On the Y axis, the vertical axis we see a metric called "Shannon Wiener Diversity" which is a way of assessing the biodiversity of the community. And the correlation that you're seeing here is that the GLEAS 51 physical habitat total is strongly correlated with the biodiversity in these streams. In one way this verifies the -- this suggests that the GLEAS 51 physical total is a good way to predict biodiversity in these streams.

Q Is biodiversity generally a sign of ecological health?

A Yes. In a general sense we try to maintain biodiversity in natural communities.

Q I noticed the Pine River on this.

A Yes.

Q And that river had the highest biodiversity according to the

Shannon Wiener method?

A Uh-huh (affirmative).

Q Where is the Pine River?

A The Pine River is on Huron Mountain Club property. It goes out of Pine Lake into Lake Superior.

MR. DYKEMA: The next slide.

Q Dr. Strand, slide number is a picture of the Yellow Dog River; right?

A Uh-huh (affirmative).

Q Have you yourself conducted surveys on the Yellow Dog River?

A Yes. Yes, I have. The past slide actually had a stream called the Iron River, which is the mouth of the Yellow Dog, and so that's one. And I've also done considerable work on the Yellow Dog proper including near where this photo was taken in the McCormick Tract Wilderness.

Q In general what kind of results did you get from your survey of the Yellow Dog biological community?

A This is another excellent quality stream.

Q What kinds of organisms did you sample there, or have you sampled there?

A I've sampled benthic macroinvertebrates, the crustaceans, mollusks and insects that occur in the stream bottom.

Q Is it a productive river?

A Quite productive, yes.

MR. DYKEMA: The next slide.

Q Slide nine is a picture of Cedar Creek; that's the stream you referred to earlier?
A Uh-huh (affirmative).
Q That's on Huron Mountain Club property?
A Yes.
Q Can you tell from published materials the quality of this river?
A My experience with it is through the MDEQ report and it looks like a very excellent trout stream.
Q You mentioned a moment ago that there is a population of Coasters at Isle Royale that spawn in the lake?
A Uh-huh (affirmative).
Q Are there any south shore Coasters that we know of that are shoreline spawners?
A Not to my knowledge; no.
Q So the south shore Coaster population are all river spawners?
A Presumably the ones that we know about, yes.
Q What's the current status of the Coaster population on the south shore of Lake Superior?
A There is one population of large Coaster Brook Trout and -- in Pictured Rocks National Lakeshore. They have been working to introduce fish and reestablish Coaster Brook Trout populations in several streams in the national lakeshore. But historically just one that we sort of refer

to as a long-standing Coaster Brook Trout population that --

Q And where does that population spawn?

A The Salmon Trout River.

Q Do you know what the documented breeding population of the Salmon Trout River Coaster is?

A It ranges between a hundred and 200, sometimes less than a hundred returning fish per year, returning to spawn.

Q Is that population -- is a population of that size at risk?

A I think so.

Q How?

A Well, I think so, because I think the population of that size is pretty small by number of individuals and the tendency of it to fluctuate fairly widely around a number that's fairly low suggests that the interannual population dynamics are such that it can reach even lower numbers than a hundred periodically. At one point the organisms will -- population size can get critically small where rapid extinction becomes more likely with removal of each individual. This is something referred to in ecology as the "Ali Affect" and it essentially is -- it makes sense with these Coasters if you think about a very low population density or number, their mate location may be compromised, inability to find a mate. And these are size sorted animals that -- effectively the big ones mate with the big ones and compete with each other, and thus finding another big

Coaster could be problematic if the population gets smaller. And also out in the lake the tendency of chars is to shoal; that is, to group together while they feed in shallow water providing them with a better defense against avian predators in particular; sort of more eyes as this big group of fish can -- and each individual then will benefit from this. Of course, if there are fewer of these individuals, the shoaling benefit will go away. And so very -- one very small population size, risk of predation becomes much greater. So risk of loss by predation is -- would occur at one level and I think we're at, again, a pretty small population size.

Q Dr. Strand, what are the harms, what are the -- in your view what are the likely causes of harm to the aquatic resources in the region of the proposed Eagle Mine?

A Well, the causes, as testimony has indicated, include acid mine drainage, groundwater drawdown, airborne pollutants --

Q Have you reviewed the -- I'm sorry.

A -- airborne pollutants as well.

Q In referring to airborne pollutants have you reviewed the deposition maps prepared by Conestoga-Rovers Associates?

A Yes, I have.

Q What are the -- taking it at a fairly high level, what are the adverse consequences to aquatic habitats from groundwater drawdown?

A Well, we can look at it as -- from the thermal environment as we're talking about cold water streams. Obviously the water temperature and maintaining cold water conditions is a function of groundwater upwelling into the stream and then, thus, the threat of warming the water is there. Productivity losses as a result of reduced groundwater input seems potentially problematic.

Q If the water is -- becomes warmer as a result of the reduction in groundwater supply, does that have an effect on the metabolism of organisms living in the water?

A Yes. Yes, it does. It's sort of a two-part effect. Effectively the -- as the water warms up the organisms' metabolism increases. This is for poikilothermic organisms, those that are -- change the temperature with changing environmental temperature, what some people would call cold-blooded organisms. As the water warms up their metabolism increases, which means their oxygen demand increases and as the water warms up the dissolved oxygen concentration goes down, and so when their oxygen demand is increasing the oxygen concentration or availability decreases and thus it's sort of a two-part effect of warming on the metabolism of organisms.

Q You mentioned what I would refer to as pollution particulate deposition in acid mine drainage. I'd like to put that off for a minute and dwell for a little while on the effects of

loss of groundwater.

A Okay.

Q Is groundwater an important source of water for the Salmon Trout River?

A Yes.

Q I'd like to go through the ways in which groundwater affects an aquatic ecosystem.

MR. DYKEMA: Slide ten.

Q Is slide ten a demonstrative you prepared?

A Yes.

Q And what is it that you would like Judge Patterson to understand from this exhibit?

A Well, this shows us the relationship between -- the relationship of the stream water and the groundwater and it also shows us the mixing zone called the hyporheic zone where stream water and groundwater mix below and laterally around a stream. It will -- in this case shows us where the water table is and we can see -- near the bottom here we can see groundwater moving into the hyporheic zone upwelling into the stream. In this case we can also see flow outside laterally in the channel, the hyporheic flow indicated there. So we have a constant sort of mixing of stream water and groundwater in the hyporheic zone and the supply of water to the stream coming from the groundwater.

Q Is the hyporheic zone inhabited?

A Yes, it is. It's inhabited by a distinct fauna of organisms, most of them very small, but many animals are hyporheic specialists. The hyporheic zone also serves as a refuge habitat for streambed insects during -- particularly insects but other invertebrates during periods of high flow and other harsh conditions. So it's utilized by stream organisms and it has its own endemic fauna. The productivity of the hyporheic zone is often in biomass terms as much as in the streams itself. So it can be energetically very important as well and the diversity is -- also, of course, can be very high.

Q Is the presence of groundwater important for the health of the hyporheic zone?

A Yes; critical.

Q And is the health of the hyporheic zone important for the health of the river?

A Yes.

Q If groundwater is taken away from a stream, if there's drawdown and, hence, groundwater supplies are lost, other than loss or compromise of the hyporheic zone, what are the consequences?

A Well, again, we will --

MR. PREDKO: I'm sorry, Doctor.

THE WITNESS: Okay.

MR. PREDKO: Your Honor, I just -- I want to place

an objection to the extent that he intends to testify as to results to the Salmon Trout. I don't have an objection if he wants to testify generally as to the effects of groundwater drawdown, but to date there has been no foundation, no testimony as to effects on the Salmon Trout River from any groundwater drawdown, so there's no foundation for specific testimony to that effect.

MR. DYKEMA: I think we'll have a foundation for that, your Honor.

Q What are the impacts on a river if groundwater is -- groundwater supplies are reduced?

A Well, if you see the water table line there, by reducing the groundwater supply we will lower that water table line. And if it gets lower than the stream channel itself, of course the stream water will then flow into the groundwater; we will not get the groundwater flowing into the stream water supporting the flow, so that --

Q So the river can become an exporter of water -- of groundwater instead of an importer?

A Yes, the stream channel will fill back in with what is the permeable sediment below it.

Q If groundwater supplies to a stream are reduced, what's the effect on temperature?

A The temperature will increase. And -- excuse me. I'd like to say one more thing. I'm talking about temperature

increasing in the summer. In the winter though the temperature will tend to decrease because the other side of this is that groundwater provides a thermal refuge from heat but also thermal refuge from cold. So the stream in the winter with the groundwater input stays warmer and it will be cooler during the summer.

Q Dr. Strand, have you yourself done a study comparing the quality and characteristics of rivers according to the extent of which they are supported by groundwater?

A Yes.

MR. DYKEMA: Can we have slide 11, please?

Q We're now looking at slide 11. Can you please describe for Judge Patterson the study that this slide reflects?

A Yes, this is one of those hydroecology studies where working with Dr. Hunt and Dr. Walker we looked at the -- over a gradient of groundwater input into streams from a place -- from a place where there's lots of groundwater input to a place where there's relatively little groundwater input to a place where there's actual stream water moving into the groundwater, so no groundwater input; a net loss of stream water. So it's sort of the gradient of -- from high input to no input. And we looked at the productivity of the microbes in the sediment, the periphyton, the algae that grows on stream substrates, the benthic macroinvertebrates and a lot of -- a lot more technical hydrology that was part

of this as well. But my part was the organismal productivity part.

Q And have you prepared a slide that summarizes the results you found?

A Yes.

MR. DYKEMA: The next slide, please.

Q We're now looking at slide 12. What were the results of your comparative study, Dr. Strand?

A Part of the results shown here, these being the benthic macroinvertebrates and the algae data from these sites. You can see the gradient from strong upwelling, weak upwelling, to downwelling there. Those are pictures of those sites and you can see they're similar streams in size and in other factors. So all things equal, we're looking at the effect of groundwater -- isolating effect of groundwater inputs on these benthic organisms. You can see in the figure to the left -- and if we go from left to right, blue to red that there's a significantly greater number of invertebrates in the high groundwater discharge site, fewer in the weak groundwater discharge or upwelling site, and fewer yet in the site that has no groundwater input; recharge, in other words.

Q So the blue bar represents invertebrate abundance in the strong upwelling river?

A That's correct.

Q And over on the right the red bar represents invertebrate abundance in the stream that's actually an exporter of groundwater?
A That's right.
Q Okay. And what's the difference between the charts on the left and in the middle: "Invertebrate Abundance" and "Invertebrate Richness"?
A The organisms are the same; I just -- in this case the number of invertebrate families is a larger grouping of -- taxonomic grouping is indicated by the middle. So the number of invertebrates families is the richness. And we see the same pattern there, that richness in the benthic community is greater in the high groundwater upwelling site, and the same pattern as we move down to the recharge site. And you can think of these reaches of streams.
Q And so the invertebrate abundance in effect refers to the biomass of invertebrates?
A The number of individuals.
Q All right. Is invertebrate abundance important for trout?
A Yes. It's one way of characterizing the food available for trout is to assess the standing stock of invertebrate biomass. And the number of individuals here is roughly equatable to that. But of course, lots of little ones and one big one would be the same amount biomass. So the number of individuals, so is what I would -- but yes, that

definitely indicates differences in food for trout.

Q And what does the chart on the right of slide 12 show?

A This shows us a periphyton or algorespiration. There's bacteria and fungus and little animals and other things that go into this sort of stuff that -- you think of the slime that grows on stream rocks and periphyton. So we sometimes simplify that as saying algae, but there's lots of other organisms there. And it's the primary production base in a basal resource for -- one basal resource for streams. And what we can see is that in the groundwater input sites the strong upwelling and weak upwelling sites we have considerably greater periphyton and respiration which is an indication of the biomass of this basal resource to the invertebrates that feed on it. In other words, we are looking at the animals on the left, the number of types of animals in the middle, and the food for those animals in the right.

Q You mentioned a moment ago that the supply of groundwater to a stream has different temperature affects in summer and winter. Have you prepared a slide that will illustrate that for us?

A Yes, I have.

MR. DYKEMA: Slide 13.

Q What is depicted in your demonstrative slide 13, Doctor?

A This is a theoretical relationship established by Vannote

and Sweeney in 1980 and it's one we use to look at the influence of groundwater inputs on what's called "degree day accumulation" in streams of differing size. As you can see on the right, the -- or on the left A, B, C, D, E, F are streams of -- going from groundwater at A and B; C, D and F, are steams of increasing larger size. And what's interesting about this is that the model that says "total degree days" on the right; this is just a way of calculating how much heat is gained over a -- in this case, a 12-month period in any given place. The reason why we do this -- it goes way back in ecology -- because many organisms, particularly in the egg stage, have a determined number of how much heat it takes to get their embryonic development to proceed. Thus, at warmer temperatures it proceeds relatively rapidly; at cooler temperatures somewhat slower. And it sort of gives us an idea of how much heat is gained by this system.

Now, you can see -- although, this is a big unimodal relationship on the right, those numbers are all about the same that -- in other words, over a year the degree days accumulated from a spring and from a large river are about the same in this model. And the interesting pattern here, of course, shows us that if we go along B or C then it sort of -- the two smaller streams -- and these are representative of the streams that we've been talking

about -- tend to have a relatively stable thermal regime as a result of cool groundwater input. Thus, if you look at the far left and over to the far right, these are the warmer streams during this part of the year, during the winter. And, of course, if we look in the middle during the spring through early fall, these streams are the cooler streams and, thus, the management term of "summer cool, winter warm" has been used to characterize prized trout streams and cold water fisheries as being what we're looking for.

MR. DYKEMA: Go to slide 15.

Q Dr. Strand, is slide 15 a photograph of the Salmon Trout near the AAA road crossing?

A Yes; yes, it is.

Q What's the approximate flow at that point?

A It's --

Q Average.

A Two cubic feet per second.

Q And slide 16.

A Yes.

Q Was this taken near the northwest highway?

A Yes. This is also the Salmon Trout River.

Q Okay. It looks like it's gotten a lot bigger?

A Yes, it has.

Q What's the approximate average flow here?

A About six cubic feet per second, so it's about three times

as much water; discharge about three times as much.

Q Do we have temperature data from both sites?

A Yes, indeed we do.

MR. DYKEMA: Can we go to slide 17?

Q Now, in slide 17 did you excerpt some text from the same MDEQ baseline stream study that we've been talking about?

A I did.

Q And what does this -- what does this slide tell us about the Salmon Trout River?

A Well, this tells us about these -- those two sites that we just looked at and what's looked at here is that they took discharge measurements in all of the six sites for this study at a period of high flow in May and a period of low flow in -- or base flow in September. And in the top paragraph what the idea was to look at the stability of flow by comparing those two measurements. And it suggests that the Yellow Dog River stability was less than that of the other streams, and importantly here, that fairly stable discharge was observed in the other streams, the Salmon Trout River and Big Pup Creek.

Q In the second paragraph that you've excerpted here; what does that tell us about the river?

A This is an analysis of the specific conductance of the stream water, which is a way of approximating the amount of ions in solution. And groundwater contributes lots of ions

to the stream water and, thus, groundwater contribution can be evaluated in the same way as we just did with discharge. If we see a relatively small range -- or a relatively -- yes, a small range of values over a season, we see -- we think of the water as having a very consistent chemical property. And in this case the combination of consistent discharge and consistent specific conductance indicates a large contribution of groundwater to base flow.

Q I'd like to look at our next slide, slide 18. And again, Doctor, I'd like you to keep the same perspective. We've just seen the relatively stable flow and relatively stable conductivity disclose the presence of a significant groundwater contribution to the river in this area.

A We did.

Q Is slide 18 a portrayal of water temperatures?

A Yes, it is.

Q And what does that -- what does this tell us about the contribution of groundwater to the Salmon Trout in this stretch of river?

A In this --

MR. REICHEL: Excuse me. I'd just like to interpose either -- I guess an objection or a request for clarification. I understand that the -- what's been put up on the screen is being proffered as a demonstrative exhibit rather than substantive evidence, but I think that there is

at least a potential to mislead the tribunal here. I note that the heading of this says, "Project Report, Michigan DEQ Water Bureau 05029, Baseline Stream Studies in the Vicinity of the Proposed Sulfide Mine." Is this being represented that everything that appears on this slide is actually including the potential effects of drawdown; those legends are things that come from the DEQ study? If so, I don't think that's accurate.

MR. DYKEMA: Thank you, Bob. I will be clear on -- with each slide.

Q Where did the graph on this slide come from?

A The part of the graph -- if you notice that there is a yellow line, an orange line and a red line and some information on the lefthand side. Those I added over the graph. The graph with the temperature data came from the report referred to above. And so the temperature data that you're looking at, those lines that move up and down, are for August at three sites, two of which we've discussed and one that is in the headwaters, the area where the orebody is.

Q Okay. But the headings here about stream water temperature and potential effects; those are headings that you put on the slide?

A Yes.

Q And we have a little picture of a brook trout; you put that

there?
A That's correct.
Q And then the information above and below the little brook trout about growing conditions and mortality and lethality; those are things you added?
A Yes. And they refer to the bars on the -- that I put on the temperature to show the sort of brook trout specific information provided by this temperature study.
Q Okay. The data -- the information here that I want to talk to you about is represented by the three squiggly lines in three different colors and the band in the middle that looks like it's going from about 13 centigrade to about 16 centigrade. Is that all copied right out of the report?
A The band was not. The band I put in there to highlight that temperature band.
Q And what does the band represent?
A That's optimal growing conditions for brook trout; optimal temperature for growth.
Q Now, the data lines here; I see a red line, a magenta line and a yellow line. What are they?
A Well, you mean -- oh, the temperature lines?
Q The temperature data.
A The temperature data. We have a -- sort of a pinkish line, which is the Salmon Trout River where it's really -- the really small site that we looked at, two cubic feet per

second; and, of course, through August of this year -- that year. And the yellow line is upstream from there, that -- the river underneath or above the ore body. And the blue line, the one on the bottom, indicating cooler water is the one from the downstream site, downstream about a half a mile from the AAA road, the northwestern road crossing. So three Salmon Trout River temperature profiles for August.

Q So the station four, the magenta line; that's at the AAA road where the average flow is about two cfs?

A That's correct.

Q And then the blue line is at the northwestern road half a mile downstream where you said the average flow was about six cfs?

A Uh-huh (affirmative).

Q In August if there weren't -- well, which is colder?

A The station three, the blue line on the bottom obviously. The river at the northwestern road crossing is colder in August.

Q What does that tell you about where the extra four cfs is coming from?

A It tells me that a lot of it is coming from groundwater.

Q You've taught me not to use the word "migratory" so I'm trying to stay away from that. Do brook trout move around a lot?

A They do move around a lot and they do also migrate, so

that's --

Q What does the yellow band in the middle of this graph -- why did you put that on?

A This would be the perfect temperature for the brook trout to be in; this is an optimal temperature zone for them. And so this -- in that range -- or on those days and those places you could see where it would be best to be foraging and growing.

Q And what does this graph indicate to you as an aquatic ecologist about the ability of brook trout in this part of the stream to find optimal thermal conditions even in the month of August?

A It shows us a couple things. It shows us that during most of the month there is -- during all of the month there is very good growing condition habitat -- or growing condition temperatures somewhere to be found within this short stretch of channel. It suggests also, if you we look at the orange band of 18 degrees, that's -- it doesn't kill the brook trout to be at 18 degrees but mortality increases at 18 degrees and it indicates thermal stress. And so whenever we're above that band, in particular when we get way above that band, it would suggest that if there is a place where they can go to cool down they'll go there. And as you can see, as the smaller streams upstream warm up the -- of course, the downstream site warms up too but it stays nice

and cool; and thus, there are relatively cool places to find thermal refuge and there are -- if you are in one of the lower parts here you can move upstream into a warmer area and maximize growth that way. So there's both sides of the temperature profile shown here in August and the ability to so-called "behaviorally thermoregulate" to find the correct temperature zone through movement.

Q If a significant amount of the groundwater being supplied to this part of the Salmon Trout River were withdrawn would the natural resources of the stream be impaired or destroyed?

A Yes.

MR. PREDKO: Objection, your Honor; no foundation. It's the same objection that I made earlier. There's been no foundation laid through this witness or any other witness that there will be any change in the stream.

Q Dr. Strand, are you familiar with -- well, I'll put it this way. Will you assume with me for a moment that the operation of the mine, as some witnesses have testified, will lead to a drawdown of the water table of eight feet or more?

A Okay.

Q Based on your experience with hydrological principles as they apply to steams, would you expect that to have an affect on the groundwater contribution to the Salmon Trout?

A Yes.

MR. PREDKO: Same objection, your Honor.

MR. DYKEMA: Your Honor, I think he's fully entitled to rely upon -- explicitly rely upon testimony by other experts in offering his own testimony.

JUDGE PATTERSON: I think that's true. My problem is there's not a specific location of the drawdown at eight feet.

MR. DYKEMA: I'm sorry, your Honor?

JUDGE PATTERSON: I don't -- I'm trying to recall the testimony and I don't know where geographically the eight foot drawdown was that was testified to.

MR. DYKEMA: I believe and I'll ask my --

JUDGE PATTERSON: I mean, obviously it makes a difference if that's a half mile from the stream or right under it or whatever I would think.

MR. PREDKO: And, your Honor, not only that -- not only geographically but within the -- how deep the drawdown occurs at. Yeah.

JUDGE PATTERSON: Yeah; right.

MR. DYKEMA: Your Honor, the -- what I'm referring to is the report by GeoTrans for Kennecott which identifies the maximum drawdown of eight feet and a drawdown of -- well, this is in the immediate area of the mine itself, and a drawdown of four feet over an area of, it looks like close to 4,000 feet from east to west. Also your Honor will

recall that Dr. Prucha testified that he anticipated that the maximum drawdown could be substantially greater than that. So I think since we're talking about -- well, that is the basis of the eight-foot assumption that I put to the witness is the GeoTrans report for Kennecott, which has been marked as Intervener Exhibit 591. And I'm referring specifically to figure 25.

MR. PREDKO: And again, your Honor, first of all, I believe that mischaracterizes what the report says with respect to the drawdown and exactly where it's going to occur not only geographically, but importantly where it's going to occur below the surface. And I don't think that there's been any testimony through Dr. Prucha or anyone else as to that fact.

MR. DYKEMA: Your Honor, perhaps I can cut this knot by putting it in terms of hypotheticals.

JUDGE PATTERSON: Okay.

MR. DYKEMA: And then either the record will or will not support the hypothetical.

JUDGE PATTERSON: Okay.

Q Dr. Strand, if the groundwater in the immediate area of the mine were drawn down by eight feet or more -- the water table were drawn down eight feet or more, would you expect a substantial reduction in the groundwater supply to the Salmon Trout River?

A Yes.

MR. PREDKO: Can I have a continuing objection, your Honor?

JUDGE PATTERSON: Yes, certainly.

MR. PREDKO: Thank you.

Q And if that were to happen, in your opinion, would the ecosystem of the Salmon Trout River in this area be impaired or destroyed?

A Yes.

Q And do you hold that opinion with a reasonable degree of scientific certainty?

A Yes.

Q Would the temperature be affected?

A Yes.

Q And would those temperature affects harm the community in the river?

A Yes.

Q I believe, Dr. Strand, you mentioned earlier a concern earlier about acidification. But whether my memory is accurate or not, are you concerned about potential effects of acidification of the proposed Eagle Mine?

A Yes.

Q What is acidification?

A Well, it's the decrease in pH in a solution that is caused by input of acid.

Q Are the surface waters in the area of the Eagle Mine well buffered?
A No, not well buffered.
Q What does it mean to say they're not well buffered?
A What does means is that there is limited base cation concentration in the soils. These are positively charged ions that -- and particularly calcium and magnesium that we were talking about when we were talking about alkalinity or when it was being discussed. The general principle is that as an acid dissociates, the hydrogen ion, the hydrogen part of it, is liberated into solution. And so when we measure pH, a low pH is lots of hydrogen ion in solution. These hydrogens can exchange with calcium or magnesium, other cations, on binding sites in the soil and, thus, they bind to -- the hydrogen binds to the soil, liberates the calcium, thus there's less hydrogen ion in solution, the pH increases and, thus, it's been buffered by the presence of the calcium or magnesium or other cations.
Q What if any effect does acidification of a water body have on the toxicity or the impact of heavy metals that are either already present or being contributed to that environment?
A It increased the toxicity of metals. So metal toxicity is increased at low pH.
Q Going back to acidification, if this mine results in the

acidification of the water bodies that you have identified as being of concern, will that impair or destroy natural resources?

A Yes.

Q How?

A Well, specifically it would lead to lowered abundance and diversity of benthic invertebrates. It would, depending on how far we go down, it would lead to behavioral responses by fish, for instance, leaving, physiological problems, some incurred by fish and invertebrates, a wide range of -- a wide range of negative affects.

Q Does acidification have an affect on the decomposition rate of organic materials in a streambed?

A Indeed. It will slow microbial breakdown of detritus and, thus, it will slow the decomposition of organic material. The point to be made there is in small streams one of the basal resources, energy resources is leaves and other material from the forest, which are first colonized by microbes which start the decomposition process and then the invertebrates that eat that material come in and feed on that sort of sandwich of foliage and microbes. So the speed at which that leaf material and wood material is so-called conditioned for the organism will decrease with acidification, because acidification -- or decrease in pH will slow microbial decomposition. Yes.

Q Doctor, I can't resist observing that only an aquatic ecologist could think of rotting leaf litter as a sandwich. I'd like to talk a little bit about the effect of heavy metals on aquatic ecosystems. Are there metals present in this orebody that are of particular concern to an aquatic ecologist?

A Sure; yes.

Q What are those?

A Well, we have a full range of metals present. I would think copper among the ones we worry about, mercury, cadmium, zinc, nickel all have known toxic effects, and others.

Q Let's focus on copper.

A All right.

Q Are stream invertebrates sensitiva to copper?

A Some are. Some are very sensitive.

Q Are there stream invertebrates for whom relatively low levels of copper concentration are lethal?

A Yes.

Q Are there families of invertebrates in the Salmon Trout River that fall into that category?

A Yes.

Q How about fish? Are salmonids as a group sensitive to copper?

A Yes.

Q At what stage of their life are salmonids particularly

vulnerable to copper, if there is such a life stage?
A Copper and other toxins the eggs and developing young, small fish. The smaller they are, the more sensitive they are. The younger they are, the more sensitive they are, too.
Q Does the greater vulnerability of eggs and juveniles pose any particular risk in population dynamics should the Salmon Trout River be contaminated with copper?
A Absolutely. If you lose a large part or all of an age class, then the population structure is going to be dramatically altered.
Q Is it your understanding based on the testimony of other witnesses in this case that there is a likelihood of substantial elevation of copper in the Salmon Trout River water?
A Yes.
Q And is it your understanding that that is also a likely -- according to other witnesses, that that's also a substantial likelihood for the other area water bodies that you've talked about?
A Yes.
Q When would you expect the highest concentrations to occur, when during the year?
A I would expect during major precipitation events, but particularly during the spring snow melt.
Q Why?

A Well, a couple reasons. First, it will have the accumulation of particulates, as other witnesses have testified, deposited on the snow itself. And as the snow melts relatively rapidly, these will -- months of accumulation will be flushed into the stream. And this involves another point about acidification. And streams around there and everywhere with our snow undergo a spike in acidity or a drop in pH at snow melt. pH declines markedly in large part because the carbonic acid in precipitation water flows directly as it melts from the snow into the stream as opposed to being -- as opposed to filtering through the soils and getting a chance to be buffered. So we have this, in this scenario that you're presenting, an increase -- a rapid increase in copper at the same time as we have a rapid decrease in pH, which, of course, as we discussed before, would be even more troubling during this period.

Q Because acidification actually increases the toxicity of copper?

A Yes, indeed.

Q And is that true of other toxic metals as well?

A Uh-huh (affirmative).

JUDGE PATTERSON: You have to say "yes" or "no."

A Yes.

MR. PREDKO: Your Honor, I would just place an

objection. I didn't know if the doctor was going to go there, but he made a statement about other witnesses that testified about the transfer of the metals. I don't think that there has been any testimony. I know that some witnesses have tried, like, Mr. Vel, who did the deposition analysis. But he admitted that he was not an expert on the mode and transfer of chemicals after they hit the ground and what was going to happen to them then on Mr. Kohl's cross-examination. And so for the record, it mischaracterizes the testimony that has been thus far.

MR. DYKEMA: Well, the transcript will say what it says. I'm not -- I'm not sure that I agree with you.

MR. PREDKO: I agree.

JUDGE PATTERSON: Okay.

Q When did the Coasters -- when do brook trout spawn?

A In the fall, in October and September.

Q And is that true of Coasters, too?

A Yes.

Q And when do the eggs hatch?

A At that latitude, those winter temperatures, they'll start hatching late March, early April.

Q When does the snow melt?

A Late March, early April, sometimes a little later into April. It depends. It can be mid April.

Q Coasters spend most of their life out in Lake Superior?

A That I think is -- differs among populations of Coasters, but they spend much of their time feeding and growing in Lake Superior, yes.
Q When they're babies and most vulnerable to toxicity, they're in the river at the time of snow melt?
A That's correct.
Q You talked about the Salmon Trout River and the Yellow Dog River, and you've mentioned Cedar Creek and Pine River a little bit. Are there other waters in the area of the mine where you can find brook trout?
A Yes, lots of them.
Q Were you here when Dr. Maest was testifying about the springs that for some reason people all call the seeps?
A Yes, I was.
Q And that's an area just to the north of the mine site?
A Yes, it is.
Q Do you find brook trout in those springs?
A Yes.
Q Did Kennecott survey the brook trout and the springs?
A Not to my knowledge.
Q If the water coming out of the TWIS is toxic, will those brook trout be impacted?
A Yes.
Q Doctor, you mentioned early on that you regard as an aquatic ecologist, you regard the Salmon Trout River as an

integrated system that includes everything from the headwaters to the coastal zone near the mouth?

A Yes.

Q Have you done a study -- no. Let me back up. Typically when there is a flood event on the Salmon Trout River or any other coastal stream, what's the impact on the near shore areas of Lake Superior?

A Of course, it depends on which stream we're talking about, but generally speaking, we have a movement of sediment and organic matter and nutrients in solutions, solutes, some from the stream to the lake and to the near shore.

Q And have you done -- conducted a study of the wave zone on the southern Lake Superior shoreline?

A Yes.

Q What did you find?

A Well, it was a study on the bottom dwelling invertebrates that occur in the wave-swept shoreline, so that's the wave zone where waves penetrate. That's sort of an unusual kind of aquatic habitat that's found only in large lakes. And it was my questions were to sort of compare the energy base of the wave zone community with that of nearby streams and also the looking for connectivity between the open lake, whether or not the pelagic zone or open water zone of Lake Superior inputs energy into fuel the wave zone, whether the energy of the wave zone is coming from primary production in that

shallow water, algae growing on rocks, and whether the stream is also contributing to -- or streams contributing to the energetics of the system.

Q Is the wave zone -- how important is it to the Lake Superior ecosystem?

A I think it's critically important in that it's a place of high biological production, and it's a place where many even open lake species of fish spend the early part of their lives, something like a nursery habitat as it's been called. And it is a place thus where energy -- there's a connectivity between the open lake and the near shore waters. And, as I found, also between the stream and those two habitats as well.

Q Is the wave zone a critical habitat for Coasters?

A I believe so.

Q I think you mentioned earlier that they're called Coasters because they hang close to shore?

A Yes.

Q Is it a concern of yours that if this stream is made to carry significant quantities of toxic metals that the nutrient plume that goes into Lake Superior on flood events could be a toxic plume?

A Yes, it's a concern.

Q Have you reviewed Kennecott's environmental impact assessment?

A Yes.
Q Did they analyze at all the potential effects of either acidification or heavy metals on the Salmon Trout?
A No.
Q Did they analyze the potential effects of acidification or heavy metals on the Yellow Dog?
A No.
Q Cedar Creek?
A No.
Q You mentioned or you discussed the fact that heavy metals can kill animals and that we talked particularly about the toxicity of copper. Can the presence of copper or other heavy metals at lower concentrations have damaging but sublethal effects?
A Yes.
Q What kinds of sublethal effects do heavy metals have on fish?
A On fish sublethal effects from problems with osmoregulation, the maintaining of internal salinity, salt concentrations. With some salmonids it's been demonstrated that they have problems with olfactory response; that is, their ability to detect odors; general cellular dysfunction disruption, lots of -- lots of sublethal effects.
Q Would an impairment of the olfactory function in Coasters be significant?

A I believe so.
Q Why?
A Well, part of the -- part of the maintenance of this population in this place is the ability to hone back to spawn in that same river, the natal river as it's called. And finding the natal streams has been demonstrated to be large part due to the olfactory abilities of salmonids. So they sniff their way and find it through olfaction. If that's impaired, their ability to find their natal waters would potentially be impaired.
Q Is slide 19, Doctor, a demonstrative that you've prepared?
A Yes.
Q Who are these charming little creatures?
A These are a couple kind of mayflies.
Q Are mayflies an important part of the trout diet?
A Yes, they are.
Q How are mayflies in terms of vulnerability to heavy metal pollution?
A As an order of insects, they are very vulnerable, some more than others.
Q In the text that you've put here, you also mention a -- there's a reference to community change. What's the point you want to make about community change?
A Well, in places that -- in streams that have been impacted by heavy metal pollution, there's a loss of metal sensitive

species, as you'd imagine. And, thus, we have a system with fewer mayflies and fewer species overall.

Q Does heavy metal poisoning also have sublethal effects when demonstrated for invertebrates as well as for fish?

A Yes.

Q You have a note here about increased drifting. What's that?

A Many aquatic insects will drift from upstream to downstream through their life. They move. They get into the flow and let the flow take them to a new location looking for new food resources or escaping harsh conditions. And this is what I'd be referring to there; that it's been demonstrated there that metal pollution increases drift rate in mayflies. They leave in more -- they leave and, thus, expose themselves to the negative effect of being a drifting organism; that is, being available to your predators. So it's been hypothesized that this increased drift response will increase vulnerability to predation.

Q Dr. Strand, what kind of creature are we looking at here?

A This is something called a hydropsychidae caddisfly or net spinning caddisfly. These animals live on the stream bottom and they spin. As you can see on the right, they have a silken net which they use to catch particles and little animals that they feed on.

Q Is this an animal you yourself have studied?

A Yes.

Q And have there been -- the sublethal effects of relatively small levels of metal contaminations been shown for this group of stream invertebrates?
A Sublethal effects of actually in some cases large amounts of contaminants as well, yes.
Q Dr. Strand, what are we looking at in slide 21?
A These are pictures of slide-mounted hydropsychidae caddisfly nets. The one on the left is a normal net. You can see the structure of the cells of the net are uniform. The one on the right includes all sorts of different anomalies, as they're called. This is an abnormal net, and it -- these anomalies can be produced or are found in places where there is pollution in the water source, and metals included.
Q So this is an example of a sublethal effect where we have clearly a behavioral change? You've mentioned, Dr. Strand, that there are classes or groups of stream invertebrates that particularly sensitive to heavy metal toxicity. Are there also stream invertebrates that are relatively insensitive to metal toxicity?
A Yes.
Q A word that's been used a couple of times in this case is bioaccumulation. As an aquatic ecologist, is that something you understand and have studied?
A Yes. I teach about bioaccumulation.
Q If sensitive bugs are killed by heavy metal pollution and

only the insensitive bugs remain, what are the implications for the animals like trout that eat bugs?

A Is that they will have a larger proportion of their diet in insensitive metal-tolerant animals.

Q And what happens to the metal in the bug when it's eaten by the trout?

A It's accumulated in the trout.

Q Can you using the flip chart, if you would like, Dr. Strand, can you give Judge Patterson an idea of -- or the arithmetic of bioaccumulation?

A Sure. All right. What we'll assume is that the assimilation efficiency of any of the animals or organisms I'll draw her is about 10 percent. And this is just a general average; that when an insect eats another insect, about 10 percent of that biomass it accumulated will be part of the -- will be assimilated by the animal. The best will be respired off. So 10 percent will be the rule there. And if we can just start with animals and just do stream animals, we can take something like a little algo consumer, something called a midge, very common insect, and let's say just for the sake of numbers that this midge is a one-calorie diet. And let's give it one part of whatever toxin we want, nonnutritive toxin we want to discuss. Maybe it's mercury. So each one of these is worth one calorie, and each one has one toxin. Now, if we take something

that's going to eat that midge, something like a stonefly, and let's say it's about ten times as big and we'll make it worth ten calories. All right. In order to get it to its ten calorie level, we have to eat 100 of these midges, because only 10 percent is going to go into the animal. So there's 100 here. So it's eaten 100, which means because this nonnutritive toxin is held within the body often bound to fat, that it will have 100 units of that toxin. Now, if we take a fish and make it a 100-calorie unit, it's obviously going to have to go to get its 100 calories. It's going to have to eat 100 of these guys as well. And then, of course, it's going to have 10,000 parts of this toxin. If we put a bigger fish next in line, of course, we're going to have another hundredfold increase in the toxin and so forth as we move up. So the toxins accumulate as we move up the food chain.

Q And assuming a 10 percent efficiency, the toxins move up a hundredfold at each trophic level?

A In this model where we have one, that's right. Yeah; yeah. That will work. It also tells us if this -- if this fish decided to eat more of these, its toxin burden would be ten times less.

Q Thank you, Doctor. Dr. Strand, approximately how far is the mouth of the Salmon Trout from the Eagle site by river miles?

A Ten to 15 -- I don't know -- 12 miles, something like that, on stream miles. I'm not positive.
Q And is it -- do you have a basis for opining as to whether if there's a significant pollution impact at the headwaters we can be comforted that all the way down in the lower reaches of the river that there won't be such an impact?
A No.
Q We're now looking at slide 22, Doctor. What is this?
A These are data from a paper published by Maret, et al, in 2003.
Q And what did the data that you have summarized here reflect?
A Well, the study was done by the USGS, and it was part of their sort of the continental or the United States water quality analysis. And what they were doing here is they took -- they had 18 stream sites that are downstream from either inactive or active mines, a combination, and then they have 18 reference sites that are outside the influence of mines. And it looked in this case as part of this study for metal concentrations in the tissues of those net spinning caddisflies. And so the numbers in micrograms per gram there are tissue concentrations of in this case cadmium, lead and zinc at those reference sites, at those mine sites, and then 40 kilometers downstream from those mine sites.
Q Now, do cadmium, lead and -- well, generally speaking, do

toxic heavy metals behave -- or are they processed through the trophic system in much the same way?

A Similar. There's variability.

Q So but is there any reason to think that a pattern revealed here about cadmium, lead and zinc would be fundamentally different from what would happen with copper or mercury or nickel?

MR. PREDKO: Objection; no foundation.

MR. DYKEMA: The question goes to how heavy metals work themselves through the trophic levels in an aquatic ecosystem. I think his experience with toxicology and with aquatic ecosystems is plenty of foundation.

JUDGE PATTERSON: I agree. I'll overrule.

A Similar. Mercury is more complex but, yes, it's similar.

Q What does this data tell us about the extent to which the effects of heavy metal pollution are mitigated as one goes a considerable distance downstream from the source?

A They are mitigated some. But given that 40 kilometers is a considerable distance, there's still quite a lot of toxin in those animals.

Q So for cadmium, the animals 40 miles downstream are still roughly have six times the metal concentration in their tissues versus the reference site?

A Yeah.

Q Am I reading that correctly?

A Yes, roughly.

MR. PREDKO: Counsel, is this article that's referenced here an exhibit?

MR. DYKEMA: No.

MR. PREDKO: Your Honor, I would just place an objection for that reason. We were given in Petitioner's proposed exhibits, as you can imagine with all the binders around here, hundreds of articles. This one was not one of them.

MR. DYKEMA: Well, again --

MR. PREDKO: Based on its date, it could have been. It's a 2003 study. And I would also note for the record that, I mean, it's a snapshot of what was in there. I don't have the ability to cross-examine this witness with other things that are in this article. I object to the substance of the article coming in as evidence. I assume that Mr. Dykema is going to offer all these at the end of the testimony. And I'll renew the objection at that time. I will also object to the extent that this article is about other mine sites, and renew Mr. Lewis' objection regarding testimony regarding other mines. And I would also note for the record that this particular study talks about particular amounts of different elements, toxins, coming from other mine sites. And there has been no testimony whatsoever that any amounts that may come from this proposed mine are

anywhere near these amounts. Or I don't think there's been any testimony regarding the amounts that will come from the mine site and be in the streams and rivers. But anyway, that's the objection, Your Honor.

MR. DYKEMA: Your Honor, perhaps I can -- I should not have spoken so quickly in saying that this was not identified as an exhibit. I will check over break to see if it was. But whether it was or not, an expert witness is perfectly free to talk about the literature that supports his views. In this case, we've put the key data so that to be helpful to all concerned so that we can all look at it. But he could have cited this paper without using the demonstrative, and he could have cited the numbers without using the demonstrative. So I don't think that makes the demonstrative at all objectionable.

JUDGE PATTERSON: I have a question. Doctor, do you know where the reference sites were in relation to the other --

THE WITNESS: They were in the same -- they're two basins in Idaho. And they were within those basins, so this is a part of Idaho, I believe, extending into Montana for one site.

JUDGE PATTERSON: I was thinking relative to the mine sites and 40 miles downstream.

THE WITNESS: They picked sites that were similar

in the same basin, similar in size, and trying to identify the effects of the mines themselves. And so, yes, they were in the same area and they're similar sites.

Q But not affected by any mines?

A That's correct; yes. Not affected by direct flow of water from a mine site.

Q How does the contamination level at the 40 kilometer downstream site compare with the contamination levels right at the mine site?

A Well, there's some variation here, but it's down a half to a third to less than that.

Q So for the zinc, for one example, it's the 40-mile --

A 40 kilometer.

Q -- flow of water mitigated the impact of the contamination by less than half?

A Yeah. The 40 kilometer, it's less than half.

Q Doctor, are there a number of threatened and endangered or special concern invertebrates in the area of the Yellow Dog Plains?

A Yes.

Q Are there threatened, endangered or special concern species of Odonata?

A (Nodding head in affirmative)

Q And those are --

A Yes.

Q You need to verbalize your answer.
A Yes; yes. Dragonflies.
Q And Odonata are damselflies and dragonflies?
A That's correct.
Q Are the Yellow Dog Plains a good habitat for damselflies and dragonflies?
A Very good.
Q Dr. Strand, do you consider yourself an environmentalist?
A Yes.
Q Have you lent assistance or affiliated yourself with environmental organizations?
A Yes.
Q Is the Yellow Dog Watershed Preserve one of those?
A That's correct.
Q What have you done for them?
A Well, as a -- I served on the board of directors for two years, one term. And my role is largely to evaluate stream research proposals and to -- one of the major things that I did was to verify identifications of organisms that were collected as part of a DEQ-funded study of the Yellow Dog River and tributaries. And so it was an advisory -- scientific advisory role, in large part.
Q Do you have a philosophical objection to mining?
A No.
Q Did you sign in effect a letter that was sent to Governor

Granholm last November, a letter that argued that allowing this mine to go forward would be a terrible mistake?

A Yes.

Q Why did you sign that letter?

A Well, because I do believe that allowing that mine -- the mine to be sited where they're planning on siting it would be a terrible mistake.

Q What's special about the area?

A Well, it's certainly the rivers, as we've discussed, are highly prized cold water rivers, relatively rare on the landscape. The amount of protected wilderness in this area is extraordinary with the McCormick tract wilderness and the Huron Mountain Club wilderness. This is a very important wilderness area for Michigan and for the Lake Superior basin in general.

Q How many people signed that letter?

A I'm really not -- I'm not certain; a couple pages of signatures, quite a number. I'm really -- I'm not sure. 50 maybe. I can't recall.

Q Speaking generally, who are -- what's this -- who are the signatories?

A Well, many of the signatories were like myself; biology professors from the area, from Michigan Technological University and Northern Michigan University, and other biology professors elsewhere as well. Those are who we

were.

Q Dr. Strand, with what degree of certainty do you believe that this mine if approved will pollute, impair and destroy natural resources of very great value and extent?

A 100 percent.

MR. DYKEMA: Thank you, Doctor. I pass the witness. Oh, a little bit of homework. I move the admission of 132, which is stipulated, his CV.

JUDGE PATTERSON: That's 132?

MR. DYKEMA: 1-3-2.

JUDGE PATTERSON: Okay.

MR. DYKEMA: And once I've pulled out the slides that I didn't use, I'd offer 146, which is our demonstratives. And again, I offer them solely for demonstrative purposes to illuminate the transcript.

MR. PREDKO: Well, I guess I'm unclear, Counsel, as to which ones you used or not used at this point. I wasn't keeping track. I'm sorry.

MR. DYKEMA: I'm going to hand you a stack when you're done so I don't -- I mean, do you want to delay responding to this until I can do that and --

MR. PREDKO: Okay.

JUDGE PATTERSON: You want to take a break?

MR. PREDKO: Yeah, please.

JUDGE PATTERSON: Okay.

(Off the record)

MR. DYKEMA: Your Honor, I apologize for delaying things.

JUDGE PATTERSON: That's all right. No problem.

MR. PREDKO: Do we have our quorum?

JUDGE PATTERSON: Everybody's here.

MR. DYKEMA: I think we can make do.

MR. PREDKO: Good afternoon, Doctor. My name is --

JUDGE PATTERSON: Did we want to address the proffered exhibit?

MR. PREDKO: Sure.

MR. DYKEMA: Yes. The demos that I handed out, I used all but the last five.

JUDGE PATTERSON: Okay.

MR. DYKEMA: And so all but the last five through number 22, although you can't see the page number on that last one, I'm offering as Part 632, Petitioner's Exhibit 146, again, purely for demonstrative purposes.

MR. PREDKO: I do have an objection to -- and I don't know what page number it is, because there is none on it -- the one that I had an objection to before.

JUDGE PATTERSON: That we talked about previously.

MR. PREDKO: The study that I don't believe was included in the exhibits. Mr. Dykema was going to check.

MR. DYKEMA: I believe that is correct.

MR. PREDKO: Okay. It was not included in the exhibits. I haven't had time to review it. I do note that it involves a large amount of metals that are not present at this site. And the doctor has already testified that these sites were in Idaho, a different climate. I imagine the mines are different. I can get into that on cross-examination. But we would object to this coming in in substantive evidence, Your Honor.

MR. DYKEMA: It's not offered for that purpose.

MR. PREDKO: I'm not sure how else --

JUDGE PATTERSON: I've got some problems with it. I think I agree with Counsel that it's too remote. It's we really don't know where it is. That's why I asked about where the reference sites were. I just don't think there's a close enough relationship or commonality with what we're dealing with here. So I'm going to exclude that part of it. And I know your mother-in-law is not here, so you don't have to worry about it.

MR. DYKEMA: Your Honor, that's why I wanted to delay this discussion. Okay. Well, then, why don't I -- in light of that ruling, I will offer one through 21 as Exhibit 146.

MR. REICHEL: Your Honor, with that limitation and, again, with the understanding these are demonstrative

only, we have no objection.

JUDGE PATTERSON: Okay.

MR. PREDKO: Same here, yeah.

JUDGE PATTERSON: All right. It will be admitted as redacted, whatever it is. It's been a long day.

(Petitioner's Exhibit 632-146 received)

MR. PREDKO: Good afternoon, Doctor.

THE WITNESS: Good afternoon.

MR. PREDKO: And as I was starting to say, I'm Chris Predko, and I represent Kennecott Eagle Minerals Company.

CROSS-EXAMINATION

BY MR. PREDKO:

Q You were talking about a drop in groundwater or a reduction in groundwater discharge to a stream having certain effects upon a stream; right?

A Correct; yeah.

Q Okay. And some of those effects that you mentioned that I wrote down was a raise in temperature; right?

A During summer months or warm periods, yes.

Q Another potential effect was the raise -- a rise in acidity; correct?

A Of groundwater water table drawdown?

Q I thought that you said that.

A No; no.

Q "No"?
A Of just drawdown itself, less water? No.
Q "No"? Okay. Well, have you been out to the site?
A Yes.
Q When was the last time?
A Last -- I guess last summer, last -- or early fall.
Q Okay. And so you're familiar with the area that is right over the orebody, then?
A Yes.
Q I'm going to put a map up on the screen here, and this is part of the environmental impact assessment, and it's the delineation of wetlands, which seems to be my favorite exhibit. It's figure 3.4. And right around the area of number 6 there, would you agree with me, Doctor, that that's the area over the orebody?
A Appears to be, yes.
Q When you were out at the site, did you take a look at the condition of the area over the orebody and then some of the upstream areas?
A And I'll correct. I haven't been at that particular site in more like -- I guess more like two years, year and a half, something like that. I wasn't there last summer but the fall before it, but, yes.
Q Now, would you -- well, when you were there, did you see the beaver dam activity?

A Yes.
Q And would you agree with me that the beaver dams have had an effect upon the streams in those locations where they're at?
A Yes.
Q And one of the effects of beaver dams, as I understand it, is a rise in temperature of the water that is being held back by the dam; is that right?
A Yes, during summer months; yes.
Q Okay. I mean, did you see that when you were there in the area that I'm pointing to that's just west of the orebody and in the headwaters?
A Did I see the rise in temperatures?
Q No. Well, did you see the are affected by the beaver dam?
A I -- yes, I'm familiar with the area.
Q Would you agree with me that they're generally in that area?
A Yes, there are beavers in that area.
Q Okay. Right around the orebody?
A (No verbal response)
Q And that area of the orebody is affected by that; correct?
A Yes.
Q Now, would you agree with me generally that the -- another effect of the beaver dams would be a rise in the acidity of the waters there.
A It can occur.
Q Well, put it this way: Would you be surprised if the data

shows that those areas that are affected by the beaver dams are lower in pH than those areas of the stream that are not affected by the beaver dams?

A It depends on how much lower, but I wouldn't be surprised if that would be the pattern.

Q Now, the beaver dams, they may also have an effect on the population of macroinvertebrates; correct?

A They certainly would.

Q When you reviewed materials regarding this project, you talked about you did review the environmental impact assessment; correct?

A Yes.

Q And you had slides that you put up here -- that Mr. Dykema put up that we looked at that came from -- it was a study commissioned by the MDEQ, the limnological study?

A That's correct.

Q And that was part of the environmental impact assessment; right?

A (Nodding head in affirmative)

Q You know, then, that that particular study that was done -- the data that comes from that study was for times occurring in the year 2004; correct?

A Uh-huh; yes.

JUDGE PATTERSON: "Yes"?

A Yes; yes.

MR. PREDKO: I'm sorry.

Q Have you reviewed the other studies that Kennecott has commissioned after that time?

A I'm not sure what -- which ones you're referring to.

Q Any aquatic studies, any limnological post 2004?

A No, I don't recall seeing anything that looked like a GLEAS 51 study or something like that.

Q Safe to say that the studies that you reviewed were part of the environmental impact assessment appendices? Is that --

A That's -- I suppose that's safe to say. They're handed to me one by one, and, yes, I suggest that it's safe to say.

Q And you would agree with me that the general environment -- as an ecologist, I would think, that the general environment is ever-changing; correct?

A This is a fundamental tenet of evolutionary biology, yes.

Q Hard to get a baseline on something that's changing all the time; right?

A Depends on the rapidity of change. It's a baseline of -- from 2004 is going to tell us a lot about what's occurring in 2008 as well.

Q Well, and a baseline taken in 2007 might tell us a little bit more about what's happening in 2008, wouldn't it?

A It certainly could and may. It depends on the hydro regime of this year and that year and how they compare.

Q Would you be surprised if the temperatures that were

recorded in the area of the orebody were over the 18 degrees Celsius that you talked about caused stress -- thermal stress to trout?

A Well, no. The MDEQ report had many days in which the temperatures exceeded 18 degrees, so, no, I wouldn't be surprised.

Q Okay. And so you wouldn't be surprised, then, if trout are already avoiding the area near the mine -- correct? -- or the orebody; correct?

A Well, they would also be using it as a relatively warm water refuge than other times. But when water -- when the water gets really warm, they may avoid it. And 18 degrees doesn't make them leave, not necessarily, but it's suboptimal at -- when it gets more than that.

Q Well, I'm -- you know, Doctor, I'm looking at the exhibit that you prepared, and it seems to me to say some pretty serious stuff when you talk about mortality increasing above 18 degrees Celsius.

A That's right.

Q I mean, you're talking about death; right?

A Well, that's right. That temperature-related mortality increases at 18 degrees and above, but it's not a lethal line. You see the lethal line there.

Q So they would feel, I would think, some great amount of stress at temperatures above 18 degrees Celsius; right?

A I guess I wouldn't go as far as saying a great amount of stress at 18 degrees. It's where the data all combine to show that we're getting out of the comfort zone of brook trout there, but they certainly occur in waters that are up to 20 degrees commonly and so -- and even warmer so -- and they're healthy fish. And so I wouldn't say a great amount of stress for the living animals that -- no.

Q Would you agree with me that, if you have a change in temperature during the summer months, that a rise in temperature in those areas around the orebody either by beaver dams or water drawdown or a change in the groundwater discharge, that, as you move downstream away from the source, that that temperature change is going to dissipate?

A The beaver-dam-related temperature change will dissipate. The water-drawdown-related temperature change could be expected to continue as the aquifers -- continuous in that area, so I couldn't say that. But I could say that the beaver dam temperature effects don't affect the entire channel.

Q Well, it would certainly depend upon how broad a scope the drawdown was; correct?

A Correct.

Q And if the drawdown -- you know, hypothetically, if the drawdown was concentrated in the area of the orebody, you would agree with me that that -- any temperature rise would

dissipate as you move downstream; right?
A If the drawdown of the Salmon Trout River? Is that what we're talking about specifically?
Q That's what hypothetically you were talking about with Mr. Dykema. And I'm asking you --
A At -- in that area; if the drawdown is -- could you rephrase that? I --
Q If the drawdown for change in groundwater discharge is concentrated just to this area right around that number "6" that I'm talking about, that the temperature rise that you see in that area will dissipate as you move downstream.
A I guess you're asking me to accept a hypothetical that a large drawdown in a relatively small area is going to only be influenced at that one point, and this isn't how it would work, and so that hypothetical is too hypothetical perhaps.
Q Well, Doctor, you would agree with me, won't you, that, as you go downstream, there are certainly other groundwater seeps in this river, aren't there?
A There's -- you mean -- "groundwater seeps," you mean springs?
Q Springs.
A Those are streams in themselves so --
Q Well, there are other sources --
A They're part of the river system.
Q Right. There are other sources -- as you move -- let me

still down here. This where I'm pointing to over the orebody, you looked at that area; right?

A I've been there.

Q And you're making assumptions or you've seen in the data that there is groundwater contribution to that area of the river?

A Well, what I spoke to specifically is to the MDEQ data at sites 3 and 4, which are downstream from that area. When we talked about those, we didn't have a -- that. So we weren't talking about that site, which is upstream from what they called, I think, site 7 or in the vicinity. But we were talking about the northwestern road and the Triple A crossings and the groundwater contribution to the flow at those places, as indicated by discharge, stability and conductivity stability.

Q Okay. Where is that on this map? This is Triple A -- well --

A Where is your Triple A Road? Let's see.

Q I believe this is Triple A Road right here (indicating).

A So there and then --

Q Is it north?

A -- up there near the ceiling somewhere. Let's see. Where are we?

Q You're going to have to -- I don't know where --

A It's going to be hard to see the stream when not on the map,

so you could --

Q Okay. Well, wherever you are in the stream, whether it's at Triple A Road or back at the orebody, this is a groundwater-fed stream; correct?

A Correct.

Q And it's groundwater fed pretty much all the way downstream 'til it reaches the mountain; right?

A To some extent. There's certainly a variation in the degree of groundwater input as we move down that channel, and it hasn't been studied thoroughly enough to say specifically how much is contributing to stream flow as we move down but, in those areas that have been studied, yes.

Q Well, assume for me that it is groundwater fed throughout the stream.

A Well, there's groundwater coming in throughout the stream, so I'll --

Q And if you have a concentrated area where there's a change in that groundwater discharge to the stream, you said that there would be a change in temperature; correct?

A There's -- yes, that's correct, that the water -- groundwater drawdown could lead to a change in temperature.

Q And that change in temperature would dissipate as you move away from the source of the drawdown; correct?

A Well, not necessarily. It depends on the connectins of the aquifer. And you can get surprising results by putting in a

well at some distance from a stream. You can get surprising results some -- at a distance if there's water connectivity directly, and so we'd have to have -- I would have to have a clearer view of groundwater flow paths in that area to answer that question.

Q Okay. And you didn't do any of that kind of work while you were there, did you?

A No.

Q Do you know where the greatest drawdown is predicted?

A I've heard --

Q Well, either --

A -- possible places where the greatest drawdown is predicted. But again, I don't know where it's going to be, because I certainly don't know the structure of the aquifer in that region well enough, not has it been characterized.

Q Fair to say, based on your testimony so far, that you're not a hydrologist; correct?

A That's correct.

Q And that, when you work in the ecohydrology field, you do the ecology part, and a hydrologist does the hydrology part; right?

A That's correct.

Q When you looked at the -- well, did you look at the aquatic study that was included in the environmental impact assessment?

A Uh-huh; yes.
Q And I assume that you looked at the different species of fish that were found?
A Yes.
Q And I had another question, actually, too before I get to that. On your CV it seems like most of your experience and even aquatic species experience is with insects; is that fair?
A In the published papers in my CV? Is that what you're referring to? Yes, I think that's what you're referring to. But I have --
Q Well, your degrees, you have two in entomology; correct?
A Yes; yes. One's an ecology evolutionary biology degree through the entomology program at Michigan State, and the other one's a master's degree in entomology.
Q And your bachelor's degree is in biology?
A Is in biology.
Q Fair to say that you're more an insect or macroinvertebrate guy than a fish guy?
A The term "guy" would probably be -- put me into -- everybody who knows me would say, "That's a tossup." And my experience as a researcher includes lots of work with fish.
Q I'll rephrase the question.
A All right.
Q Fair to say that your expertise lies more in insects and

macroinvertebrates than it does with fish?
A That's fair to say.
Q But you did look at the aquatic surveys, and I assume you're familiar with fish species; correct?
A Yes; that's correct.
Q Now, of those species that were found in the surveys -- and I understand surveys were done of not only the Salmon Trout River in the area of the proposed mine but also in Cedar Creek and the Yellow Dog River. You remember that?
A Yes, and Big Pup Creek.
Q And Big Pup Creek. These are the species that I wrote down, and you can tell me if I've forgotten one, but I want to ask you a couple of questions about them. The black nose dace, you're familiar with that species?
A I know that species.
Q Now, is that a rare, threatened or endangered species?
A No.
Q Very common in Michigan?
A It's a common cold water fish.
Q The brook stickleback, that's not a rare or endangered species, is it?
A No.
Q Very common in Michigan?
A Common.
Q Brook trout, that's not a rare or endangered species in

Michigan, is it?

A No.

Q Also very common; correct?

A Yes.

Q The fine scale dace, another common species in Michigan?

A Yes; yes.

Q Northern redbelly dace, also common; correct?

A Yes. It's a regular part of the cold water fauna, I believe.

Q The pearl dace is another common fish species in Michigan; correct?

A I'm not as familiar with the pearl dace, but I've seen them. I don't know their distribution, but, yes.

Q How about the creek chub?

A Yes, very common.

Q And as far as brook trout go that are in the Salmon Trout River in this area of the proposed mine and in the Yellow Dog River that was surveyed, Big Pup River that was surveyed, Cedar Creek that was surveyed, those aren't coaster brook trout, are they?

A No.

Q And brook trout are not only common in Michigan, but they can't be restocked; correct?

A They're common in Michigan, and they can be stocked, and they've been stocked in all sorts of places.

Q And in fact, historically, when the brook trout population went down in Michigan, brook trout have been restocked all over the state, haven't they?
A Yes, all over North America, including places where they weren't native.
Q Now, the invertebrates that you mentioned that are in the area of the mine site, the mayflies, the caddisflies, stoneflies, none of those are rare or endangered species in Michigan, are they?
A There are no listed species within those orders that are rare and -- rare, threatened and on the Michigan list that I'm aware of.
Q And they're fairly common, aren't they?
A Well, as orders? There's lots of rare -- relatively rare species in all of those orders, yes.
Q Well, you looked at the environmental impact assessment?
A Yes.
Q And you looked at the survey that was done, and that listed macroinvertebrates on it; right?
A Identified to family, and you were discussing species.
Q Okay. Did you see any macroinvertebrates in the survey that were either rare, endangered or threatened in the State of Michigan?
A Again, the families do include in some cases special-concern species. And so when you look at a family name -- but I

could say for the orders that we just discussed that there are none listed and, thus, it makes sense to say that there are none of those species in those families, since they're not listed, would be considered threatened or have been no information to conclude that.

Q You talked about heavy metals having an effect on mayflies or -- I'm not sure if you said stoneflies.

A Stoneflies tend to be more tolerant than mayflies, so we did talk about both of them.

Q Did you do any research for your own study on the concentrations of metals that will come from the proposed mine?

A No.

Q When you reviewed materials, Doctor, did you review the mining permit?

A Yes, I reviewed it.

Q And so you're familiar, then, with Kennecott's responsibilities under that permit?

A I am.

Q And then you know that Kennecott is to monitor all wetland areas; correct?

A Yes.

Q And they're to monitor specifically for changes in the environment?

A Yes.

Q And they are to specifically monitor groundwater quality and elevation; correct?
A Correct.
Q And they are also to monitor groundwater surrounding what is called the TWIS; correct?
A Yes.
Q Are you familiar with that --
A Through testimony and brief, yes --
Q Okay. You sat through some of the --
A The treatment -- yes, I saw that. I was there.
Q And Kennecott is also required to monitor surface water of the streams; correct?
A Correct.
Q They're to monitor stream flow for changes; right?
A Discharge, correct.
Q Monitor water quality in the streams; right?
A Correct.
Q And that's to determine if there are any impacts; correct?
A Presumably, yes.
Q To protect the stream; right?
A To determine if there are any impacts.
Q Well, you understand that those are permit requirements that Kennecott must abide by; right?
A I understand that.
Q And when they monitor a certain change in the quality or a

certain change in the elevations, that there are certain actions that they have take. Do you understand that from reading the permit?

A Yes, but the specifics I didn't see, so it's -- the action -- when you say "protect," I don't necessarily see where that fits in the question.

Q You understand that they're also to monitor temperature of the stream?

A Yes.

Q That they must do this not only in the Salmon Trout, but they also must do it in the Cedar Creek and the Yellow Dog River? Do you remember that?

A That those three sites were going to be monitored continuously?

Q Yes; yes.

A I don't recall that but --

Q No reason to disagree with that?

A No reason to disagree with that.

MR. DYKEMA: Your Honor, I'll object to what seems to be a fairly extensive memory test. If he wants to talk about the permit, I ask that the witness be permitted to look at it.

MR. PREDKO: I think he's remembering quite well. I'm not, you know, browbeating him or tasking him.

MR. DYKEMA: I'm not accusing you of either. I

just --

JUDGE PATTERSON: Doctor, would you prefer to look at it, if that would help? Would that be -- do you have any more questions about it?

THE WITNESS: That's sort of my question.

MR. PREDKO: Three.

A Let's move on.

JUDGE PATTERSON: Okay.

Q Okay. Did you see the permit requirement that Kennecott must monitor and assess the fisheries and macroinvertebrate populations?

A I'd like to see that. I saw a version of that and, if I could see the most up-to-date version -- if I could.

(Counsel hands document to witness)

Q I'm looking at number 40 there.

A Yes.

Q Does that refresh your recollection as to the --

A Yes, that does. And it doesn't tell me enough to -- it doesn't tell me enough about what assessment and monitoring is in this context to let me know what's going to actually be done there. It just says "monitor and assess," and it also says it's going to do this once a year. That's -- that doesn't tell me anything. That could be a walk-by.

Q How about the next one? Do you recall that one?

A Yes. That's tissue sampling prior to --

Q I can't fit it all on there.

MR. DYKEMA: I have a hard copy. Do you want me to give it to him?

MR. PREDKO: Sure. That might be --

(Counsel hands document to witness)

A All right.

Q Page 25. And number 41 on page 25, Doctor, says that Kennecott is to take brook trout tissue samples, including liver samples, to collect them, analyze them, and that's to determine whether contaminants, metals or toxins are getting into the fish; correct?

A This is to determine the level of metals and toxins in the fish prior to mining activities, and it doesn't specify where these fish come from. So it doesn't tell me that much really. It looks like a baseline tissue metal --

Q Well, doesn't it say, Doctor, if you read down about four lines, "And subsequent samples shall be collected as part of the aquatic annual survey until ten years after closure"?

A Yes, it does; it does.

Q Okay. So that's a regular sampling that they have to do; right?

A It says "subsequent." It doesn't tell me --

Q Well, it says "as part of the aquatic annual survey."

A Okay. So they're going to do this once a year.

Q Right. And they're going to do it throughout the operation

of the mine, and as it says until ten years after it closed; right?

A Correct. Still the fish -- where the fish are coming from is still not clear to me, which of the many populations they're talking about testing.

Q Now, Dr. Strand, you testified you were a director of one of the Petitioners here, the Yellow Dog Watershed Preserve; correct?

A That's correct.

Q When did that term end for you?

A Last June, the end of June, I believe it was official so --

Q But when you were the director, you were --

A I was on the board of directors then.

Q You were on the board of directors?

A Yes.

Q You were a director; correct?

A Yeah; yeah.

Q When you were a director for the Yellow Dog Preserve, you actively objected to construction of this mine, didn't you?

A Could you be a little more specific about what I actively did --

Q Well, sure, Doctor. And what I'm looking at is a -- it's from a board of directors meeting, December 13th, 2006. And it looks like a resolution from the board along with this 520 members, they asked the State of Michigan to deny the

application of Kennecott Eagle Minerals in opening a sulfide mine under the Salmon Trout River. Do you recall that?

A I'd like to see the document, but I certainly recall --

Q Do you recall a resolution?

A Yes. I think there were more than one, and I'm not so sure if I was there for all of them. May I see that?

Q Sure. And if you look at the back page, --

A Yes; yup, I remember this.

Q -- you're listed as a director.

A Yup, I remember this.

Q And you were actively opposing the mine, weren't you?

A If that's the definition, yes.

Q You were opposing the mine; correct?

A I was opposing the mine.

Q Publicly?

A Yes.

Q And you also did so on the "Say no to sulfide mining on the Yellow Dog Plains petition;" do you recall that?

A That's the letter we referred to -- could I see that again?

Q Sure.

A Yes, I understand.

Q Okay. And in fact, Dr. Strand, if you look out of the people who have signed this, you're number three on the list; right?

A Oh. Okay. Yes, now I know; yes. That indicates when I

walked through the door, I suppose.

Q Now, Dr. Strand, Mr. Dykema asked you some questions to the effect of do you philosophically oppose the mine. Do you remember those questions?

A I remember him asking me whether I philosophically oppose mining.

Q And then he asked you questions about a letter that you signed or authorized?

A Yes, authorized.

Q In that letter he was talking about is dated December 16th, 2007, is it not?

MR. DYKEMA: For the record, can I have the exhibit number?

MR. PREDKO: It has not been made an exhibit yet, Counsel.

MR. DYKEMA: Is it identified as an exhibit?

MR. PREDKO: No.

Q We're waiting on technology which I thought was supposed to be faster than the old way but --

A Yeah. Well, I can say I can't testify to the date at which this was finalized as this was done as sort of a work in progress.

Q We'll get it right here. Okay. Here's the letter, Dr. Strand. Do you recall the letter?

A Yes, I recall the letter.

Q Okay. And as you testified here today, you authorized your name to be put on this letter and sent to the governor; correct?

A Correct.

Q And in this letter in the first paragraph, you say to Governor Granholm along with your colleagues,

> "We, the undersigned, urge you to reject the proposal to allow Kennecott Mining Company to create a nickel-sulfide mine in the Upper Peninsula of Michigan. Many of our colleagues have offered appropriate environmental reasons to reject the mining proposal. We appreciate those reasons here. We present additional reasoning for rejecting the mining proposal, reasoning that we believe has been underappreciated."

That's what it says; correct?

A Yeah, that's what it says.

Q And then further on in the letter, you talked about these reasons or reasoning that has been underappreciated.

> "First, many appreciate the various environmental costs that scientists tell us will or may occur if this mine were built. Despite well-appreciated complexities that that uncertainty brings to a decision-making process, uncertainty about the costs inevitably results in those costs being

discounted, at least to some extent. Sadly, this accounting overlooks an important dimension of the costs -- the dimension that transcends science and economics; namely, many Michiganders very simply and quite reasonably think that the proposed nickel-sulfide mine represents an inappropriate relationship with Michigan's natural environment. In the same way that human prostitution is not made right because it would create jobs or because psychologists debate what exactly are its effects on human health, the value of nickel-sulfide mining cannot be made right by scientific or economic arguments. In contrast to the science and the economics of nickel-sulfide mining, there is no uncertainty that many, perhaps most, Michiganders respect nature in a way that precludes nickel-sulfide mining. Manifesting their respect is to manifest our democratic principles."

Did I read that right, Doctor?

A You read it correctly.

Q Okay. Now, did you read the letter before you authorized your name to be put on it?

A Yeah, I read I think -- what was it? -- a draft of it, and I had trouble with some of the language including the language

that you cite there. Certainly about the transcending science for me, that's not my position. My opposition in this case was about the science. And for me, the -- I think what they're getting at for the relationship between humans and natural resources, in my view, is -- it doesn't transcend science; my appreciation doesn't. And certainly the, I think, poor phrase -- poorly worded phrase with the bad analogy to prostitution, it's not a well-written -- it doesn't directly characterize my views. So I guess I'm --

Q Well, did you send colleagues a note saying "take my name off that letter"?

A I did not.

Q In fact, you authorized them to put your name on the letter; right?

A That's correct.

Q And I assume that you haven't sent any sort of retraction to the governor saying, "Whoops, I don't agree with any of those paragraphs," have you?

A That's correct. I have not.

MR. PREDKO: Thank you, Doctor. I don't have anything further.

MR. REICHEL: Good afternoon, Dr. Strand. My name is Bob Reichel. I represent the Department of Environmental Quality. I'd like to follow up on a few things that were raised on cross-examination.

BY MR. REICHEL:

Q A number of questions -- you were asked a number of questions about potential impact of metals that might be associated or it's believed may be associated with the operation of the mine. And, I guess, many of the questions were phrased in general terms about metals generally, and I'm going back through my notes. I want to make sure I understand your testimony as to the particular concerns. My notes reflect -- hopefully this is accurate -- that at one point on direct examination when you were asked to identify metals of concern you identified copper, mercury, cadmium, zinc and nickel. Again, I'm just going by my notes. But let me read those again: copper, mercury, cadmium, zinc and nickel. Are those the particular metals of concern to you here or --

A Well, I think my testimony was that these are among the metals that are part of the orebody, --

Q Okay.

A -- and thus they are among the metals that are of concern to me.

Q All right. You haven't independently attempted to determine, have you, Dr. Strand, what concentration, if any, these particular compounds would be present at any particular location off the mine site as a result of the

mining activity, have you?
A No, I have not.
Q You were also asked some questions about the subject of bioaccumulation. In fact, you drew a conceptual diagram. It's still up on the notepad there. Again, I guess one thing I'd like to be clear on, is it your testimony that all the metals about which you've expressed concern here are equally bio- -- have an equal potential to bioaccumulate?
A No, that's not my testimony. That's not my --
Q In fact, that's not true. I mean, --
A That's not true.
Q -- as a matter of scientific fact, they differ?
A That's right. That's correct; yes.
Q So, for example, would you agree that mercury, that the potential and existence for bioaccumulation of mercury differs from that of some of the other metals that have been listed?
A It does and I indicated that as being one that's -- it's very different.
Q Okay. With respect to the other metals, putting aside mercury, --
A All right.
Q -- is it your testimony that the other metals that you've identified as being a concern are equally bioaccumulative or behave -- will bioaccumulate in the environment in exactly

the same way?

A No. And that's why I made the point of saying what we were talking about here were non-nutritive, nonessential elements; those that have -- are not metabolized and essentially accumulate. Maybe it was for simplicity of the model but, yes, they're non-nutrient metals, that there will be differences. And so that I didn't discuss any in specific --

Q No. I understand.

A Yeah.

Q I mean your testimony frankly it was on some level of generality.

A Yes.

Q I understand that. So this hypothetical or conceptual example you have behind you which you use to try to explain this --

A Yes.

Q -- just so I'm clear, which, if any, of the compounds of concern here do you believe this is relevant to?

A The numbers themselves are unitless, and thus this would work non-nutritive metals. This would certainly -- I would say that that general model could be looked at for mercury. That general model could be looked at for a variety of different compounds if they're non-nutritive and accumulate in tissues.

Q But just again so I'm clear, it's not your testimony that each and every one of the metals of concern that you refer to in the course of your direct examination, you're not testifying that they will necessarily bioaccumulate or move up the food chain in these -- with these orders of magnitude that you've hypothesize here?

A That's correct if I understand your question.

MR. EGGAN: Just a moment, please?

JUDGE PATTERSON: Sure.

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

REDIRECT EXAMINATION

BY MR. DYKEMA:

Q Am I right, Dr. Strand, that the December letter to Governor Granholm was signed by virtually every biology professor in the Upper Peninsula of Michigan?

A Many of the biology professors, yes; the majority in my department.

Q When you commented that or you responded to Brother Predko's question about the commonness of brook trout, just so the record is clear, you weren't referring to Coaster Brook Trout?

A That's correct.

Q They are not common?

A They are extraordinarily rare.

MR. DYKEMA: Your Honor, one piece of housekeeping that I neglected. I think for purposes of illuminating the transcript it would be worthwhile for me to mark Dr. Strand's drawing as Exhibit 147.

JUDGE PATTERSON: 147?

MR. DYKEMA: 147.

MR. PREDKO: Are you offering it?

MR. DYKEMA: Yes.

MR. PREDKO: As demonstrative?

MR. DYKEMA: As a demonstrative; that's right.

MR. PREDKO: No objection for demonstrative purposes.

MR. REICHEL: That would be my position as well.

JUDGE PATTERSON: Okay.

MR. DYKEMA: And I have no further questions.

JUDGE PATTERSON: Okay. Thank you.

(Petitioner's Exhibit 632-147 received)

(Hearing adjourned at 4:47 p.m.)

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