UNITED STATES DISTRICT COURT

DISTRICT OF MASSACHUSETTS

Civil Action
No. 82-1672-S

SKINNER, D. J.
and a Jury

ANNE ANDERSON, ET AL

V.

W. R. GRACE & CO., ET AL

Seventieth Day of Trial

APPEARANCES:

Schlichtmann, Conway & Crowley (by Jan Richard Schlichtmann, Esq., Kevin P. Conway, Esq., and William J. Crowley, III, Esq.) on behalf of the Plaintiffs.

Charles R. Nesson, Esquire, on behalf of the Plaintiffs.

Herlihy & O'Brien (by Thomas M. Kiley, Esq.) on behalf of the Plaintiffs.

Hale & Dorr (by Jerome P. Facher, Esq., Neil Jacobs, Esq., Donald R. Frederico, Esq., and Deborah P. Fawcett, Esq.) on behalf of Beatrice Foods.

Foley, Hoag & Eliot (by Michael B. Keating, Esq., Sandra Lynch, Esq., William Cheeseman, Esq., and Marc K. Temin, Esq.) on behalf of W. R. Grace & Co.

Courtroom No. 6
Federal Building
Boston, MA 02109
9:00 a.m., Friday
June 27, 1986

Marie L. Cloonan
Court Reporter
1690 U.S.P.O. & Courthouse
Boston, MA 02109

A
MC/jm

THE COURT: Good morning, ladies and gentlemen, your complaint has been reported to me, and I will get in touch with the supervisor of this floor of the cleaning staff.

At the close of court we were working with a formula which somehow or other --

MR. SCHLICHTMANN: Excuse me?

THE COURT: -- somehow or other didn't come out right.

MR. SCHLICHTMANN: Right.

THE COURT: I take it you are going to pursue this?

MR. SCHLICHTMANN: Yes.

THE COURT: The last time there was a wall of water ten feet high sweeping down the Aberjona Valley.

MR. SCHLICHTMANN: Yes, that is true, your Honor.

THE COURT: Either the formula was incorrect or the equation was improperly worked out or one of the figures is wrong.

MR. SCHLICHTMANN: Yes.

THE COURT: We have to find out which of those figures occurred.

MR. SCHLICHTMANN: All right.

THE COURT: One or more of the figures.

MR. SCHLICHTMANN: Exactly.

JOHN GUSWA, Resumed

Continuation of Cross-Examination by Mr. Schlichtmann

Q Dr. Guswa --

THE COURT: Unless there was, in fact, a wall of water ten feet high.

MR. SCHLICHTMANN: We will probably get a stipulation on that.

Q Just for the record, Doctor, put here in parentheses' this is the outflow formula.

A (Witness complied.)

Q Doctor Guswa, do you have a calculator today?

A Yes, I do.

Q I have, too, if you run out of batteries.

A It's not that I don't trust you, but they are sometimes complicated to figure out. I am familiar with mine.

Q Right.

Now, Dr. Guswa, this side of the equation, the outflow equation, should equal this side of the equation (indicating)?

A That's correct.

Q Now, we have put values in for each of the factors that go into the equation. Could you, for the jury, just do

the calculation for this side of the equation?
A Okay.
Q Maybe we could draw a line here and can do today's calculations.
A Should we put the date on?
Q Why not, that is a good idea.
A (Witness writing on the chalk.)
Q (Indicating)
A Oops, that must have been the day you came.
Three hundred thirty-three cubic feet per day.
Q All right.
In other words, when you do the calculation on this side of the equation, you come to a value of 333 cubic feet per day is not equal to 990 cubic feet per day?
A That's correct.
Q There is a problem with one of our values in the equation?
A Or the underlying assumption.
Q Let's stay with the equation, then we will do the underlying assumptions.
A Sure.
Q Each one of these factors in the equation has to do with a particular physical parameter in the field?
A That's correct.

Q Now, the 20 is the depth of the saturated zone on the southwestern side of the Grace plant?

A At G-3.

Q Yes.

And I asked you if that was the average saturated -- average depth of the saturated zone on the south and westerly side?

A I think that is a fair representation.

Q All right.

So when we go into the field and we measure the water level, we know it's 20, so we can't change that value, so that value we can be assured of we are correct because we checked it in the field?

A That's correct.

End A
MC/jm

Q Now, when we look at the next value, which is 600 feet, that is the width of the opening?

A Yes.

Q And there is not too much we can do about that. That is the width of the Grace property where the water is flowing through?

A Correct.

Q We can't change that value?

A Not significantly, no.

Q All right. Now, the gradient, that is also dependent upon the differences in the water table contours on the Grace site?

A Yes.

Q And Maslansky had figured it out, and you generally agree that is about right, the gradient is somewhere around there?

A Some parts of the property, that is correct. That number -- I am not sure Steve testified that is the average gradient. That was in his early report, March of '84. I am not sure he testified that is the actual gradient. I am sure we will go through the calculations, and I would like to have the opportunity to show what the gradient on the property is.

Q In his June, 1984 report, Mr. Maslansky did state, just so we are clear, it says that groundwater gradients to the south side were measured to, varied from .02 to .056?

A Correct.

Q Typical gradient along the flow lines to the Well Cluster 3.037?

A Okay. Now,the trench excavation area there, I believe in the pit area in the back of the property?

Q Yes.

A There are the wells installed as part of that report. We now have 31 wells on site. I think we will see that is not a fair representation today.

Q Well, do you have an opinion as to what is the appropriate gradient value to put in to this? Yesterday you accepted .037. Do you have another value to put in there that you think is better than---

A .04 to .1.

Q You can put .04 or .01 in there?

A No. .1.

Q .1?

A Yes.

Q Or .04?

Q Correct.

Q That is quite a variation.

Q That is correct.

Q So, yesterday you accepted this as average gradient. Do you want to change it today and have another average gradient for the opening the water is going through?

A Let's make it .07. I don't think .07 is the average gradient. I think this is the highlighting one of the problems with one-dimensionals. We look at site maps, we have steep gradients and thicker than 20 feet. At G-3 it is thinner. But what we are assuming here is a cross section goes off flow. We are also assuming there is no water going in the bedrock.

Q All right.

Q If we look at wells on the south side, we have downward flow. There is water going to the bedrock. A gallon a day, a gallon a minute. It would knock the 900 to about 600 cubic feet a day.

Q You have a question mark over the gradient?

A Yes.

Q Why don't we put a question mark here?

A Uh-huh.

Q But you have no doubt about this figure, the 620?

A Not as representative average values.

Q All right. Now, the other two values are the amount that, of water which you calculate going in the groundwater at the Grace site?

A That is the -- That is correct. Variable recharge.

Q Do you happen to have the calculation just so -- Here it is.

The way you calculated that was pretty straightforward. You said that the westerly side of the Grace property, which is going towards Wells G and H, is 600 by 600 feet?

A Yes.

Q Which means 360,000 feet?

A Yes.

Q You said out of 44 inches a year of rainfall, you came to the opinion that the 12 inches goes in the groundwater?

A Yes.

Q Now, 12 inches a year is one foot a year?

A Yes.

Q And if you have 360 thousand the rain is falling on and it is one foot deep, that is a cubic, you can make that -- take the 360,000 square feet and make it a cubic foot?

A Yes.

Q You are putting rain on top of it.

Now then, to find out what that is on a daily basis, you took 360,000 cubic feet per year and you translated it into gallons, is that right, it came to 2,700,000 gallons a year?

A Yes.

Q Divide that gallonage by 365 days and came to 7,400 gallons a day?

A Yes.

Q So this value you calculated, 7,400 gallons, 12 inches a year flowing out, you have no question about this figure?
A No.
Q So now, we have hydraulic gradient and we have the hydraulic conductivity?
A Yes.
Q Now, if, in fact, the gradient is correct, that is a correct gradient, then the only value that is going to have to be changed in this equation to make this equal this is your hydraulic conductivity?
A Yes.
Q Correct?
A Correct.
Q And what would be the hydraulic conductivity that would make the equation balance? Can you figure that out?
A I have everything else stays the same, the hydraulic conductivity would be 2.25 feet per day.
Q That would be three times?
A Three times 333 is about one third of 990, make this balance keeping all these others fixed, multiply that by three to .25.
Q Now, if in fact more water out of that 44 inches a year goes into the groundwater then, and all the other values are correct, you will have to increase the hydraulic conductivity even more, aren't you?

A If everything else stays the same, yes.
Q And you made an estimate that 12 inches out of the 44 inches goes into the groundwater?
A Yes.
Q But you are aware of the fact that the others who investigated the study area have come to the opinion that 14 inches, or most of 24 inches, is a, of the 44 inches, 20 inches is runoff?
A Correct.
Q Of the 24 inches, most of that goes into the groundwater. You are aware others have come to that conclusion?
A I know the statement in the report.
Q That is in the FIT report of the EPA?
A Yes.
Q If in fact 24 inches falls on the site, goes into groundwater, then this hydraulic conductivity is going to be doubled?
A Correct.
Q And if in fact you are wrong and water enters the site from the north, just so we are clear here---
If in fact water is coming down from the north onto the Grace site, all right, and---
A Just a minute. I assumed water was coming down when I drew the 600 by 600 square. The 600 -- I took the divide back here and did say water is coming in from off the site

based upon the recharge.

Q If in fact more water is coming in from the north---

A More than that.

Q ---than your area, then you figured that hydraulic conductivity had got to go greater than that; am I correct?

A If everything else stays the same, correct.

Q Now, our equation is not in balance. You agree with that?

A I am sorry?

Q Our equation---

A The two numbers don't agree.

Q You agree with that?

A Yes.

Q You agree that someing is wrong with one of these values?

A Or the assumptions.

Q Or the assumptions?

A Yes.

Q When you say "assumtions," you mean the assumption the values or the assumption behing the equation?

A Behind the gradients or the value itself, and the assumption no water is going in the bedrock.

Q Well, if water is going in the bedrock, you will agree that water can move very, very fast in the bedrock through cracks in the bedrock?

A If it is in the cracks, yes.

C
MC/jm

Q So if, in fact, water is moving into the bedrock, if more water -- if the saturated zone includes the bedrock and water is actually moving in the bedrock, then the K values, the ability of water to move through that bedrock could be very, very high; couldn't they?

A The K values will be low because the bedrock itself is a low conductivity. A long individual fracture, the movement may be fast. The conductivity of the bedrock is not high.

Q No. The bedrock is solid rock?

A Right.

Q So if you looked at the rock it has no hydraulic conductivity, nothing is getting through?

A Yes.

Q But a crack through the bedrock, that can make the water go very, very fast?

A That is correct.

Q The K value through that crack can be extremely high?

A The crack itself?

Q Yes.

A Yes.

Q As a matter of fact, between fine gravel, which has the highest hydraulic conductivity, and a crack in the bedrock, a crack in the bedrock can be even higher than it can be for the highest conductivity of unconsolidated soil, am I right, like fine gravel?

A If you look just inside the crack where there is nothing else but the crack, it would be very high conductivity.

Q It would be like free flowing water?

A Right.

Q So we've come down to the fact, then, there is either this value is wrong or the gradient is wrong?

A Or the assumption is wrong, the underlying assumptions.

Q Which one?

A There is no water going into the bedrock.

Q All right.

Have you calculated how much water is going into the bedrock?

A No.

Q So you don't have an opinion as to how much water is going into the bedrock?

A No. I have an opinion that water is going into the bedrock but not how much.

Q Do you have an opinion as to how fast that water is moving through the cracks in the bedrock?

A I don't know which direction the cracks are going in the bedrock, and I would not have an opinion as to how fast it is moving at any individual crack. It is still a

3

small volume of water, that is the whole thing we were talking about yesterday. Most of the water is in the unconsolidated material. Some gets into the bedrock.

Q All right.

Now, you can't assign a value, then, for the water in the bedrock?

A No. Value for volume or value for conductivity?

Q For the depth? Well, for the hydraulic conductivity. If water is going into the bedrock, it will change your hydraulic conductivity, won't it? Because if, in fact, water is going into the bedrock, you have to make a determination as to what the hydraulic conductivity is in those cracks to figure out how fast that water is moving?

A In our water analysis, which includes the bedrock in which we did the calibration, we have a representative conductivity for the bedrock.

Q You have one for the bedrock?

THE COURT: This formula, your height measurement is from the top of the bedrock, so if you are going to get the bedrock involved, you have to change that measurement, too.

THE WITNESS: That is what I'm saying, if we say there is no water going into the bedrock, then these height measurements are not correct.

4

Q Well, yesterday you agreed with me that the area that the groundwater is moving through is the saturated zone for the most part, you agreed with that?

A For the most part.

Q Well, we have to do another equation, wouldn't we, since we have one hydraulic conductivity for this area, we'd have to do another equation with a hydraulic conductivity for the bedrock?

A Yes.

Q And we have to figure out how much of that bedrock, how much of that opening is in the bedrock, is that right?

A Yes.

Q To be able to figure -- To take into account this other water that you don't know, you know, may be going into the bedrock?

A Yes.

Q Now, have you done that?

A The exact amount going into the bedrock?

Q Yes.

A No.

Q Did your model do that?

A Internally it probably has. I haven't extracted that.

Q You don't know what the figure is?

A In terms of volume, no. In terms of rate, no.

Q You don't know how much of this flow from the Grace site is going through cracks in the bedrock?

A No.

Q Now, when you gave us this value, this amount of water is coming from the Grace site, you were making a calculation of the amount of water whether it went through the unconsolidated zone or whether it went through the bedrock was actually leaving the Grace site and going over to Wells G and H, right?

A No, no. I was making a comparison of the amount of water that falls on the property and gets into the ground.

As a point of reference, it gets into the groundwater system. As a point of comparison saying how does this number compare to what pumps from G and H, not making any statement at all whether that water ever gets to G and H.

Q Wasn't that -- I just had it here. Here it is right here. All right.

If all the groundwater gets to G and H, this is the percent of contribution (indicating)?

A Yes.

Q You are now telling the jury, 7,400 gallons doesn't leave the Grace site and goes to Wells G and H, it is even a lesser figure? It is not even one half of one percent?

A It says if all Cryovac groundwater got to G and H,

6

one half of one percent. What gets into the bedrock, the groundwater flow in the bedrock are not well defined.

Q But regardless of whether it gets to G and H or not, it still has to get through that opening, doesn't it?

A The opening, meaning whatever zone it is flowing through, yes.

Q Yes.

It is going through the unconsolidated zone, and you say it is also flowing in the bedrock zone?

A Yes.

Q It has to move through that opening in the bedrock?

A Yes.

Q Well, what is the hydraulic conductivity of those cracks in the bedrock it has to move through, is it .75, the same as ground moraine, greater than ground moraine?

A It is less than ground moraine.

Q Less than ground moraine?

A Yes.

Q It moves slower through the cracks?

A Mr. Schlichtmann, the individual crack itself will have high hydraulic conductivity. The bulk conductivity for bedrock is slower. The vertical is likely to be larger than the horizontal because of the way the fractures are oriented.

Q So this hydraulic conductivity, then, for this opening that the water is flowing through on the Grace site, the 7,400 gallons that has to be even lower, this hydraulic conductivity has to be lower?

A I'm sorry, I misunderstood the question.

Q Let's be very, very clear.

A Yes.

Q There is no doubt in your mind that you have told the jury -- correct me if I'm wrong -- 7,400 gallons of groundwater leaves the Grace site and it goes through this opening, it goes through an opening in the property, right?

A It goes into the ground and is part of the groundwater system.

Q And flows off the Grace site at least right there at that point?

A Yes, sir.

Q Whether it goes to G and H or up north to National Polychemical --

A It is not going to go up north.

Q Well, wherever it goes it has to go past the opening?

A Yes.

Q Now, the opening has a certain width?

A Yes.

Q And the opening has a certain height?

A Yes.

Q Now, we could extend it down into the bedrock a foot?
A Yes.
Q But it still has to get through material, it either has to get through the ground moraine, which you said has a hydraulic conductivity of .75, at least part of it has to get through this one foot of bedrock and that has to have a hydraulic conductivity. Now, that hydraulic conductivity is either greater -- equal to this, it has to be greater than this, or it has to be less than this?
A Yes.
Q And correct me if I'm wrong. You have just stated at least that one foot is less, the hydraulic conductivity is less than the ground moraine, am I right about that?
A Yes.
Q That would then tend, if we are just looking at the height of the water table, that would make the water table above the Grace site --
A No.
Q If the hydraulic conductivity is even lower?
A What you said now is instead of having unconsolidated material as the flow material, you said the unconsolidated material plus one foot of bedrock?
Q Right.
A It is more than one foot of bedrock.
Q How many feet?

A There are wells that go 300 feet into bedrock that pump water out of the bedrock.

Q All right.

Well, do you think, then, the saturated zone of water is actually 300 feet into that bedrock?

A The bedrock is saturated to a depth of 300 feet.

Q All right.

A Saturated thicker than that. I think we are not on the right sync on the way to approach this problem. I will continue to listen to your questions and then hopefully get a chance to explain my position.

Q All right. Well, I'm trying to give you that opportunity, but why don't you just tell the jury, explain your position to the jury. Would you like to do it on a board?

A I would like a board and also the water table maps, the pre-pumping and the post-pumping, please.

MR. KEATING: Pre-pumping and post-pumping?

THE WITNESS: Yes, please.

End C
MC/jm

A The first thing I am going to do is draw some---

MR. KEATING: Do you want Dr. Guswa to say what he is doing?

MR. SCHLICHTMANN: Sure.

THE WITNESS: On the pre-pumping map, I am drawing two lines from which I will calculate hydraulic gradient on the Cryovac Plant. And I will label one pre-1 and the other pre-2, Line 1, Line 2.

For line pre-1, the difference is 15 feet in water elevation and the length of that line, the distance between those two points is one inch, which is 200 feet. So we have a 15-foot water level distance difference in the 100-foot spacing and that is a gradient of .075.

The second line, we actually have two wells that form the end of Line G-8, with elevation of 95.43. I will put that number up here.

And G-3, elevation 71.25. And the difference is 24.18 feet. And the distance between the two wells is about 590; we will call it 600 feet.

24.18 feet is the water level distance. Six hundred feet is the distance between those two points, and the gradient there is .04 with a few small numbers at the end.

On the post-pumping map, we take the same line near G-1 and I will call that post-1 and I will connect

G-8 and G-3 again and call that post-2.

Post-1, we have a 15-foot water level difference, 90 feet minus 75 feet. And the distance between those two is 180 feet.

Post-two, we will do the same calculation; 48.24 is the water level for G-8. 71.6 is the water level for G-3. 23.64 is the water level fiference, and there they are the same distance apart as the last time. So we will call it 23.64 divided by 600.

The post-1 gradient is .0833. Post-2 gradient is .039.

Now, this is sort of what we mean by sensitivity analysis, when we look at sensitivity results to the assumptions we made. So we look at Q pre-1, Q pre-2, Q post-1 and Q post-2.

We will assume the same hydraulic conductivity for all four and we will assume 600-foot length. And then for the pre-1, it turns out the bedrock is a little deeper here, about 25 feet, not that it is significantly different from Mr. Schlichtmann's number, but I want to show the range of numbers one can come up with. We use 18 feet for G-3, for this little S. And for the depth to bedrock below the water table is actually about 80 feet deep as Mr. Schlichtmann, I mean the thickness of the saturated zone.

Now, just put in the gradient. In this case we use .075. In this case we used .04. In this case we used .0833. And in this case .039.

This equals 844 cubic feet per day, the first one. The second one is 324 cubic feet per day. The third one is 937 cubic feet per day. And then the fourth one is 316 cubic feet per day.

Just doing this calculation, depending upon which number we chose, if we chose the steepest gradient and thickness, we get 844 to 940, if it all goes through the unconsolidated material. If we go down toward G-3 and use the gradient across the site there and the thickness of the zone there, we get numbers in the 300 range.

Now, we were looking at a cross section that was 600 feet long and 20 beet high. We were assuming all the water was coming out of that cross section. Now, we have wells on that cross section, G-3, G-11, G-12. Those all indicate water is going down into the bedrock.

Now, if we look at what is happening to that water, if we have a surface area on the plant, the plant and up to the divide, that is a 600-by-600-square-foot area. So we have water coming horizontally out of the plant from the rain and water going vertically down, not possible to quantify it. We have wells here. We could get a gradient. We don't know what the gradients are here,although they do vary across the area. We are talking about cross sectional area for downward flow from the precipitation, that is 30 times greater than the cross sectional area for the flow. So if we want equal amounts of water, if we were to assume equal amounts of water were going through each of these two sections. This conductivity would be about 1/30 of this conductivity. So I think this highlights to me, these are useful calculations to do some basic approximations. That is not how I do hydraulic conductivity. We ignored fundamental information. Water is moving down through the land surface into the bedrock through the unconsolidated material. That volume only had to be, would only have to be one. Actually, if we took the average of all these, let's just say that it comes out to about 600 cubic feet per day. Let me check that.

Yes, 605 cubic feet per day. If you take the average of that and if 600 cubic feet per day is coming across the property, then all of these elevations, these thicknesses, would be in balance between the elevation of the bedrock and the elevation of the water table. So to get our equation in balance, we have to figure out where is that other 390 cubic feet per day going? The 390 -- let's see, 390 cubic feet per day versus 990 cubic feet per day is .39 or 39 percent. Now, that number was also five gallons a minute, I believe. 7,400 cubic feet per day is the same as five gallons per minute.

I'm going to mark that A, because that is where we went first, and this is B, that is where we went second, and this is sort of C, where we went third, and now D, where we are now, 7,400 cubic feet per day is equal to five gallons per minute. And if I multiply that by .39, five gallons per minute times .39 equals 1.96 gallons per minute, and that's equal to -- Now, how am I going to do this here? What I want to see is how much across this 600 by 600 square foot area would that be. In other words, if 1.96 gallons per minute is going down into the ground vertically through the bedrock, how thick, how much water is going in uniformly through that, if it were going through uniformly, which it's not, but that is the hazard of the sample assumption.

So we have 1.96 gallons per minute. 7.48 divided -- that is .26 cubic feet per minute, and that's -- if you multiple that by 1,440 minutes in a day, that is 379 cubic feet per day. I guess we can get that from here. 379 cubic feet per day going down into the bedrock.

Now, if the bedrock is 600 feet by 600 feet, that means we've got a height of water -- so let's see -- I will divide that by 600 times 600, and I'm going to get a height of water of .001 feet. I multiple that by 12, so we have .01 inches, a column of water, lake of water, if you will, .01 inches high on top of the bedrock getting into the ground. I think that is a reasonable number to expect to get into the bedrock. That would make the whole equation balance at the 990.

Q Now, if, in fact, water reaches the bedrock, it actually is going to get into the bedrock, right?

A Yes.

Q If, in fact, the cracks in that bedrock are going in the direction of the groundwater flow as shown on your arrow --

A Yes.

Q -- will you agree with me that the speed of that water in that bedrock, those bedrock cracks, if they follow your groundwater flow means that water that moves through those

3

cracks can move a lot faster than the water that is trying to get through the ground moraine, what you have called the ground moraine and the unconsolidated layer, am I right about that?

A The water that moves through the rocks, in this case that comes from the Cryovac plant, was 1.96 gallons per minute. Now, that will move into the rock, and it will move faster through the cracks than it will through the other part of the rock, as long as the cracks are open.

Q Yes.

A Depending upon which way the cracks are oriented. We have no way of knowing which way the water is going in that rock.

Q But you have calculated that the groundwater flow is in the direction that is indicated in your exhibit?

A That is for the unconsolidated material.

Q I understand.

Have you made any calculations or any determinations as to where the groundwater flows in that bedrock, that lake underneath the unconsolidated material?

A The concept that underlying it, the water table map is based on an assumption of equivalent porous media, porous material. The actual movement of water in a fractured rock is not controlled by the right angle rule that we apply to the water table map contours. Because the flow direction is actually constrained by the actual orientation and position of the cracks. The concept of water table maps and the concept of right angles at water table maps is not appropriate and not valid for bedrock.

Q But you will agree with me here, Dr. Guswa, that if you have bedrock which is higher here and lower here --

A Yes.

Q -- and the whole bedrock is fractured, it has cracks from high to the low --

A Yes.

Q -- that the water is going to move through those cracks from a high elevation to a low elevation, am I right about that?

A The water will have a driving force to go that way, but I have spent the last six years working in fractured rocks in Upstate New York, and I will tell you it does not flow directly from the high to the low because if those fractures or cracks are not aligned directly to that but, in fact, are like this or at an angle, that water will have a tendency to move that way, but it hits the wall and goes parallel to the fracture (indicating). That is the direction it goes. It doesn't go at right angles to a contour that we draw.

Q You have never made a determination as to how the fractures are going in the bedrock, have you?

A No, I haven't.

Q Everything leads us to believe from what we know from nature if there are cracks in the bedrock, they are going to go in every which way?

A No, that is not true at all.

Q You have not made such a determination?

A No, I haven't.

Q You have no basis to tell this jury where those cracks go?

A That is correct.

MR. SCHLICHTMANN: Why don't we have this marked as P-909.

Q Now, Dr. Guswa, yesterday when we went through the formula and we constructed the area that the water goes through, you agreed that that area would be 600 by 20 feet, is that right?

A I read through the transcript last night, Mr. Schlichtmann, and I believe I said the flow of the water is in the unconsolidated material and the bedrock, and then I agreed to use your assumption that the flow was only in the unconsolidated material.

Q Yes.

And the flow in that bedrock is still going to have a hydraulic conductivity if you keep it at .75, it is not going to change any of those calculations that we did yesterday, am I right?

A Mr. Schlichtmann, if I -- Yes, it would change the numbers.

Q Well, it would keep the same hydraulic conductivity --

A Yes.

Q -- but increase the opening by a foot to take care of the bedrock?

A Mr. Schlichtmann, you may have to increase the opening by 300 feet to take care of the bedrock.

Q Well, didn't you just tell the jury how deep you think that water goes into the bedrock?

A No. I told them of all the water that falls in the ground, if 39 percent of that water moves down into the bedrock, that's the same as .01 feet -- no, .01 inches of water lying on the bedrock surface and filtering down into bedrock that may filter down for 50 feet, 100 feet, for 1,000 feet.

Q And would that then -- would that mean less than 7,400 gallons of water leaves the Grace site every day?

A No, 7,400 leaves the Grace site. It falls on the Grace site, goes into the unconsolidated material, goes into the bedrock, some goes into the unconsolidated material, some goes down into the bedrock, all leaves the ground site.

Q Part of that 7,400 actually went straight down, it didn't leave by going off in a southwesterly direction, is that right, or it did?

A No, that is exactly correct. It does leave vertically down into the bedrock. The direction from then on is undetermined.

Q At what point when it goes down does it leave the Grace site? Where does the Grace site end vertically?

A That seems to me a matter of mineral rights or something else that I'm not familiar with.

THE COURT: The point is, the bedrock, I take it, has a saturation point, it will only hold so much water?

THE WITNESS: That's correct.

THE COURT: So if this water is coming in, whatever amount you say on a daily basis, the same amount is leaving the bedrock?

THE WITNESS: That's correct.

THE COURT: But you don't know where it's going?

THE WITNESS: No, sir.

THE COURT: Okay.

So we have a flow through the bedrock coming in from the Grace site from the top of the bedrock and going in --

THE WITNESS: It is going down.

THE COURT: -- going down and eventually out?

THE WITNESS: Well, going down and picking up a lateral component in some direction, it is going off the property, but --

THE COURT: You don't know what the lateral component is?

THE WITNESS: No, that is correct. And don't know how thick of a vertical section it is moving through.

Q (By Mr. Schlichtmann) And, Dr. Guswa, have chemicals -- have contaminants at the Grace site been detected in deep bedrock?

A Yes.

Q At GW3?

A Yes.

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(Ambulance noise.)

(Pause.)

THE COURT: I am surprised to find any of the city left when I leave the Courtroom.

Okay.

Q And so we detect -- in the Grace wells we find contamination on the southwesterly side of the Grace site in the unconsolidated as well as in the deep bedrock, part of the bedrock?

A That is right.

Q And when we sampled wells in a southwesterly direction from the Grace site, going towards Wells G and H, we also detected contaminants in the bedrock?

A I am not sure the characteristics of the material are the same. Let me get my summary sheet.

You have a particular well you are referring to?

Q How about GW-1, deep bedrock?

A Yes.

Q GW-1?

A Yes.

Q Contaminants in it?

A Yes.

Q And in the deep bedrock?

A Yes.

Q And just so the jury knows what we are talking about, GW-1 is Grace's off-site Well No. 1?

A That is right.

Q And that was put in by W.R. Grace?

A Mr. Maslansky.

Q That is located right here near S-21?

A It is a little -- No, the north and west of S-21.

Q So we are clear, I don't think it is necessary to come up, but if you wish to, on your cross section, that would be underneath the Cummings building, if we interpolate that the Cummings industrial area, and into the bedrock right near S-21?

A Yes.

Q And G-3 would be where the blue dot is? That is what you did yesterday.

A The blue dot with the water above the land surface?

Q Yes.

A Yes.

Q Now, Dr. Guswa, you made some calculations to the jury concerning the travel time of contaminants; do you recall that?

A Yes.

Q And you are familiar with the formula for making those calculations?

A Which one?

Q Well, is there a formula for determining how fast a particular contaminant moves through a particular type of media, coarse media? Is there such a mathematical formula?
A There is one-dimensional, two-dimensional, and three-dimensional.
Q Are you familiar with any of them?
A Yes. Some more familiar than others.
Q Now, when a, one of the things you know when a -- What is the water velocity, how fast is water moving through the system?
A Yes.
Q Volatile organics, the ones we are talking about, don't move as fast as water?
A Correct.
Q The reason they don't move as fast as water is that they have an infinity for particles?
A They prefer, have a tendency to absorb to the particles.
Q That absorption tendency, that is the stickiness, the stickiness potential? It sticks to the particles it passes through?
A Yes.
Q It is being borne by water molecules, this chlorinated TCE, and as it passes a solid particle it tends to stick to the particle and leave the water?
A Correct.

Q Not all of it does?

A No.

Q Just a certain percentage?

A Yes.

Q And that is why this retardation factor is really the slowness of the chemical in relationship to the water?

A That is correct.

Q Now, you have a retardation factor of 3.8 TCE?

A Yes.

Q And---

A Excuse me, that was representative of the low range for TCE.

Q Low range?

A There is no single value for a chemical.

Q Now, what did the 3.8, how was that related to the speed of water?

A That means that the velocity of the chemical -- Let me do it the other way. If you take a velocity of the water and divide by 3.8, you get the velocity of the chemical.

Q So, correct me if I am wrong, the 3.8 means TCE moves 3.8 times slower than the velocity of the water?

A That is right.

Q Are there other physical factors working on chemical transport other than velocity and the stickiness of the chemical as it is passing through the media?

A Physical forces?

Q Yes.

A There would be dispersion.

Q Dispersion is another force?

A It is a phenomenon, yes.

Q Now, you don't know, you don't know the magnitude of dispersion; is that right?

A The magnitude is a reflection of the general direction of velocity or uncertainty in the velocity direction field. That is a lousy technical jargon term, but it is a measure of the mixing. If you, you may remember the skier or the science museum experiments. That represents the process of dispersion. It is generally not well known, because it is being measured in the laboratory and being measured in the field, and the numbers don't exactly agree.

Q And you are familiar with some of the people doing research in the area of dispersion?

A Some of them.

Q Who are they?

A There ia a group of people doing that work at the Waterloo, University of Waterloo, John Cherry; a group working at Stanford in conjunction with John Cherry who is a project -- they are doing field determination of dispersivity, dispersivity is the term which Lynn Garfield of MIT is looking at some of the statistical aspects of dispersion.

There are, I am sure there are others I can pull out some reference book if you need more names.

Q Well, you are familiar with your book, groundwater?

A Oh, yes.

Q With Freeze and Cherry?

A Yes.

Q And they have a section on dispersion; is that right?

A Yeah.

Q You have a copy of the book?

A Yes.

Q All right.

Page 399, actually the section starts on 397, but Page 400, they discuss some of the people doing work in the field on dispersion and some of the results of their studies; is that right, Page 400, third paragraph?

A Yes.

Q Who are those people?

MR. KEATING: Could I take a look at this? Do you mind if I look over his shoulder?

MR. SCHLICHTMANN: Why don't you look over Dr. Guswa's shoulder.

MR. KEATING: Which paragraph?

MR. SCHLICHTMANN: Third paragraph down.

Q Who are those people?

MR. KEATING: Just let me take a look at it.

I am sorry, excuse me. It is the old prblem, your Honor. I object to it.

THE COURT: Overruled.

A The reference is to Pinder, 1973, Konikow and Bredehoeft, 1974, and Robertson, 1974. All those people are actually, I don't know, Konikow and Bredenhoeft were doing the work for the Geological Survey.

Q Dr. Pinder was, too?

A I don't know in 1973 if he was or not or if it was consultant work. It is the Long Island study. I don't know if he did it at Princeton.

Q You are familiar with the study?

A Yes.

Q Now, you haven't done any work in the field of dispersion?

A In terms of designing experiments, I did it in the same way that these people have. I used dispersion in mathematical simulation model. That is all it says here. That is all they did. These are values at longitudinal dispersivity as large as 100 meters and lateral dispersivity values as large as 50 meters have been used in mathematical simulation sutdies of the migration of large contaminant plumes in sandy aquifers.

I will tell you now, I know in 1973 Dr. Pinder did not measure dispersion. It was the parameter in his model. I will tell you the other two do it the exact same way that I used values; they did not make dispersion measures. Jack Robertson, in the facility of the Idaho Nuclear Test Facility did the exact same thing. He used range of values. He did not make measurements. If you want to use measurements you can go to Walton.

Q Page 104, don't they discuss the fact that Dr. Pinder and others use numerical models and simulations to make determinations of dispersivity?

MR. KEATING: I object. I think you know the grounds.

THE COURT: Yes. I overrule it.

MR. KEATING: Can I look over his shoulder?

THE COURT: Sure.

(Pause.)

MR. KEATING: Is there a question? I can read this while he answers the question.

MR. SCHLICHTMANN: I think he answered the question.

A No, I haven't. What was the question?

Q On Page 104, did they discuss the fact that Dr. Pinder and others have published in the field of use of numerical models and simulations, making determinations of dispersivity, is that what they are discussing there?

A Wait a minute.

That is not what that says.

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MC/jm

Q Well, what does it say?
A It says, "Other numerical models have been developed by Reddell and Sunada, Bredehoeft and Pinder, Pinder, and Schwartz."
Then it goes on, "The simulations presented in 9.10," but that is after two individuals, Pickens and Lennox, it has nothing to do with Pinder, Pinder and Bredehoeft, or Sunada.
Q What is Pinder doing in there?
MR. KEATING: I object, your Honor. That is a good question.
THE COURT: It is a good question, but I think we have to have the author of the book.
The objection is sustained.
Q I will let him know he doesn't belong there.
Now, when we are trying to determine how fast a contaminant moves through a porous media, we can't be concerned just with the average flow of the contaminant but the porous media, can we?
A That's correct.
Q Because in any porous media in the field in life, the hydraulic conductivity, you can figure out averages for an area but there are things known as heterogeneties, right?
A Corect.

Q Heterogeneity is the fact that a natural formation for different factors is going to have different hydraulic conductivities at different layers and at different places in that formation?

A That's right.

Q Because of that -- One of the reasons is because just the percent of one particular type of material like sand and another particular material like silt or another particular material like gravel, just the percent that mixed together can have an effect on hydraulic conductivity, water moving through there; is that right?

A I hate to ask that, but could you read it back?

Q Let me say it again. There is no reason to have it read back.

Isn't it true that hydraulic conductivity contrasts as large as an order of magnitude or more can occur as a result of almost unrecognizable variations in grain size characteristics? For example, a change of silt or clay content, of only a few percent in a sandy zone, can have a large effect on the hydraulic conductivity. Would you agree with that statement?

A I would agree with that statement.

Q And these differences in a heterogeneous mixture of material are ubiquitous and widespread?

A Yes.

Q Now, at the Grace site, the Grace site isn't one lump of homogeneous material, is it?
A That is correct.
Q The Grace site is a lump of heterogeneous material?
A Yes.
Q In fact, Mr. Maslansky has described it as not a lump but as a formation that is heterogeneous not homogeneous?
A Yes.
Q You would describe it as a formation that is heterogeneous, not homogeneous?
A Yes.
Q You would agree in your science there are very few physical parameters which can have as wide a variation of orders of magnitude than hydraulic conductivity?
A Could you read that one, again?
Q Let me try it again.
A It sounds like we are getting very technical. I would like to hear it.

(Question read.)

A I think that is a fair statement.
Q And, in fact, Dr. Freeze and Cherry discussed this very topic in the book, hydraulic conductivity can have 13 orders of magnitude differences?
A Yes.

Q That is a tremendous amount, isn't it?
A Thirteen orders for the total ranges of materials that exist in the world.
Q Exactly.
Now, when you are trying to determine contaminant flow, you have to take into account that not only the average flow of water through a system but the fact that the water also is going to go in the path of least resistance and some part of that water is going to move very fast in those small scale heterogeneities where the hydraulic conductivity is much greater than in other areas?
A It is not exactly that simple, but that is a fair representation.
Q And that concept of the movement of water at different speed through a heterogeneous material and the fact that contaminants are going to follow not only the average but they are also going to be following along with the water in those small scale heterogeneities, that fact is called fingering; isn't it?
A Yes.
Q And the reason it is called fingering, I can probably -- (Mr. Schlichtmann looks through the charts.)
A I think it is up front.
Q Yes, the one from the textbook.

5

A I think yesterday it was down toward the left-hand side.

MR. KEATING: Is this one of ours, Mr. Schlichtmann?

MR. SCHLICHTMANN: No, it is one of mine.

(Mr. Schlichtmann looking through the chalks.)

Q Here we are. You can see that from here?

A Yes, I am familiar with it.

Q That is an example of the fingering effect?

A Yes.

Q All right.

Let me just show that to the jury. It is not necessary for you to come up if you don't want to. That is average flow. Do you have the page?

A I will find it.

Q 398.

A Actually, I think I will come up, just to protect my interest here.

398, you say?

Q Yes.

The top diagram is average flow of a contaminant through a porous media, is that right?

A Yes.

Q And the next one shows the fingering effect?

A Yes.

6

Q And so does the next one?
A Yes.
Q And this fingering effect, these Ks mean there are different hydraulic conductivities in this porous media?
A Yes.
Q And because there are these small scale heterogeneities with different conductivity, you are going to have different movements?
A Yes.
Q That is very good. That is all I wanted to point out. Could we have that marked just for the record, P-910.
Now, on the Grace site, in doing your test and Mr. Maslansky doing his test, he found a wide range between permeability at different places on the site, hydraulic conductivity?
A I think his range was about .01 to maybe 10 feet per day.
Q Right. When it goes to K values, that range went from, I think, .3, K values, now, up to 46 feet a day?
A Oh, from the slug test data?
Q Yes.
A Yes. That is the same thing, permeability. So the slug tests were .3 to 46, and the other analysis on the grain size and such was .21 up to 46.
Q That is a tremendous range,isn't it?

A That is a normal range.
Q Well, it is a normally large range. You expect to find that in the field?
A Yes.
Q A tremendous range like that?
A Yes.
Q And there is -- and that's an indication to you, as a scientist, that on this formation, which is heterogeneous, there can be wide variations in the hydraulic conductivity in that formation?
A Yes.
Q And the only way you can determine where exactly they are is you've got to drill a well down and you've got to do a test in that area, either a slug test or pump test, to determine what is that hydraulic conductivity right in that area?
A Yes.
Q And if you drill another well right into that area and you do another test because of this heterogeneity, small scale heterogeneities and the effect the K values -- you can do another well test and that K value can be different than the other K value; isn't it?
A Yes.
Q In fact, Mr. Maslandky encountered that when he did his test on the Grace site?

A Yes.

Q Those can be wide ranges?

A That is why he did so many tests, yes.

Q He didn't put wells every square foot of that site, did he?

A It seemed that way, but, no, he didn't.

Q Now, getting back to chemical transport. You made a calculation about the travel time of TCE?

A Yes.

Q And would you just tell us, you made -- What were the elements of that calculation? You made a calculation about retardation?

A Yes.

Q You made a calculation about dispersion?

A Dispersivity, yes.

Q And you made a calculation about water velocity?

A Yes.

Q And you put that altogether and came to a travel time of TCE, am I right?

A Came to a -- Yes, a travel time or a distance it would have traveled in a certain amount of time.

Q All right.

And how far, TCE, according to your calculations, with a retardation factor of 3.8, do you know what the dispersion coefficient was, do you know that?

A Seventy feet.

Q Do you know what the dispersion coefficient that Dr. Pinder used was?

A I think maybe it was 50, I'm not sure.

Q Now, so you did that and you calculated that TCE travels in 11 years 750 feet; am I right, isn't that what you said?

A Let me get the illustration out just to -- I'm sure you wouldn't misrepresent it, but I just want to check.

Q No, I wouldn't do that.

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MC/jm

A I wrote it down on one chart.

MR. KEATING: Do you want him to have the chart?

MR. SCHLICHTMANN: If he wishes. Maybe he has the value.

(Pause.)

A I wrote up on the upper right-hand corner for all three. I am trying to remember which exhibit I wrote it on.

THE COURT: I made a note on that. Do you want to rely on it?

THE WITNESS: Sure.

THE COURT: My notes say TEC was 750 feet in 11 years, a thousand feet in 19 years, and 1,100 feet in 25 years.

THE WITNESS: That is it, yes.

Q I am sorry, what was that, 750 feet?

A Seven hundred fifty.

THE COURT: In 11 years, a thousand feet in 25 years, 19 years rather and 1,100 feet in 25 years.

Q What did you use as your gradient for that area?

A The gradient was based upon the calibration of the groundwater flow model, so it was gradient that existed in November of 1985, and it would be at varied, different gradients over different segments of the travel path.

Q Do you know what the average was?

A Well, the average would probably have been -- I don't know how to average something that averages spacially. It curves like this. It is steep at Cryovac and steep east and flattens out again. I am not sure average is the appropriate way to look at it.

Q Didn't Mr. Maslansky average, give a value for the gradient from the trench area right behind the Grace building to the southwestern boundary of the Grace site. Didn't he do that in his report?

A That is what he did, yes.

Q Did you accept that. You don't accept that value, .073.

MR. KEATING: It is not a question whether he accepts it. He said to average his own value---

MR. SCHLICHTMANN: Is there an objection?

MR. KEATING: There is an objection.

THE COURT: Sustained.

Q Well, is Mr. Maslansky's average gradient an acceptable figure for you for the area that Mr. Maslansky discussed in his report?

A No. I think what we went through this morning shows you that, the sort of variation. The averages are useful for some application. We were subdividing the area into small blocks, each of which block had its own gradient, depending upon the hydraulic conductivity and water level. The ultimate gradient results from the flow calibration.

It is---

Q Do you know -- You don't know what the average gradient is?

A I am saying the average gradient is not an appropriate way to do our travel time calculation because we are looking at travel in very small segments which are governed by the permeability of the material in that segment as well as the gradient in that segment.

Q How about the porosity? Mr. Maslansky used .15. Do you accept that?

A .15? We have used .15 as the porosity. We used .25 for the bedrock and ~~.03~~ 0.30 for the sensitivity analysis. We used a whole range of porosity values.

Q Now, there is a formula to determine water velosity, the actual water velocity through a porous media; is that right?

A Yes.

Q And that is a formula too?

A Yes.

Q And that is velocity equals hydraulic conductivity times gradient, divided by porosity?

A Yes.

Q And that is used in your profession to determine water velocity through a coarse media?

A Subject to the same limitations any simple back-of-the-envelope calculation is subject to, yes.

Q Well, if you use that formula, you are talking about averages over an area, are you not?
A Yes.
Q Now, if you use that formula and you accept the value of hydraulic conductivity of .75 and you multiply that times the average gradient that Mr. Maslansky used in his report---
A Okay.
Q ---for that area of the aquifer---
A .037.
Q .037?
A Yes.
Q And that equals a number, right?
A Yeah.
Q What is that number?
A You will have to wait for me for a minute.
Q All right.
.02775.
Q And then you divide that by porosity?
A Yes.
Q And that, if you accept Mr. Maslansy's figure of average porosity of .15, you come to a figure of what?
A .18 feet per day.
Q And that is how fast the water would move on a daily basis. If you multiply by 365, how many feet is that?
A Sixty-seven feet, now -- yes, 67 feet per year.

Q And if we multiply that by 11 years, how far does water move?

MR. KEATING: Under that formula?

THE COURT: Under that formula?

MR. KEATING: Not in his opinion?

MR. SCHLICHTMANN: Yes.

THE COURT: Adopting Maslansky's---

MR. SCHLICHTMANN: Average figures.

THE COURT: Which -- This?

MR. KEATING: That was average for a very small period of part of this area.

THE COURT: I understand. That is what this figure is. We know it is subject to all these limitations.

MR. SCHLICHTMANN: Yes.

THE COURT: You want 67 times 11?

A Seven hundred forty-two.

Q Feet?

A Seven hundred forty-two feet in 11 years.

Q Could you come up here to the jury?

A Wait a minute.

MR. FACHER: Six hundred thirty-seven, not 737.

THE WITNESS: I will do it again.

Seven hundred thrity-seven. My battery light is on here. Seven hundred thirty-seven feet in 11 years.

(Pause.)

Q You better do it again. I have a little different number. I want to be exact.

A Seven hundred thirty-seven.

Q No, I have 742.77.

A That is what I got the first time.

(Pause.)

THE WITNESS: .185 feet per day. 67.3 feet per year times -- 743 feet in 11 years.

Q All right.

Now, would you show the jury on this cross section, if we use the flow -- Mr. Maslansky, in making his averages, used the area of the Cryovac site which goes down to here; is that right?

A Just quickly, let's look at the -- We have the same problem. The building is discussed in this. The building actually looks like this. So let's -- That is the one.

Yes, from about, I think, about from here.

Q Yes.

His average gradient went from there to GW-3; is that right?

A Yes.

Q And his porosity covered the same area?

A Yes.

Q And how many feet is that approximately? You can use your scale.

A I am going to figure how to translate it.

Q Do you need a ruler?

A I have one in my briefcase.

Five hundred Fifty feet.

Q So Mr. Maslansky's average is taking place over this particular area, is 550 feet. What is the distance between GW-3 and S-21?

A Four hundred and seventy-five feet.

Q So what is the distance between here and S-21, approximately?

A I want to make sure I add these up together.

One thousand twenty-five feet.

Q So if we use Mr. Maslansky's figures in this equation, the water from the back of the Grace plant won't have gotten much past, would not have gotten much past Washington Street in 11 years; is that right?

A That is correct.

Q And the values of the speed of water, using hydraulic conductivity of .75 and using Mr. Maslansky's average figures for that area, is going to equal what you say is the travel time for the TCE, approximately 750 feet in 11 years?

A Run that by me again.

MR. KEATING: I can't hear you.

THE WITNESS: Could I have the question

read back?

(Question read.)

THE WITNESS: Okay. If -- Could you rephrase that question, please. Smaller subsets.

Q All right.

A I am trying to anticipate where you are going, which I should not do.

Q Don't anticipate.

THE COURT: Answer one question at a time, Doctor.

THE WITNESS: Right.

Q Sometimes I don't know where I am going. So we will stick to where we are.

A Yes.

Q If we use this formula, Darcy's basic formula of water velocity speed, and use Mr. Maslansky's average figures for that area as we reported, as he reported in his report---

A The water moves 740 feet.

Q In 11 years.

And that equals approximately the same distance that you say TCE moves in 11 years?

A Yes.

Q In that area?

A Yes.

Q Okay.

THE COURT: Is it a fact TCE and water move the same distance in 11 years?

THE WITNESS: I am glad you asked that, your Honor. The Darcy law and the calculation we did on that are based upon the water moving as a slope or a front. What Mr. Schlichtmann referred to earlier, the dispersion phenomena, is what accounts for the fact chemicals, even though as a bulk they're retarded, there is a frontal edge that shoots out in front because of the fingering phenomenon what I calculate at the frontal edge of the plume. That is why the numbers are in agreement. This dispersivity factors because of this, the velocity field will shoot some of the chemicals out, a small percentage, but that is the way life is.

Q All right. So you are saying then, that the chemicals that shoot out will move with the speed of water?

A No. It is not that simple an analogy to make. The dispersivity itself is a function of velocity, and the velocity will change along the path the water is moving as a function of the amount of recharge that is coming in, as a function of the amount of water coming in laterally, as a function of the change of permeability of the material, as a function of the change of porosity of the material. It is not easy, it is not appropriate to make that kind of simplifying assumption. I am explaining why there is no inconsistency in my opinion between what Mr. Maslansky calculated and what I calculated.

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MC?jm

Q You will agree that to use his calculations and your calculations, you've got TCE moving out in that front now to the fingering the same speed that Mr. Maslansky has worked, is that right?

A I don't think it is an appropriate comparison, Mr. Schlichtmann. I will agree what I have defined to be the front of the plume is the same as Mr. Maslansky's calculation of the average work velocity.

THE COURT: This average gradient figure, to what extent -- Mr. Maslansky's average gradient figure that is here, to what extent does that differ from what you feel should be the appropriate gradient?

THE WITNESS: Well, as a matter of fact, the two calculations I did this morning, we would revise the gradient to be no lower than what Mr. Maslansky had at the front edge of the property because we went through and calculated the .04 compared to .037, but one point was up .08 and .09. It would be in faster in response to that gradient.

THE COURT: It would be faster.

Now, when you have made your calculation about TCE going 750 feet in 11 years, I take it you used a different gradient figure than the one that Mr. Maslansky used?

THE WITNESS: Yes.

2

Q (By Mr. Schlichtmann) Are there parts of that site that go .037, has a .037 gradient?
A I'm sure there are. It depends upon how far apart you measure the water levels.
Q There are parts of the site that TCE will move at the same speed as water?
A No, that is an inappropriate characterization. TCE doesn't move at the same speed as water. We are talking about the speed of water being a bulk volume of water as if you consider a cubic foot of water moving down. Let's get out the Freeze and Cherry book, again. I'll show you exactly what the effect of dispersion is, if I may?
Q Please.
A Could we have a board, please?

What I am going to do is trace this figure, Figure 9.2 from the Freeze and Cherry text, which explains how dispersion and the velocity of the chemicals or velocity of water are related.

And we are making a simplified assumption that we are looking at flow in one direction only for the purpose of this illustration. I'm going to call it dispersion effects.

I'm going to label it "nonreactive species." That means -- this represents -- I'm doing that to show

3

basically how dispersion effects something that would move at the exact same speed as water, that is, not retarded, and then we will show one that shows the effect of a retarded species. I will try to be true to the illustration here, but I might, I hope, simplify it so it is easier to understand for the jury.

The scale on the left-hand side here represents percent of relative concentration. That is, the concentration of the chemical we would calculate versus the concentration that would exist right here at the source. So if, for instance, we had a concentration of 100 at the source, then wherever we had the concentration, its position would be plotted somewhere along this horizontal access, but at this elevation representative of .1, meaning one one hundredths of the source concentration.

Now, first we have a line which represents the average water velocity. That was the number we were calculating earlier, hydraulic conductivity times the gradient divided by the porosity. So if we just put water in, and it's coming in in this direction -- I'm going to show it over here going in this direction at time T1. That means sometime after we started putting the water in, the water is just moving as a steady front right through here, we would say the front of that water we are putting in is located right here, and it is a sharp vertical front.

4

(Writing).

Now, if we put a chemical in that water, and this chemical is not retarded, in fact, moves at the same velocity of the water, that is, it is not absorbed and has no stickiness factor to put onto the soil, the chemical is not going to occur other than immediately at the location we put it in, it is not going to exist as a sharp front because some of the chemical, as Mr. Schlichtmann was pointing out, will go in -- follow the water going through the faster zone and some follow the water going through the slower zone and gets what we call a dispersed front. This is where the dispersion coefficient comes from. It gets spread out a little bit. And the way we represent that, I'll use a different color (writing on the chalk). Like that. Can you see that black line? Let me just kind of -- I think you nodded your head, but I'm not sure (drawing on the chalk).

Now, that black line represents what the chemical concentration would look like at time Tl over this zone, this as a distance, also, a tube or a pipe that we are moving through. What that concentration would look like over this zone. And the lower end of the zone, we will call this the mixing zone, at the lower end of this mixing or dispersed zone, we would get this characteristic backward S shaped curve. Within the mixing we would get this characteristic backwards S shaped curve. At the low end the concentration is still equal to the concentration that was put in. At the front end it is a very small percentage of the concentration that's put in. But it's dispersed out in front.

This point right here, the average velocity point, is where the concentration of the chemical, the 50 percent concentration exists, and that represents and that coincides with the distance that the bulk -- that the water moved corresponds to the distance where we put the 50 percent concentration of the chemical. So that for a chemical that is not retarded, if we look at this location, look down into the ground, the concentration would only be 50 percent of what we had at the source area. If we look a little bit downgradient, we would see the concentration is dropping off, and if we look upgradient, we would see higher concentrations in the upgradient direction.

Now, the second illustration, and I will try and keep it as simple as possible, the average velocity point, this is the T1 point. Only now we're looking at a chemical that only moves half as fast as the water. And if that chemical were not dispersed and only moving half as fast as the water, it would be right here. So I'm going to label that -- I don't know,

6

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yet. Let me think a minute (writing on the chalk.) I am going to label this line here "nondispersed retarded chemical front," and I'll say R equals 2.0 to represent half the velocity of water.

A So that all we have done is slowed the chemical down 50 percent because of retardation. And if we were to look at the groundwater, all we see here is pure water. We have to look up gradient, halfway back to the source area to see the chemical.

Mr. Facher, can I borrow one of your red markers, please?

MR. JACOBS: Here is one.

THE WITNESS: Thank you.

Now, the red I will call a dispersed, retarded chemical. Again, are equal to .0. This is the 50 percent line. I showed the different retardation.

The net effect is this same dispersion phenomena which indicates some of the chemical to be out in front of the average position of the chemical if there is no dispersion, a lag before the maximum concentration arrives. The comparison I was trying to illustrate and, unfortunately, I didn't draw a picture exactly to work out perfectly, this number represents Steve Maslansky's bulk velocity of water. This number also represents what I am saying is dispersed, tapered out front, that arrives here. We are comparing, however, the retardation number and its respect, the velocity of chemical with respect to water, we always compare that, the 50 percent concentration, and that is the retardation means, that is retardation of the 50 percent concentration front compared to the bulk velocity of the water. The fact we get chemicals out in front of that point does not mean that we say the chemicals are moving the same velocity of water; it is a function of the dispersivity phenomenon., the finger phenonmenon.

Q The retardation factor you used here was 2?

A For illustrative purposes, I said 2.

Q The trichloroethylene is 3.8?

A Correct.

Q But---

A The fundamental phenomenon is the same.

Q Now, Dr. Guswa, you will agree that Mr. Maslansy included a typical gradient along the flow lines from the trench excavation area to Well Cluster 3 is .037, you agree he said that in his report?

A I agree he said that.

Q Now, in your profession, you do things like simplifying equations; you take averages to help you understand the system, don't you? It is a standard practice in your profession?

A Not to understand the system. Maybe to do some scoping calculations to get a ball-park estimate for the system. We want to understand it. Depending upon the level of detail, we want to understand it. We may or may not use the one-dimensional or simplifying assumption.

Q But, the formula we used with the average figures from

Mr. Maslansky, that was a simplifying assumption, wasn't it, a simplifying assumption?

A Yes.

Q That is standard practice, isn't it?

A I think I explained how it is used as standard practice.

Q Well, now, Dr. Guswa, when I asked you on January 22 at your deposition---

A Yes.

Q ---as to how fast contaminants or chemicals in the groundwater move---

A Yes.

Q ---I said, "What would you have to know to do that?"

A Yes.

Q You remember that?

A Yes.

Q And you said, "Well, you would have to know what the chemical is you are looking at and how it physically, chemically and biologically, and what the physical, chemical and biological process that act on it as it moves through the ground." Do you remember that?

A Yes.

Q Now, you didn't know then, the magnitude of those processes; is that right?

A That is probably true, yes.

Q That is what you told me?

A Right.

Q And when you meant that, you meant the processes such as chemical, biological and physical such as dispersion, that would all affect it?

A Yes.

Q That is what you were referring to when you said you didn't know the magnitude?

A Yes.

Q And I asked you your opinion as to how those things affect trichloroethylene in the groundwater, and what you said was that the limit of your understanding of those things is that physical dispersion would tend to reduce concentration.

A That is correct.

Q And then I asked, "Do you have an opinion then, as to how trichloroethylene was affected in the groundwater in this case?" And you didn't have one, did you?

A What did I say?

Q No.

A Then I didn't.

Q You didn't.

Then I asked you, "You had not done the work if you intended to do the work to determine the specific details of measuring those particular properties." Do you remember me asking you that?

A I guess I do.

Q What you said was you didn't intend to make measurements of the specific details of those particular properties; is that what you told me?

A Correct.

Q And then I said, "How can you form an opinion if you don't have that specific information?" And what you told me was "Well, you can use some simplifying assumptions, standard practice." Is that right?

A If I said that, I said that.

Q Well, is that what you said?

MR. KEATING: Can I take a look over his shoulder. You ought to read the whole answer, Mr. Schlichtmann.

THE WITNESS: One assumption might be---

Q Read the question.

A I am sorry.

"Why can you still form an opinion if you don't have that information?"

"Well, you can use some simplifying assumption, standard practice. One assumption, and please pardon my grammar, one assumption might be let's assume nothing happens to TCE as it moves to the ground. Look at travel time for the conditions when nothing happens to it."

MR. FACHER: Slow down.

THE WITNESS: "Look at travel time for the conditions when nothing happens to it. Look at the conditions. I am not familiar with the information, but there are, I believe, reports available that talk about those kinds of factors that affect TCE. So there are reaction rates that could be incorporated into the analysis. And so you might say, let's say there is an effect of a 10 percent reduction in the travel time because of absorption. Let's suppose there is a certain amount of biodegradation that is going on."

Q You can go to the next page.

A "It sounds exciting to me, actually.

"I don't know what those numbers are. Those numbers can be incorporated and those are typically done either with what might be called a sensitivity analysis, which you heard before, or a bracketing time analysis when there is form that affects the transport but which is not readily measurable or interpretable. You bracket the range of conditions likely to expect, calculate travel time for each of the alternate areas, and on the basis of that form an opinion on what would be the most likely condition to exist."

Question: "Do you intend to make simplifying equations?"

Answer: "I intend to do bracketing-type analysis."

Q That is a simplifying equation?

A The bracketing I did what was the three-dimensional flow model, so it is not a simplifying assumption in that way.

Q Well, didn't you tell me that the reason you weren't going to get those specific details of measuring those particular properties was that, "It is not necessary because the values you measure at one location may not be for another location, and so I don't know."

"How many points do you measure?"

"I don't know how many points to measure would be necessary to make those determinations."

A That is correct.

Q Is that what you said?

A Yes.

MR. SCHLICHTMANN: This is probably an appropriate time for the break.

THE COURT: I think it would be about time to take a break.

(Break.)

THE COURT: Is it probable, yes or no?

THE WITNESS: You are asking me the question?

THE COURT: I am asking the question.

THE WITNESS: Probable? I think it is a probable source. It is a probable possibility; it is a probable---

THE COURT: No, no.

MR. SCHLICHTMANN: That is good enough.

I am asking you flat out.

THE WITNESS: Flat out?

THE COURT: In your opinion, if the explanation that Mr. Schlichtmann has presented to you is, in your opinion, a probable explanation of the result that you see?

THE WITNESS: And the question was phrased to the north and to the east with no particular, specific locations; is that correct?

MR. SCHLICHTMANN: Yes.

THE COURT: Northeast and west.

MR. SCHLICHTMANN: Northeast and west.

THE WITNESS: Yes, that is a probable source.

THE COURT: All right.

Q Now, Dr. Guswa, you were given a copy of Dr. Pinder's three-dimensional model of the aquifer, am I right about that?

MR. KEATING: I object to the characterization of what that was. He can ask what he got but I think---

THE COURT: I will sustain the objection.

MR. KEATING: Thank you.

MR. SCHLICHTMANN: On that ground

THE COURT: Yes.

Q Did you get from Dr. Pinder, Dr. Guswa, a model of the aquifer?

MR. KEATING: I object, your Honor. This is not the basis of Dr. Pinder's opinion. It was not introduced into evidence.

MR. SCHLICHTMAN: Are you making an argument or objection?

MR. KEATING: I will make it at the Side Bar.

THE COURT: I will sustain the objection to the question in that form.

Q Dr. Guswa, were you, did you analyze or did you receive materials which Dr. Pinder used in analyzing the East Woburn aquifer?

MR. KEATING: I object, your Honor.

THE COURT: Did he receive materials? How can he tell? How can he tell what he is, he received.

Did you receive some material from Dr. Pinder? I suppose we have to start with that.

THE WITNESS: Yes.

THE COURT: All right.

Q And the materials that you received were these (indicating), weren't they?

MR. KEATING: Your Honor, I renew the objection.

THE COURT: Overruled. Were those the materials you received?

THE WITNESS: Your Honor, I received similar materials. I don't know if these are exactly the ones we received. Some form in February, we also received some form in April or May, which was different from what we got in February. And I don't know whether this is the same or different from either of those.

THE COURT: All right.

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THE COURT: All right. Was it in that form, in the form of the printout it is in now?

THE WITNESS: In that form.

THE COURT: All right. So you have two patches and they were different in terms of the content, is that right?

THE WITNESS: Yes.

THE COURT: All right. But both in the same form?

THE WITNESS: Both in the same form in that they were on computer paper.

THE COURT: All right.

Q Now, could you examine those and tell me if that's the stuff you received or looks like the stuff that you received?

A Mr. Schlichtmann, I'll tell you whether it is generally similar, but I won't tell you it is exactly.

THE COURT: Should we take a week's recess?

Q All right. It looks generally similar?

A The same green and white paper with lots of numbers on it.

Q What is that? What was that stuff?

MR. KEATING: I renew the objection, your Honor. I don't want to ask for a conference, but you

2

know the grounds.

THE COURT: What was that stuff? I will allow that.

Q (By Mr. Schlichtmann) What were these things that you got?

A These were results or outputs, and I think in April or May we even got some input for a computer code called PTC.

Q And what was it?

A PTC is the Princeton Transport Code.

Q What is the Princeton Transport Code?

MR. KEATING: Your Honor, I object. This isn't what he relied on. Dr. Pinder didn't, and I do not know why we have to have it with this witness.

THE COURT: I don't know what the question is.

MR. KEATING: I don't know what the question is, but I know what the thrust of the questions are.

THE COURT: I don't know what it is, so I will have to wait and see. I will permit this question.

A My understanding is that the Princeton Transport Code is a code which is being developed at Princeton University to evaluate the groundwater flow in chemical

3

transport.

Q How many spaces?

A Pardon?

Q How many species?

A Three dimensions.

Q So, Dr. Guswa, you received from Dr. Pinder this three-dimensional model, did you not?

MR. KEATING: Your Honor, I object to that. That is absolutely irrelevant.

THE COURT: Well, I think it could be put into a question. I don't know where it is going.

Does that thing represent all this stuff that you got, does that represent a three-dimensional model?

A I believe this is the input that we have here, which I think we received in April or May. There were several outputs, but there was no description of what level of calibration or testing or evaluation that represented.

THE COURT: Well, I'm sure that is so, but that is not my question.

THE WITNESS: All right.

THE COURT: Are these things components of a three-dimensional model?

THE WITNESS: The first set were the output components and the second set, I think, are input

4

components, but I haven't verified that because I didn't have time to do that.

Q (By Mr. Schlichtmann) Well, Dr. Guswa, is it not a fact that these were provided to you the first time in January, 1985, and the second time February of 1985, and the third batch, the third set from the three-dimensional model was given to you in March; isn't that correct?

MR. KEATING: I object.

THE COURT: Excluded.

Q (By Mr. Schlichtmann) Dr. Guswa, is it not -- Would you please read to the jury --

MR. KEATING: '85 or '86?

MR. SCHLICHTMANN: I meant '86.

MR. KEATING: I still object.

MR. SCHLICHTMANN: I imagine it is still sustained.

Q Would you read to the jury this statement (indicating).

MR. KEATING: Your Honor, I object to that.

THE COURT: Sustained.

Q Well, Dr. Guswa --

THE COURT: That thing has not been identified.

Q Would you please examine that?

5

MR. KEATING: I object, your Honor. Goodness.

THE COURT: What?

MR. KEATING: I object.

MR. SCHLICHTMANN: This is on goodness.

MR. KEATING: My objection is against what is going on now. I object, sir.

THE COURT: The question is or the direction is to examine the document. I will permit him to examine it.

MR. KEATING: He asked him to identify it, your Honor.

THE COURT: No. He asked him to examine it so far.

A I believe this is the same document which is the source code that we received in March of 1986.

Q And you also received one in January, 1986?

A We received a different version in January or February, I'm not sure.

Q And, Doctor, this is a flow and mass transport model?

MR. KEATING: I object.

Q Three-dimensional space, is it not, sir?

MR. KEATING: I object, your Honor, it is not in evidence.

THE COURT: No, it is not. Let me get the relevance of it.

(CONFERENCE AT THE BENCH AS FOLLOWS:

MR. NESSON: Your Honor, this witness on his direct examination said that any hydrologist who didn't use a three-dimensional model, just did one-dimensional, obviously would find the document -- hadn't done an adequate job. In fact, Dr. Pinder used a three-dimensional model, not as the basis but as a confirmatory --

THE COURT: He didn't testify about it.

MR. NESSON: In fact, we have before the jury the output of that, which was used as an exhibit.

THE COURT: No, you don't.

MR. NESSON: With all of the flow arrows on it.

MR. KEATING: That is one little tiny bit of it.

THE COURT: That is clearly two-dimensional.

MR. NESSON: No, two-dimensional representation but it is a two-dimensional representation of a three-dimensional model. That is the way the arrow is shaped.

THE COURT: That was never indicated and never testified to.

MR. NESSON: That is not the point.

THE COURT: It is clear when you have a

three-dimensional model, you make a projection that shows --

MR. NESSON: There are different representations. His are all two-dimensional, too.

MR. KEATING: Judge, how can the --

MR. NESSON: Excuse me. The point is on cross-examination of the witness, and the witness has tried to impeach another witness by saying he didn't do something when, in fact, the witness --

THE COURT: He didn't say Pinder didn't do anything.

MR. KEATING: He never mentioned Pinder once.

THE COURT: He never said that.

MR. NESSON: He certainly suggested --

THE COURT: I don't think what I referred to as the permanent underlying layer of paranoia here is the basis for cross-examination.

MR. NESSON: Let me go further with the argument, if I might.

Listen, this man himself made a model.

THE COURT: Who?

MR. NESSON: Guswa. His model, I believe, will turn out to be related to Dr. Pinder's model. If he had Dr. Pinder's model in front of him, if his criticized results of Dr. Pinder came to -- and if he didn't evaluate Dr. Pinder's model, that is a basis for cross-examining the expert witness. This goes to what he did as a means of forming his opinion.

THE COURT: He said there is something missing.

MR. SCHLICHTMANN: On the transport, your Honor, Mr. Facher used material not put into evidence. I objected, and I said he can't read from the document. And you said sure he can. That is what you said. And he did it many times. Mr. Keating and Mr. Facher read from documents.

THE COURT: This kind of argument doesn't appeal to me a damn bit, that somebody did something and therefore it has to be done again.

MR. SCHLICHTMANN: The principles apply to both sides.

THE COURT: Maybe they do. And it may well be that I made a mistake. It doesn't mean that I should make it again.

MR. SCHLICHTMANN: I don't think it was a mistake. It was quite proper.

THE COURT: It all depends upon the context. You are a great one for fishing out one page of a transcript, Mr. Schlichtmann, and saying see? That,

9

I don't think is quite the way to do it.

Now, I still don't get what you want to put it in for.

MR. SCHLICHTMANN: I asked the witness if it is a three-dimensional model. That is the one I reviewed. The statement on its face says it is a three-dimensional model. He denied it.

THE COURT: He hasn't.

MR. KEATING: He has not denied it.

MR. SCHLICHTMANN: Then have him admit it.

THE COURT: The point is relevance.

MR. SCHLICHTMANN: It goes to whether the quality of the work that Dr. Pinder --

THE COURT: The quality of the work that Dr. Pinder did, it is up to Dr. Pinder to put that in.

MR. SCHLICHTMANN: Mr. Keating will be arguing to the jury in his summation that Dr. Guswa used a three-dimensional model and he did a better job.

THE COURT: Dr. Pinder did not testify from the three-dimensional model.

MR. SCHLICHTMANN: He used it to illustrate his opinion and --

THE COURT: Show it to me.

MR. SCHLICHTMANN: All right.

10

MR. NESSON: To illustrate and confirm.

THE COURT: Show it to me.

If you are talking about the Pac Man diagrams. I remember them so you don't have to get those out.

MR. SCHLICHTMANN: No, right here.

(Mr. Schlichtmann hands a transcript to the Court, Volume 39, Pages 90 and 91.)

THE COURT: I remember him saying this, and that is how he says he generated what Mr. Facher or somebody has referred to as the Pac Man diagrams, the ones with the little --

MR. SCHLICHTMANN: That could only come from a three-dimensional --

MR. KEATING: Bring him back and put him on the stand.

MR. SCHLICHTMANN: That is what he said. It is the computer printout. This is what it is. It states it, and I want to establish it on the record.

THE COURT: It doesn't state it. He didn't state it, and all I have is you stating it. If you want to bring him back on rebuttal, all right.

MR. SCHLICHTMANN: The witness has identified this document. It states on its face, and I want to --

THE COURT: I don't care what you want to do,

11

I will not let you.

MR. SCHLICHTMANN: I want to impeach the witness for using the statement. I have a right to do that.

THE COURT: I don't think you do under the circumstances when the objection is sustained.

MR. SCHLICHTMANN: Thank you.

END OF CONFERENCE AT THE BENCH.)

Q (By Mr. Schlichtmann) Dr. Guswa --

THE COURT: For the record, the transcript pages that you were showing me should be stated.

MR. SCHLICHTMANN: Volume 39 Page 90 and 91.

THE COURT: Because there was some difference of opinion as to what they say, so we should know for purposes of later consideration exactly what pages you were referring to.

Q (By Mr. Schlichtmann) Dr. Guswa, when did you provide your three-dimensional model to Dr. Pinder?

MR. KEATING: I object. It wasn't requested, and I think that is a totally improper question.

THE COURT: Well, a simple objection will do, Mr. Keating.

MR. KEATING: I simply object.

THE COURT: All right. The objection is

12

sustained.

Q Dr. Guswa, did you ever provide your three-dimensional model that you used in this case to any consultant or any expert outside of Geotrans for analysis for evaluation?

A No.

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Q Did you analyze and evaluate computer output and input that was provided by Dr. Pinder?

MR. KEATING: Objection.

Q Did you evaluate or analyze it?

MR. KEATING: I object, your Honor.

THE COURT: Did he evaluate the computer analysi or computer document?

MR. SCHLICHTMANN: Yes.

THE COURT: I will permit that, objection is overruled.

A Repeat the question, please.

Q Did you evaluate or analyze computer input or output Dr. Pinder provided?

A I tried to, yes.

Q Were you successful?

A Some areas, yes; some areas, no.

Q You weren't able to put it all together?

A Not to put it all together, no.

Q Are you aware in your analysis of this document, were you able to determine if, in fact, Dr. Pinder was able through this computer input and output, to determine the groundwater flow from the Beatrice site to Wells G and H?

MR. KEATING: Objection.

THE COURT: Sustained.

Q To your knowledge, does this computer output and input, based on your analysis and evaluation, does that provide the groundwater flow from the Beatrice site to Wells G and H?

MR. KEATING: Objection.

MR. FACHER: Objection.

THE COURT: Overruled.

A I don't know.

Q Have you ever seen this exhibit?

A Yes.

Q You did?

A Yes.

Q Do you understand this is output, this was prepared by Dr. Pinder?

A Yes.

Q It is an illustration of his testimony?

A Yes.

MR. KEATING: I object, your Honor.

Q And, in your opinion as a hydrogeologist in examining this diagram, does that diagram indicate the groundwater flow in Dr. Pinder's opinion from the Beatrice site to the well field?

MR. KEATING: I object.

THE COURT: Dr. Pinder has given his opinion. I don't think it is appropriate to ask someone else about what was the basis of, what was the standard of a prior expert's opinion. The jury will have to make the determination as to how they can deal with the opinions. That is what they are here for.

MR. SCHLICHTMANN: I have no more questions, your Honor.

THE COURT: Before we take the second round, I have a question, too. I will try to be brief.

Doctor, you are aware that in January of 1985, excuse me, 1986, as a result of, at the end of the pumping test, that a chemical analysis was made of Wells G and H?

THE WITNESS: Yes.

THE COURT: And the complaint chemicals were found at that time?

THE WITNESS: Yes.

THE COURT: Now, you talked about five or six pathways of chemicals coming to Wells 5 and 6, I mean to Wells G and H?

THE WITNESS: Yes.

THE COURT: Now, at the time of the pumping, you said that they didn't, the pumping didn't last long enough to bring river water, river water would take two months and the pumping only lasted a month?

THE WITNESS: Correct.

THE COURT: So this contamination found in January of 1986 didn't come from the river?

THE WITNESS: That is correct.

THE COURT: Now, is there any evidence there was any infiltration or flooding of sewer systems within a relevant time which would cause the contamination to occur in the wells in January of 1986?

THE WITNESS: (Pause.)

THE COURT: Do you know?

THE WITNESS: I am not aware of any infiltration at that time.

THE COURT: So that is not a reasonable explanation of the contamination in January of 1986?

THE WITNESS: I think, your Honor, my understanding is that, my understanding of the groundwater system, the chemicals in it, is that there is pervasive groundwater contamination in the Aberjona River Valley and it was there before the pump test started, and those chemicals were in the ground before the pump test started. The mechanism of the exact location of where the chemical came from, I don't know.

THE COURT: All right.

Well, let's go down through your -- There was no historic flooding within the relevant time period which would have directly brought the chemicals to the wells?

THE WITNESS: Well, again, I am confused by the term "relevant time period."

THE COURT: Okay. What would be the relevant time period for determining a flooding situation in the valley had, was responsible for the contamination found in the wells in January of 1986?

THE WITNESS: If, for instance, the flood of 1979 were to bring down chemicals as they, either by washing out one of the lagoons or draining a ditch or barrel companies, or flow in the sewer and spreading that material out so, since they are pulled in the ground during 1979, they could have stayed in the ground for that time period. In other words, it could have been in the ground, got in the groundwater system as early as '79. Some of those chemicals may still be there and still leaking out, if you will, in the aquifer.

THE COURT: You have been asked if you could identify the source of the chemicals in the wells as of May of 1979. I will ask you now if you can identify the source of the chemicals in the wells as of January of 1986?

THE WITNESS: No, I can't.

THE COURT: Well, that was the series of questions I had. Do you want to start the next round?

MR. SCHLICHTMANN: The jury?

THE COURT: Do you want to do that before or after? The jury seems to have some questions.

THE FOREMAN: There are several pages of questions that have come up. I think that if the witness will be back Monday---

THE COURT: He will be back Monday.

THE FOREMAN: We will pose them then.

THE COURT: You would rather hold to the second round?

THE FOREMAN: Yes.

THE COURT: Okay. Mr. Keating?

REDIRECT EXAMINATION, By Mr. Keating

Q Dr. Guswa, let me ask you a couple of questions about the bedrock, the issue that came up today concerning the existence of the bedrock and the fact that part of the water in the aquifer, in your opinion, I take it, moves through the bedrock?

A Yes.

Q Does your model or did your model take into account the bedrock, and if it did, in what respect it took in bedrock?

A It was one of the layers in the model. And it was an approximation of the bedrock in the sense that it allowed water to move through it under a low, under the permeability of gradient that would exist in the bedrock. it was not an exact representation of the fractures that existed there because there is no form to describe exactly what those fractures are. So in the sense of the way we approach things, it was just a general material through which groundwater could move.