

CH 88 02
T. H. H. H.

CONSOLIDATED HEARINGS BOARD

IN THE MATTER OF Sections 2 and 3 and 6 (3) of the Consolidated Hearings Act, 1981, S.O. 1981, c.20;

— and —

IN THE MATTER OF Section 12(2) of the Environmental Assessment Act, R.S.O. 1980, c.140;

— and —

IN THE MATTER OF Sections 30, 35 and 38 of the Environmental Protection Act, R.S.O. 1980, c.141, as amended;

— and —

IN THE MATTER OF Sections 24 and 61 (2) of the Ontario Water Resources Act, R.S.O. 1980, c.361, as amended;

— and —

IN THE MATTER OF Section 28 (3) of, and Regulation 164 under, the Conservation Authorities Act, R.S.O. 1980, c.85, as amended;

— and —

IN THE MATTER OF Section 40(12) of the Planning Act, S.O. 1983, c.1, as amended; in connection with site plan control of the sanitary landfill site;

— and —

IN THE MATTER OF Section 22(1) of the Planning Act, 1983 in connection with a referral to this Board by the Honourable Bernard Grandmaitre, Minister of Municipal Affairs, on a request by the Regional Municipality of Halton to amend the Official Plan for the Town of Milton to redesignate a parcel of land comprising Part Lots 3 and 4, Concession 2 N.S. in the Town of Milton from "Agriculture" and "Conservation and Hazard Lands" to permit the construction, operation and maintenance of a landfill site, Minister's File No. 24-OP-0208-A01;

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IN THE MATTER OF Section 34(11) of the Planning Act, 1983 in connection with an appeal to this Board by the Regional Municipality of Halton for an order directing an amendment to By-law 61-85 of the Town of Milton to rezone the lands situated at Lot 3 and part of Lot 4, Concession 2 N.S., in the Town of Milton from "Agriculture" to permit a regional sanitary landfill site and ancillary uses;

— and —

IN THE MATTER OF Section 15(1) of the Planning Act, R.S.O. 1980 ch.379 in connection with a referral by the Honourable Claude F. Bennett, Minister of Housing on a request by Tremaine Britannia Citizen's Group for consideration of part of the Official Plan for the Halton Planning Area with respect to Sections 1 to 5 inclusive, 7, 9 and 10 of Part III D3 Solid Waste Management, Minister's File No. OPC-0026;

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IN THE MATTER OF Section 64 of the Ontario Municipal Board Act, R.S.O. 1980, c.347 as amended in connection with an application by the Regional Municipality of Halton for an order approving:

a) the acquisition of land for the construction, operation and maintenance of a sanitary landfill site to contain 7.96 million cubic metres of waste in the Regional Municipality of Halton and to do so by one of two alternative methods as follows:

- (i) landfilling at the site referred to in Halton's Environmental Assessment as Site F in the City of Burlington;
- (ii) landfilling at the site commonly referred to in Halton's Environmental Assessment as Site D in the Town of Milton

at an estimated cost of \$12,775,000.00, and the borrowing of money by way of temporary advances not exceeding in the aggregate such estimated cost pending the sale of debentures, and

(b) the issuance of necessary debentures to a maximum of \$12,775,000.00 for a term not to exceed fifteen years;

— and —

IN THE MATTER OF Section 193(5) and Paragraph 84 of Section 210 of the Municipal Act, R.S.O. 1980, c.302, as amended;

— and —

IN THE MATTER OF Sections 6, 7 and 8 of the Expropriations Act, R.S.O. 1980, c.148;

— and —

IN THE MATTER OF an undertaking of the Regional Municipality of Halton to provide facilities for the purpose of receiving, dumping and disposing of waste as required by section 137 of the REGIONAL MUNICIPALITY OF HALTON ACT, R.S.O. 1980, c.436, as amended, by acquiring the land for, constructing, operating and maintaining a landfill to contain 7.96 million cubic metres of waste in the Regional Municipality of Halton.

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NETHERCUT & COMPANY LTD.

185 RICHMOND ST. W.,

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I N D E X

WITNESSES:

DR. RONALD KERRY ROWE (Resumed)
DR. DAVID LEONARD CHARLESWORTH (Resumed)
Cross-examination by Mr. Hodgson (Cont'd)

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BEFORE: H. H. Lancaster, Q.C. - Chairman
Dr. D.J. Kingham - Member



Nethercut & Co. Ltd.

Toronto, Ontario

Hearing conducted at The Oakville
Granary Commercial Centre, 105 Robinson
Street, Oakville, Ontario, on
Monday, February 8, 1988

VOLUME 87

APPEARANCES:

T.R. Lederer and
H.D. Hodgson

for the Regional
Municipality of Halton
(Proponent)

J.R. Tidball

for the Ministry of the
Environment

T. Vigod
J.F. Castrilli

for the West Burlington
Citizens Group

D. Estrin,
F.E. Leitch and
H. Dahme

for the Corporation of the
Town of Milton

S.R. Garrod and
A. Nurvo

for the Milton Area Citizens
Coalition and several
affected Milton area
landowners

R.B. Tuer, Q.C.
E.A. Cronk and
F. Perrier

for National Sewer Pipe
Limited

L.F. Longo

for Azova Investments
Limited

M.J. McQuaid, Q.C.
and C.J. Tzekas

for the City of Burlington

C. Mansfield

for the Ministry of Natural
Resources

P. Renaud

for Cumis Limited



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Toronto, Ontario

APPEARANCES (Cont'd):

1	C. Stevenson	for Framgard Holdings,
2	P. Hancock	Fosseri Investments
3		Limited, Seriphos
4		Investments Limited and
5		Topic Investments
6		
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J.H. Olah for the Halton Region
Conservation Authority

* * * * *

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Per: C.F. Nethercut, C.V.R.



1 --- Upon Commencing at 9:30:

2 MR. LANCASTER: Good morning, thank you,
3 please be seated.

4 DR RONALD KERRY ROWE (Resumed):

5 DR. DAVID LEONARD CHARLESWORTH (Resumed):

6 MR. ESTRIN: I invited Mr. Leitch back
7 so I could have someone with me for lunch.

8 MR. LANCASTER: Are you filling in for
9 National Sewer Pipe? Mr. Hodgson, you were still at
10 it, were you not?

11 MR. HODGSON: Thank you. I notice the
12 number of hydrogeologists I see in the room has dropped
13 precipitously, so obviously the entertainment value of
14 this hearing is dropping. We have one hydrogeologist
15 in the witness box and one non-hydrogeologist, so
16 perhaps we could continue.

17 CROSS-EXAMINATION BY MR. HODGSON (Cont'd):

18 Q. Dr. Charlesworth, Friday when we
19 left off, we had discussed at some length the geology
20 at Site F and you had been kind enough to assist the
21 Board in interpreting one of the rock cores that was
22 developed at Site. F. Turning from geology to hydro-
23 geology at Site F, I wonder if you would review with me
24 very, very quickly some of the hydrogeological data

25



1 which was developed at Site F so we could just have
2 this before us and we could jump to some mechanism for
3 using this data. Could I ask you to turn to Exhibit H-
4 40A, the indices to the Site F report prepared by Trow.
5 You will notice, Dr. Charlesworth, that Trow had done
6 packer tests on three holes, HC 6-86, HC 4-85 and HC 3-
7 85. First of all, would you agree with me that a
8 packer test is a pumping test in reverse and what you
9 are doing here instead of pumping water out of a
10 borehole, you are pumping water into the borehole, or
11 injecting water?

12 DR. CHARLESWORTH: A. Yes, and you can
13 also extract these packers and extract water as well,
14 but in this case that is a very standard description.

15 Q. That is a standard technique for
16 testing the hydraulic conductivity?

17 A. Yes.

18 Q. A technique that you would use in
19 studying a site?

20 A. It is.

21 Q. All I wanted you to do is look at
22 page 2 under Appendix 11, borehole HC 6-85. What we
23 find here, let's see if you would agree with me, the
24 lowest permeability is 1.5×10^{-5} , is that right?

25 A. Sorry, which borehole?



- 1 Q. HC 6-85.
- 2 A. 6-85. The lowest permeability?
- 3 Q. The highest.
- 4 A. The highest.
- 5 Q. I have trouble with these numbers.
- 6 A. They sound like they should be
- 7 getting higher.
- 8 Q. It is hard for me to understand
- 9 that 5 is higher than 7, but the highest is 1.5×10^{-5} ?
- 10 A. Yes.
- 11 Q. The lowest permeability found at
- 12 that hole is 3.2×10^{-7} ?
- 13 A. Well, the lowest sort of
- 14 measurable value, although I understand the two zeroes
- 15 represent a zero take-up of water...
- 16 Q. What would that translate to in
- 17 terms of permeability; zero uptake of water?
- 18 A. There was some discussion based on
- 19 the equipment they were using, but Trow assigned a
- 20 value of 10^{-8} . You have to know exactly how the test
- 21 was run and it could conceivably be less than 10^{-8} .
- 22 Q. It could be less than 10^{-8} ?
- 23 A. I would think so, but I wasn't
- 24 there when the actual test was run.
- 25 Q. If we assume it is 10^{-8} that would



1 be a conservative assumption?

2 A. In my opinion, it would.

3 Q. You would agree that what we have
4 here is a spread of something in the area of four
5 orders of magnitude in permeability?

6 A. Three or if we say 10^{-5} to 10^{-8} ,
7 yes, I would think that that's reasonable.

8 Q. Four orders of permeability and
9 these tests, would you agree, were conducted at
10 different levels within the shale?

11 A. That is correct.

12 Q. What we are measuring is
13 permeabilities at different points down borehole HC 6-
14 85?

15 A. That is correct.

16 Q. Could we briefly look at HC 4-85.
17 Here we have first a correction made during the
18 evidence given by Mr. Beechinor and Mr. Sobanski; there
19 is a value between 128.3 and 125.2 that was originally
20 recorded as 1.2×10^{-6} and in evidence that was
21 corrected to 1.2×10^{-3} ?

22 A. That is my understanding.

23 Q. And also in evidence between 120.9
24 and 120, it was noted there was a zero uptake recorded
25 as well, a zero uptake similar to the zero uptake found



1 which we just discussed, in HC 6-85?

2 A. I would have to check the
3 transcript. I thought that was a longer section than
4 you mentioned, I thought between 120.9 and 125. My
5 recollection is somewhere between 125 and 122, but in
6 that zone there was a zero take-up.

7 Q. We can agree there was a zero
8 take-up in some zone?

9 A. Yes.

10 Q. The zero take-up you have told us
11 conservatively translates into a K value of 10^{-8} and it
12 could be up to 10^{-9} ?

13 A. Yes.

14 Q. What we have in terms of spread of
15 hydraulic conductivities at HC 4-85 are hydraulic
16 conductivities ranging all the way from 10^{-3} to 10^{-8} ;
17 at least a spread of 5 orders of magnitude?

18 A. Yes.

19 Q. And HC 4-85, you will confirm, is
20 the borehole core we were examining Thursday afternoon?

21 A. That is correct.

22 Q. That core we had displayed on the
23 floor contains tested permeabilities using a packer
24 test that range 5 orders of magnitude.

25 A. Yes.



1 Q. Dr. Charlesworth, looking at HC 3-
2 85, we find recorded variations in permeability based
3 upon packer tests that go from 9.1 to 10^{-4} to $3.0 \times 10^{-}$
4 6 or about two and half to three orders of magnitude
5 variation?

6 A. That is correct.

7 Q. Just on packer test information
8 alone, looking across three boreholes we find
9 variations in permeability in the shale of at least 5
10 orders of magnitude?

11 A. Yes, that is correct.

12 Q. Interestingly enough the Hvorslev
13 results are also recorded in Appendix 11 in the column
14 to the left, rising head K is the Hvorslev tests, is
15 that right?

16 A. That is right.

17 Q. Just eyeballing the Hvorslev
18 results, and I would like you to look at the Hvorslev
19 results on the first two pages and the results for HC
20 8-85 on the third page after that where the boreholes
21 go off the site, but I am interested in the Hvorslev
22 results on-site.

23 Would you agree with me that there is a
24 substantial variation in permeability based upon the
25 Hvorslev results?



1 A. Yes, and they vary from 10^{-4} to
2 4×10^{-7} .

3 Q. Approximately 3 to 4 orders of
4 magnitude?

5 A. In that order, yes; I would say
6 three orders of magnitude.

7 Q. How would you compare these
8 results with the packer test results. Are they more or
9 less reliable?

10 A. I would say the packer test
11 results are generally more reliable and also the packer
12 test results are likely to give you a larger range. If
13 I understand what Trow did at this site, and I think
14 Mr. Sobanski's testimony was they tended to locate
15 their piezometers in the fractures, and so one might
16 assume that the Hvorslev values would be selective in
17 terms of the higher permeabilities whereas the packer
18 tests they actually tested across larger zones.

19 The packer tests will give you a greater
20 range and probably any specific test I would have more
21 faith in than the rising head, depending on how the
22 test was actually conducted.

23 Q. Could I ask you to refer next to
24 Exhibit N-203A. This is an exhibit put to Mr. Sobanski
25 and Mr. Beechinor that reflects the results of the



1 pumping test. Do you recall this?

2 A. Yes, I do.

3 Q. First of all would you agree that
4 where a more permeable zone has been found then a
5 pumping test can be used to explore the hydraulic
6 characteristics of the zone?

7 A. Yes. A pumping test can be used
8 but I would caution that a pumping test in fractured
9 systems such as this is quite -- a great deal of care
10 needs to be taken in the execution of the pumping test
11 and in the analysis of the data.

12 Q. I accept that and I think that's
13 probably true for everything at Site F, but would you
14 agree that a pumping test can provide data both on the
15 hydraulic continuity and also on hydraulic
16 permeability?

17 A. Certainly it gives you an
18 indication of the hydraulic continuity and, yes, it can
19 give you the hydraulic characteristics in terms of
20 transmissivity and K values.

21 Q. Just in terms of hydraulic
22 continuity, would you accept, subject to check, based
23 on the results shown on N-203A, that the pumping test
24 conducted at pumping well 2 on Site F produced a cone
25 of influence that went to the north 275 metres, to the



1 east more than 210 metres, to the west 120 ...

2 A. Could I jot these down because I
3 would like to check them after?

4 Q. To the north 275 metres?

5 A. Yes.

6 Q. To the east more than 210 metres,
7 to the west 120 metres and to the south 300 metres?

8 A. I would have to check back on the
9 data on that. My recollection is that I am not sure it
10 demonstrated there was a connection 300 metres to the
11 south, for example, and I have a question about the
12 connection to the north. It certainly did indicate
13 that there was a cone of influence around that well.

14 Q. Subject to that check can we work
15 with those numbers for a moment?

16 A. Yes.

17 Q. Assuming that I have accurately
18 represented the results of the pumping tests and the
19 results of Mr. Sobanski's evidence, would you agree
20 that an area that extends north-south 575 metres and
21 east-west a total of 330 metres is an area of
22 approximately 19 hectares?

23 A. I would have to check that. Yes,
24 I have in the order of 21 or 22, but that was very
25 approximate and it sounds like quite a reasonable



1 number.

2 Q. Can we agree that it is
3 approximately 20 hectares?

4 A. Yes.

5 Q. More or less.

6 A. Yes.

7 Q. 20 hectares is about 50 acres?

8 A. Yes.

9 Q. Would you agree with me, based on
10 the assumptions we have made, that this pumping well
11 produced a cone of influence over a very wide area?

12 A. Yes, with those numbers it
13 produced a cone of influence over a wide area.

14 Q. So there is established hydraulic
15 conductivity over a very wide area?

16 A. There is a degree of connectivity
17 over that area, yes.

18 Q. There has been a lot of discussion
19 at this hearing as to how to interpret the hydraulic
20 conductivity of the zone that was pumped, and I don't
21 want to get into a discussion with you, I want you to
22 accept for the purposes of our discussion that what you
23 propose in your report on page 4-8, we should interpret
24 the hydraulic conductivity of the zone that was pumped
25 at approximately 10^{-3} ?



1 A. What I was pointing out there,
2 Mr. Chairman, was that using Trow's analysis of the
3 pump test data, but adding a more reasonable factor for
4 the thickness of the aquifer would give that kind of
5 figure. I have some concerns and it is always
6 difficult to interpret someone else's pump test
7 analysis, as it is presented.

8 I have some concerns about how rigorous
9 their analysis was as presented in their report, and I
10 would go so far as to say that the reasonable analysis
11 of a pump test in this formation could form quite a
12 substantial document in itself which I don't see here.
13 I would be very careful -- I have reservations even
14 about the value recalculated using the different
15 saturated thickness. I will accept the degree of
16 connectivity, but I have questions about the actual
17 interpretation of the data.

18 Q. You don't dispute the pumping test
19 developed a cone of influence over a very wide area?

20 A. I don't.

21 Q. You don't dispute it must have
22 been pumping a zone of fairly high hydraulic
23 conductivity in order to develop that cone of influence
24 over that wide an area in that short a period of time?

25 A. Yes. There are a number of



1 factors which need to also be taken into account if one
2 is going to truly analyze what that pumping test means.
3 For example, barrier conditions. There may be some
4 evidence that the draw-down starts to increase quite
5 dramatically which could suggest that the cone of
6 influence has reached the limits or essentially an
7 impermeable barrier and that kind of an analysis can be
8 quite useful.

9 I see some evidence of that. The water
10 levels, if one looks at the pumping test results, the
11 water levels start to drop quite dramatically in the
12 pumping well. In terms of the actual values that come
13 out of it, I have some reservations, but it does
14 demonstrate some degree of connection.

15 Q. And you agree it is a much more
16 permeable zone than some others found in this same
17 shale deposit?

18 A. It is certainly much more
19 permeable than some of the other zones found in the
20 deposits, yes.

21 Q. The figure of 10^{-3} is within the
22 range of figures, or is within the range of values for
23 hydraulic conductivities that were also developed, for
24 instance, using the packer test?

25 A. It is at the limit of the value,



1 yes.

2 Q. It is within the range of
3 believability?

4 A. It is at the end of the range.

5 Q. Going back over the information we
6 have on hydraulic conductivities, you have packer test
7 results, you have Hvorslev results and a pumping test
8 result, and aggregating those results, we have a range
9 which demonstrates, would you not agree, that the
10 variability in the hydraulic conductivity in the
11 various strata of the shale at this site is something
12 in the order of 5 orders of magnitude?

13 A. Those results do range over that
14 kind -- certainly cover that kind of range.

15 Q. Could I next ask you to consider
16 with me, and explain if you would or if you would help
17 to explain to the Board, the hydraulic gradients we
18 find at Site F. Just talking abstractly for a moment,
19 Dr. Charlesworth, would you agree that the range of
20 horizontal gradients usually observed is something in
21 the order of .001 to .05, the horizontal gradients?

22 A. At this site?

23 Q. Not necessarily at this site, but
24 in the ground. When you were talking about horizontal
25 gradients as a hydrogeologist, don't you expect to find



1 horizontal gradients, more or less within that range of
2 .001 to .05?

3 A. Yes, that is a reasonable range.

4 Q. Just so we understand what that
5 means, a horizontal gradient of .05 means a gradient of
6 5 per cent or a one foot drop in 20; correct?

7 A. That is correct, yes.

8 Q. That would be a very strong
9 horizontal gradient, a one foot drop in 20, horizontal
10 gradient?

11 A. That is a reasonably steep
12 gradient, yes.

13 Q. To go to the other end of the
14 range we discussed, .001 is one-tenth of one per cent,
15 or a one foot drop in 1000 feet; is that right?

16 A. Yes.

17 Q. That represents a very weak
18 lateral gradient. Would you agree?

19 A. Yes, I would agree.

20 Q. Now, can we talk for a moment
21 about vertical gradients. Vertical gradients can range
22 from zero, i.e. no vertical gradient which flows
23 laterally...

24 A. Yes, that is correct.

25 Q. And they can go up to one?



1 A. Yes.

2 Q. And in fact on very rare occasions
3 they can go over one, is that not correct?

4 A. That is correct.

5 Q. But it would be rare to find a
6 vertical gradient above one?

7 A. Yes.

8 Q. A vertical gradient of one
9 represents a gradient of 100 per cent which means a one
10 metre drop in head for every one metre increase in
11 depth?

12 A. Yes.

13 Q. Let's talk about weak vertical
14 gradients. Would you agree that a reasonable range for
15 weak vertical gradients goes from zero at the low end
16 to approximately .05?

17 A. I would say yes, subject to
18 sleeping on it, but that sounds reasonable.

19 Q. I am not trying to mousetrap you.

20 A. I realize that, but sometimes you
21 will appreciate it that sometimes one says yes and then
22 has second thoughts about it afterwards... it does
23 sound reasonable.

24 Q. If weak vertical gradients range
25 from zero to say .05, then a gradient of .1 would be a



1 moderate vertical gradient and a gradient, say, ranging
2 from .2 would be a strong vertical gradient?

3 A. Yes, I would agree with that.

4 Q. So .2 is a strong downward
5 gradient and .3 is a stronger downward gradient and 1
6 is a much stronger gradient still; is that right? Have
7 I got that right?

8 A. I think that's about right.

9 Q. Dr. Charlesworth, could I ask you
10 to open Exhibit H-40A at Appendix 5. What I would like
11 you to turn up is that data for WAT-3. This is
12 University of Waterloo borehole 3?

13 A. Right.

14 Q. First of all, can you estimate for
15 the Board the distance between piezometers 11 and 12 in
16 terms of how far apart they are in the shale?

17 A. 2.3 -- 4 metres.

18 Q. 39.01 taking away 37.6, -- 37.26
19 and I get 2.76?

20 A. Sorry. 2.74, 2.75. So, say 2.75.

21 Q. 2.75 metres. What is the
22 difference in water level elevation between those two
23 piezometers?

24 A. The static elevation ... 13 metres
25 roughly or 14 metres.



1 Q. We got 13.92, so let's call it 14
2 metres.

3 A. All right.

4 Q. What do you calculate to be the
5 gradient, the vertical gradient between piezometers 11
6 and 12 in WAT-3 at Site F?

7 A. Something very suspicious. It is
8 14 over -- what did we agree on -- 2.75, so about 5.

9 Q. Is that a strong downward
10 gradient, Dr. Charlesworth?

11 A. I think that would probably fall
12 into your ridiculously optimistic maybe, so I would say
13 it is a very strong gradient.

14 Q. I am not suggesting anything of
15 the sort. In fact, there is no reason to suspect that
16 that is not an accurately measured gradient in that
17 well, is there?

18 A. It suggests to me that there are
19 questions about the whole WAT series of piezometers as
20 we had some discussion about it, but that suggests to
21 me that you have virtually two separate systems there.

22 Q. What do you mean by "two separate
23 systems"?

24 A. If those are truly representing
25 the water in the formation at those two elevations,



1 then it would seem to me there is virtually no
2 connection between the two and you have got a flow path
3 here and a flow path here not connected (indicating).

4 Q. Are you suggesting that it doesn't
5 represent the strength of the downward gradient at that
6 point?

7 A. Well, certainly there is a
8 gradient across there, but it is such a strong gradient
9 that one has to wonder just what degree of connection
10 there is between the two.

11 Q. But it is possible to find
12 vertical gradients that high, even though they are
13 unusual, is it not?

14 A. Yes, it is possible.

15 Q. Dr. Charlesworth, I would like you
16 to look at a series of profiles, gradient profiles.
17 All that has occurred here is that one of my advisors
18 has taken the data on gradients. I am asking you if
19 you would to take this information, and perhaps we
20 could mark this as the next exhibit and then letter the
21 pages A, B, C, D and E?

22 MR. LANCASTER: This will be H-480.

23 MR. HODGSON: The first page would be
24 marked as A.

25 MR. LANCASTER: Very well.



1 ---EXHIBIT NO. H-480: Series of charts on Site F
2 (Numbered A to H)

3 MR. HODGSON: Q. You would see we have
4 plotted on the horizontal axis at the top the elevation
5 of piezometers in metres, and ...

6 A. I am sorry? The elevation?

7 Q. We have plotted across the top the
8 hydraulic head and we have plotted down the side the
9 depth in metres. What I would like to do very, very
10 quickly is run through these and just have you describe
11 for the Board, if you would, whether or not what you
12 find in these various boreholes is, or is not, a strong
13 downward gradient or perhaps an upward gradient.

14 Dealing first with HC-3, how would you
15 describe the gradients that we find here?

16 A. The first piezometer -- it would
17 be helpful if you have, and to save everyone some time,
18 if you happen to have the piezometer numbers, but this
19 is HC-3, and the first one on the right-hand side, and
20 I guess I could look. I guess that is No. 5 and what I
21 am asking there is that the dot on the right-hand side
22 of that graph is piezometer No. 5 and the next dot
23 presumably would be piezometer 3, I presume?

24 MR. ESTRIN: I don't think it is for the
25 witness to presume and perhaps Mr. Hodgson could assist



1 us.

2 MR. HODGSON: That is correct.

3 Q. The first is piezometer 5 then 3
4 then 2 then 1. How would you describe the change, or
5 how would you describe the gradient as between
6 piezometer 5 and piezometer 3?

7 A. That's quite a strong gradient.

8 Q. How would you describe, very
9 briefly, the other two gradients you find there?

10 A. There is also a strong gradient
11 from 2 to 1.

12 Q. I don't think we need to do from 3
13 to 2 because it is a short area?

14 A. I was just going to check to see
15 the significance of it.

16 Q. The point is over two measured
17 areas we have strong downward gradients at HC-3?

18 A. That's correct.

19 Q. Now, could we go to HC-4. Could I
20 have you briefly describe the strength of the gradients
21 that we find, the vertical gradients we find at HC-4?

22 A. Eyeballing it, we also have strong
23 gradients there and we have HC-4 and we have some
24 piezometers. Would you give me the piezometer numbers?

25 Q. Yes. They are four on the right,



1 3, 2 and 1?

2 A. We see a drop of about 2 metres
3 over 5 metres which is a gradient of nought .4 and then
4 we are seeing ...

5 Q. And .4 you agreed earlier was a
6 strong downward gradient?

7 A. Yes. Then there seems to be a
8 reduction in gradient and one really needs to know the
9 spacing and there seems to be a reduction in gradient
10 between 3 and 2 and then a strong gradient between 2
11 and 1.

12 Q. Can we go to HC-5. I am advised
13 that the dot on the top of the page is the third
14 piezometer, the dot to the right is the fourth
15 piezometer and then they go 2 and 1 to the left?

16 A. You were ahead of me. The dot at
17 the top of the page is ...

18 Q. ...3.

19 A. And to the right-hand side ...

20 Q. The right-hand side is 4, the
21 middle one is 2 and the left-hand end would be 1.
22 Let's ignore between 3 and 4 and look at between 4 and
23 2. How would you describe the gradient between
24 piezometer 4 and piezometer 2?

25 A. It seems to be a strong gradient.



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Q. And between 2 and 1?

A. It is also a reasonably strong gradient.

Q. Can we go to HC-6?

A. Yes.

Q. The piezometers here are 5 on the right-hand side, 3, then 4, then 2 and then 1?

MR. ESTRIN: Could you do that again?

MR. HODGSON: 5 is at the right-hand side, 3, 4, 2 and then 1.

Q. How would you describe the uppermost gradient from 5 to 3, Dr. Charlesworth?

DR. CHARLESWORTH: A. Well, that's a strong gradient, yes.

Q. And from 2 to 1?

A. It is a strong gradient. I have a question and I don't know if it was ever resolved and I didn't notice it in the transcript, but about the numbering of 3 and 4. It seemed to me at one point that probably 3 was located at a depth of 17 metres rather than 11 and it is strange if you look in the appendix the numbers go 1, 2, 3, 4, 5 from bottom to top except 3 and 4 are reversed. It is one of these little confusions that works into the data.

DR. KINGHAM: Isn't that the same case



1 at HC-5?

2 DR. CHARLESWORTH: Yes, it is as well.
3 It kind of throws you off when you try and make sense
4 of it all.

5 MR. HODGSON: Q. Looking at the
6 gradient from 4 to 2, how would you describe it?

7 DR. CHARLESWORTH: A. From 4 to 2 is a
8 much shallower gradient.

9 Q. And from 2 to 1?

10 A. It is a steeper gradient.

11 Q. Would you describe the gradient
12 from 2 to 1 as being a strong gradient?

13 A. It seems to be.

14 Q. Let's go to HC-8 and the
15 piezometers are 4 at the top and then 3, then 2, then
16 1. How would you describe the gradient between 3 and 2?

17 A. Steep.

18 Q. And between 2 and 1?

19 A. Also steep.

20 Q. Can we then go to WAT-3. I am
21 advised we start at the top at No. 1 and 2 over a
22 little bit to the left, then 4?

23 A. Four comes after 2?

24 Q. Four comes after 2, a wonderful
25 numbering system; 5, 6, 7 and sharply to the right to



1 8, 9, 10, sharply to the left to 11 and the last one is
2 12. Clearly the data here is a little noisier, I think
3 that is the expression that is sometimes used, but if
4 we could screen out some of the background noise, would
5 you agree the gradient drop between 1 and 2 is fairly
6 steep?

7 A. Yes, I would.

8 Q. And between 4 and 5?

9 A. Yes.

10 Q. And between 10 and 11?

11 A. Yes.

12 Q. And we have already talked about
13 the drop between 11 and 12, it is precipitous, isn't
14 it?

15 A. Yes.

16 Q. You would agree that we find
17 gradients in both directions at WAT-3?

18 A. That is correct.

19 Q. But in terms of the vertical
20 gradients they are strongly down?

21 A. I am sorry, could you repeat the
22 last part, where there are vertical gradients ...

23 Q. Where there are vertical gradients
24 they are strongly downward?

25 A. Yes, except we also have upward.



1 Q. How would you describe the trend
2 on this diagram?

3 A. I would say the trend there is
4 quite a mixture of upward and downward in the upper
5 part of the hole and then strongly downward in the
6 lower part of the hole.

7 Q. Overall from 1 to 12, how would
8 you describe the gradient?

9 A. Well, that is deceptive and that
10 comes back to the kind of discussion that we were
11 having at Site D.

12 Q. Overall, isn't it a downward
13 gradient here?

14 A. The head in 12 is a lot lower than
15 in 1, but between 1 and 12 you have some upward
16 gradients and it is a bit like saying if the gradient
17 from the top of the hill to my left, to the top of the
18 hill here is downward, but you are going down and up in
19 between.

20 DR. KINGHAM: The Board would like to
21 know that. You go from 1 to 12 and if you release a
22 ball at the top of the hill it will wind up at the
23 bottom?

24 DR. CHARLESWORTH: That is the question.
25 It is not going to get -- if you accept these values,



1 it is not going to go from 1 to 12, at least at that
2 particular point, because it won't get past where there
3 is an upward gradient.

4 MR. HODGSON: Q. You are suggesting
5 that by generalizing it the way I have, you could
6 really misconstrue the data significantly?

7 DR. CHARLESWORTH: A. Yes. I think that
8 that's a fair statement, but certainly from 10 to 12
9 there is a downward gradient.

10 Q. Can we now go to WAT-5, and
11 numbering the piezometers here I am instructed they go
12 from the right-hand at the top at 1, 2, 3, 4, 5, 6, 7,
13 8, 9, 10, 11 and then 12. How would you describe the
14 vertical gradients, Dr. Charlesworth, from 1 to 2 to 3
15 to 4 and to 5, those first four head drops.

16 A. You have strong downward gradients
17 between 1 and 5.

18 Q. Then you have upward gradients or
19 almost no gradient between 6 and 7?

20 A. That is correct.

21 Q. A slight upward gradient between
22 8 and 9?

23 A. Yes.

24 Q. Another slight upward gradient
25 between 11 and 12?



1 A. That is correct.

2 Q. How would you describe the
3 gradient between 9 and 11?

4 A. There is a downward gradient
5 between 9 and 11.

6 Q. Is it a weak gradient or a strong
7 gradient?

8 A. It is not as strong as from 2 to
9 4, but stronger than from 6 to 7 which is almost
10 horizontal. I am trying to recall, I think we actually
11 coloured these on the cross-sections we put up.

12 Q. You have the directions of flow
13 coloured?

14 A. Yes, to show it and which helps
15 clarify this up and down pattern that occurs in these
16 WAT holes.

17 Q. It is not the pattern I am asking
18 you about or disputing, but what I want you to describe
19 for the Board isn't the pattern of gradients but the
20 strength of the gradients?

21 A. We have strong downward gradients
22 in this case over the upper part of the borehole.

23 Q. Can we then look at WAT-7 and
24 numbering from the top at the right it goes 1, 2, 3,
25 and in fact it goes from 1 to 12 neatly without any



1 confusion?

2 A. Nine and 10 we concluded were not
3 functioning correctly, and I just wanted to check back
4 there. If you recall, we did test out them because we
5 were suspicious of the values. We were suspicious
6 about 9 and 10 and those were the ones we tested.

7 Q. Dr. Charlesworth, would you agree
8 that if 9 and 10 aren't working then we can scratch out
9 9 and 10 and draw a line from 8 straight to 11, and we
10 can measure the gradient change between 8 and 11, is
11 that right?

12 A. Yes, you could do that.

13 Q. I would like you then,
14 Dr. Charlesworth, to describe for the Board the
15 strength of the gradients between 2 and 5 and 7 and 11,
16 the downward gradients?

17 A. From 2 to 5 they seem to be quite
18 strong and from 7 to 11, recognizing that the more
19 piezometers you cut out the longer the section you are
20 extrapolating over and therefore the greater potential
21 for missing some pattern in there.

22 Q. Eyeballing the data here, what in
23 fact is the gradient between 7 and 11?

24 A. Between 7 and 11? I would rather
25 do it from this table if that's okay.



1 Q. From the table it is about 13
2 metres and change; is that right?

3 A. It is about 10 metres over 11
4 metres, from 7 to 11, so we appear to have a head drop.
5 We have a 112.5 static elevation in WAT-7(7) and we
6 have 102.98 in WAT-7(11) and so that is almost 10 and
7 the piezometers appear to be at 22.7 and 33.8 and so it
8 seems to be about 10 metres over 11 metres, almost
9 unigradient.

10 Q. We agreed when we started our
11 discussion about vertical gradients that it is unusual
12 to find a vertical gradient above one?

13 A. Yes.

14 Q. And one is a very, very strong
15 downward gradient?

16 A. Yes, we agreed on that.

17 Q. So what we find in at least a
18 portion of this borehole, are again strong downward
19 gradients?

20 A. That is correct.

21 Q. Finally we find at the bottom of
22 the hole an upward gradient from 12 to 11?

23 A. That is right, and also of course,
24 from 5 to 6, we shouldn't overlook that. From 5 to 6
25 where we have a drop of only .2 of a metre over 3



1 metres.

2 Q. Dr. Charlesworth where we find a
3 very strong downward vertical gradient, from 7 to 11,
4 then an upward gradient from 12 to 11, what does that
5 suggest that 11 is screened in?

6 A. Well, it is conceivable, although
7 I would be reluctant because of the problems with 9 and
8 10 and what they really represent, but it is
9 conceivable that 11 is a zone which flow is occurring
10 through and you are having movement from both above and
11 below into that flow zone.

12 Q. Now, could I ask you to put up
13 another overhead. This is yet another section of
14 Dr. Cherry's and Dr. Freeze's publication.

15 MR. LANCASTER: Who is going to file
16 the balance of the book here?

17 MR. FEENSTRA: I can get some
18 autographed copies.

19 MR. LANCASTER: That will be H-481.

20 MR. HODGSON: I have the balance of the
21 book, but if I file it I will have to cross-examine on
22 the whole thing, and I think we can agree it would be
23 better to do it a little bit at a time and not put,
24 perhaps, the whole thing in.

25 MR. LANCASTER: The Board was thinking



1 they might subpoena Dr. Cherry.

2 MR. HODGSON: That sounds like an
3 excellent idea, then we could all go home.

4 ---EXHIBIT NO. H-481: Extract from book by
5 Drs. Cherry & Freeze

6 MR. HODGSON: Q. Dr. Charlesworth, you
7 will recognize on the overhead that this overhead
8 contains an abstraction from the pages of Dr. Cherry
9 which I handed out and the figure at the top is Figure
10 6.2(a) from page 196 of Dr. Cherry's book, and that was
11 the figure we looked at when we started cross-
12 examination on Thursday?

13 DR. CHARLESWORTH: A. Yes.

14 Q. And then Figures 6.4(a) and (b)
15 appear as the second and third figures on the overhead
16 and they appear as the top two figures on page 198 of
17 Dr. Cherry's text; is that correct?

18 A. That is correct.

19 Q. I wonder, Dr. Charlesworth, if you
20 would assist me in reading portions of the text that
21 surrounds these figures and then relating what
22 Drs. Cherry and Freeze have to say in their text with
23 the figures on the board so you could assist the Board,
24 this Board, in understanding what these figures are
25 describing about variations in groundwater regimes we



1 find in various topographies and flow systems?

2 A. I will do my best.

3 Q. Starting on page 195 of the text,
4 and I wonder if the overhead could be marked as H-481A
5 as everyone has a copy of it in H-481, but it may be
6 necessary to find it?

7 MR. LANCASTER: It is not the same
8 page, I notice, but H-481A.

9 ---EXHIBIT NO. H-481A: Three charts from Exhibit H-481

10 MR. HODGSON: Q. Reading under the
11 section on page 195, the Effect of Topography on
12 Regional Flow Systems. You will notice in looking over
13 the page that we are referring really to the top figure
14 on H-481A as well as perhaps the second figure, but it
15 is the top I want to concentrate on:

16 "Figure 6.2 shows the flow nets for two
17 vertical cross sections that are
18 identical in depth and lateral extent.
19 In both cases there is a major valley
20 running perpendicular to the page at the
21 left-hand side of the system, and an
22 upland plateau to the right."

23 So, referring to the diagram, Dr. Charlesworth, would
24 you agree that what Dr. Cherry is depicting at the top
25 of this overhead is an upland plateau to the right?



1 DR. CHARLESWORTH: A. Yes.

2 Q. And a major valley running
3 perpendicular to the plateau and off to the left, is
4 that right?

5 A. Perpendicular to the page, yes.

6 Q. Like a river valley?

7 A. Or a lake.

8 Q. To continue from the text:

9 "In Figure 6.2(a) ..."

10 That is the top figure on the overhead:

11 "...the upland water-table
12 configuration, which is assumed to
13 closely follow the topography, has a
14 uniform gentle incline such as one might
15 find on a lacustrine plain."

16 You would agree that a lacustrine plain is a plain with
17 more or less homogeneous geological materials?

18 A. At the surface; and this is
19 referring to the surficial deposits, flat lying
20 surficial deposits.

21 Q. Lacustrine materials aren't
22 bedrock, are they?

23 A. No.

24 Q. "Figure 6.2(b), on the other hand,
25 has a hilly upland water-table



1 configuration such as one might find in
2 a glacial terrain."

3 Reading on:

4 "The uniform water table produces a
5 single flow system. The hinge line lies
6 on the valley wall of the major valley;
7 the entire upland plateau is a recharge
8 area."

9 So we find recharge to the right and discharge to the
10 left?

11 A. That's right.

12 Q. "The hilly topography produces
13 numerous subsystems within the major
14 flow system. Water that enters the flow
15 system in a given recharge area may be
16 discharged in the nearest topographic
17 low or it may be transmitted to the
18 regional discharge area in the bottom of
19 the major valley."

20 And then continuing:

21 "Toth (1963) has shown that as the depth
22 to lateral extent of the entire system
23 becomes smaller and as the amplitude of
24 the hummocks becomes larger, the local
25 systems are more likely to reach the



1 basal boundary, creating a series of
2 small independent cells such as those
3 shown in Figure 6.1. Toth (1963)
4 suggests that on most flow nets and in
5 most field areas, one can differentiate
6 between local systems of groundwater
7 flow, intermediate systems of
8 groundwater flow, and regional systems
9 of groundwater flow, as schematically
10 illustrated in Figure 6.3"

11 And that's at the bottom of the page?

12 A. Fine.

13 Q. "Where local relief is negligible,
14 only regional systems develop. Where
15 there is pronounced local relief, only
16 local systems develop. These terms are
17 not specific, but they provide a useful
18 qualitative framework for discussion."

19 Stopping there, Dr. Charlesworth, in your evidence you
20 have distinguished between a regional flow system and a
21 local flow system, and I wonder whether or not you
22 would agree with the statement that where local relief
23 is negligible, only regional systems develop.

24 A. I would agree with that statement.

25 Q. Where there is pronounced local



1 relief only local systems develop?

2 A. I am not sure if I would agree
3 with that statement because then we get into the whole
4 concept of what is local and what is regional.
5 Certainly on the scale of the drawing he has there,
6 yes, I will agree with it in the context that he is
7 using it there.

8 Q. What I am using this passage to
9 try and understand is the evidence you have been giving
10 about Site F and what I am trying to do is understand
11 how you have used these terms in relation to Site F.

12 Now, if I could frame my question then
13 you can go ahead. You have agreed that in effect, I
14 think, that where there is more local relief it is less
15 likely that you are going to have -- you will be
16 looking at a regional flow system and more likely you
17 will be looking at a local flow system?

18 A. Yes.

19 Q. We are talking a matter of degree?

20 A. I would agree.

21 Q. At some point in changing the
22 relief you pass from a situation where you can describe
23 it in terms of regional flow and it becomes necessary
24 to look at particular geographical locations as a local
25 system rather than a regional system.



1 Do you not agree that at Site F the
2 topography is sufficiently extreme that what we have to
3 examine is a local flow system rather than a regional
4 flow system?

5 A. I think at Site F that the relief
6 is such that the major flow system existing there is a
7 local flow system, a very shallow system, and we go
8 back to this discussion of the shallow system and I
9 think the kind of pattern you see in 6.2(b) exists
10 within the hill and gully structure we have on-site,
11 and the vast majority of the infiltration that goes
12 into the ground at Site F will come out within a very
13 short distance and so I feel you have a very local
14 system that is the major system superimposed on a
15 regional system. I would agree to that point, but I
16 think it is a very local system.

17 Q. How deep is this very local
18 system?

19 A. That is an interesting question.
20 If you took it in its idealized sense, much like they
21 have shown there, it may be a matter of -- someone
22 suggested, and it is not unreasonable, that the depth
23 of the active system below the creeks may be something
24 equivalent to the height of the mound between the
25 valleys.



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It may be the nature of the shale is such that you don't actually have this local pattern of going down and coming up into the stream, but it is controlled by the structures within the shale.

Q. Doesn't that sort of follow intuitively, Dr. Charlesworth, that where the bedding planes of the shale are horizontal but the ground surface is sloped at something in the order of 2 per cent or something in that area up by the site itself, that bedding planes are going to constantly outcrop at



1 the interface with the surface of the earth?

2 A. Yes.

3 Q. So the water that seeps vertically
4 into the bedding planes, if it finds a more permeable
5 zone will then move horizontally along the bedding
6 plane and it will outcrop?

7 A. Exactly. I think that's a major
8 factor which keeps almost all of the recharge within
9 the very shallow system, and I say very shallow system,
10 just a matter of metres.

11 Q. Agreeing with you that in fact
12 that is the case, that most of the recharge is handled
13 on the very shallow flow system, we have just looked at
14 a series of head profiles, and I am instructed that
15 Exhibit H-480 constitutes head profiles, and are you
16 familiar with that term?

17 A. These were your plots of head,
18 yes.

19 Q. You agreed the head profiles show
20 we have very strong downward gradients?

21 A. Once you get below this very
22 active, very shallow system, yes.

23 Q. Strong downward gradients don't
24 tell us how much water is going down, and for the
25 purposes of this question I am not disputing your



1 evidence that most of the water is being handled by the
2 shallow flow system, but some portion of that water is
3 not being handled by the shallow flow system and some
4 portion is moving down through the shale, would you
5 agree?

6 A. Yes, I agree.

7 Q. There are very strong downward
8 gradients pulling it down?

9 A. Yes, there are.

10 Q. In fact those strong downward
11 gradients are created in part by the topographic relief
12 at this site, are they not?

13 A. I think those strong downward
14 gradients would move beyond the local patterns, and I
15 am pointing, for example, to Exhibit H-40-D21 which is
16 a profile across the site and down to the lake. We
17 have now moved down beyond these shallow, going down
18 and moving laterally and coming up and we are into a
19 bigger system in my opinion. So, you have downward
20 gradients that will take the water down certainly.

21 Q. Would you agree with me that the
22 topography of this site does make it necessary to
23 consider at least the possibility that we are dealing
24 with a local system rather than a regional system?

25 A. I think so. I think that that is



why I suggested that we consider this shallow, but not quite so shallow -- an upper active zone within the shale which we have gone through, how I constructed that. I thought it was prudent for modeling purposes to model that, although I think most of the activities in an even shallower system, that comes back up on site and the balance goes down in a regional system and moves towards the lake.

Q. Could we continue reading on page 196:

"Figure 6.2 and 6.3 make it clear that even in basins underlain by homogeneous, isotropic, geologic materials, ..."

And what we don't have at Site F are homogeneous, isotropic, geologic materials, but even where you have them:

"...topography can create complex systems of groundwater flow. The only immutable law is that highlands are recharge areas and lowlands are discharge areas. For most common topographic configurations, hinge lines lie closer to valley bottoms than to ridge lines. On an areal map, discharge areas commonly constitute only 5-30% of



1 the surface area of a watershed."

2 Do you agree that the only immutable law is that
3 highlands are recharge areas and lowlands are discharge
4 areas?

5 A. Yes.

6 Q. What we have at Site F is a
7 recharge area?

8 A. Yes.

9 Q. What we have to address and answer
10 to this Board, is where that discharge is going to
11 occur?

12 A. That is correct.

13 Q. It is going to occur somewhere
14 below the recharge area?

15 A. That is correct, but bearing in
16 mind all the time that you have to know which system
17 you are talking about, a local or intermediate or deep
18 system.

19 Q. Now, we have focused in that
20 section ...

21 A. Could I go back because you made a
22 point when you said that this is anisotropic and
23 inhomogeneous, but when we are looking on a regional
24 scale certainly it is anisotropic, but we must not lose
25 sight of the fact that the Queenston shale on a



1 regional basis, and I could refer to the work of Caley
2 who mapped the Queenston shale and his memoir, and I
3 think the reference is Memoir 224 of the Geological
4 Survey of Canada, but he said the Queenston shale, and
5 I can remember the exact quote, but it is to the
6 effect, that it was remarkable for its uniformity both
7 in lateral and vertical extent, or words to that
8 effect. So when we are looking at a regional scale,
9 let's be careful when we start talking about the in-
10 homogeneity of it.

11 Q. Who was the person you were
12 quoting, Calley?

13 A. C-a-l-e-y. This is an old work,
14 he did his mapping back in the 1930's.

15 Q. Do you think he instrumented the
16 shale?

17 A. He wasn't doing the hydrogeology,
18 but was looking at it on a geological basis and just
19 the observation that it was worth keeping in mind on a
20 regional scale and it may not be as inhomogeneous as we
21 are inclined to say.

22 Q. Keeping in mind that we are on a
23 regional scale, let's go the next section of this text
24 on page 197 entitled Effect of Geology on Regional Flow
25 Systems. We are now moving from topography to geology



1 which is where we were Thursday afternoon:

2 "Figure 6.4 ..."

3 You have the first two sections of 6.4 on the overhead:

4 "...shows a sampling of numerically
5 simulated flow nets for heterogeneous
6 systems. Comparison of Figures 6.4(a)
7 and 6.2(a) shows the effect of the
8 introduction of a layer at depth with a
9 permeability 10 times that of the
10 overlying beds. The lower formation is
11 an aquifer with essentially horizontal
12 flow that is being recharged from above.
13 Note the effect of the tangent law at
14 the geologic boundary."

15 Do you know what the tangent law at the geological
16 boundary refers to?

17 A. Oh, yes. It is the equivalent --
18 I can't give it to you exactly, but it has to do with
19 refraction of flow at the boundary when you go from a
20 zone of one permeability to another and in light I
21 believe it is Snell's law, and I believe it's the sign
22 is the governing factor, but in groundwater flow you
23 can show it is the tangent of the angles which is the
24 factor which governs it. I would have to look it up to
25 give you more detail than that.



1 Q. I didn't mean this to be a final
2 examination in hydrogeology, notwithstanding you have a
3 Ph.D.

4 A. The final examination was easy.
5 This is probably the hardest.

6 Q. Let's go back to the second
7 sentence in the paragraph and I would like to read it
8 and have you look at the top two figures on H-481A
9 which is behind you and I would like you to describe
10 it:

11 "Comparison of Figures 6.4(a) and 6.2(a)
12 shows the effect of the introduction of
13 a layer at depth with a permeability 10
14 times that of the overlying beds."
15 Could you point out, first of all, in the second figure
16 where the layer of higher permeability is?

17 A. Yes, Mr. Chairman. Here at the
18 bottom of the section we have K equals the head and
19 this is a more permeable horizontal layer underneath
20 the layer which has one-tenth of the permeability.

21 Q. What happens to the flow system
22 when you introduce a more permeable layer which is only
23 more permeable by a factor of 10. Can you describe the
24 difference between the top two figures on H-481A?

25 A. We have more of a horizontal



1 component and you still have some vertical gradients in
2 the less permeable zone here, very slight vertical
3 gradients, and the flow becomes more horizontal in the
4 higher permeability zone.

5 Q. Going to the right-hand end of the
6 diagram, the potentiometric lines are much closer
7 together, is that correct?

8 A. Yes.

9 Q. That suggests much stronger
10 downward gradients?

11 A. Yes.

12 Q. Those downward gradients are in
13 fact created by the permeable zone?

14 A. By that permeable zone, yes.

15 Q. Can we read on:

16 "If the hydraulic conductivity contrast
17 is increased ..."

18 And that is 6.4(b) and the hydraulic conductivity of
19 that lower more permeable zone has gone from K equals
20 10 to K equals 100?

21 A. Right.

22 Q. We have two orders of magnitude
23 change in permeability between the upper zone and the
24 lower zone?

25 A. That is correct.



1 Q. "...the vertical gradients in the
2 overlying aquitard ..."

3 In relation to the highly permeable materials the
4 materials are described as an aquitard and what is an
5 aquitard?

6 A. An aquitard is almost the opposite
7 to an aquifer and instead of bearing water it tends to
8 slow down or resist the movement of water, or retard
9 it.

10 Q. So the weathered till at Site D
11 would be considered to be an aquitard, would it not?

12 A. The weathered till?

13 Q. Not the weathered till but the
14 unweathered till at Site D?

15 A. Yes, the till you would consider
16 an aquitard.

17 Q. "...the vertical gradients in the
18 overlying aquitard are increased and the
19 horizontal gradients in the aquifer are
20 decreased. The quantity of flow, which
21 can be calculated from the flow net
22 using the methods of Section 5.1, is
23 increased. One result of the increased
24 flow is a larger discharge area, made
25 necessary by the need for the large



1 flows in the aquifer to escape to the
2 surface as the influence of the left-
3 hand boundary is felt."

4 Forgetting about the left-hand boundary and focusing on
5 the right-hand boundary, isn't it the case that when
6 you have large permeability contrasts between the upper
7 materials and the lower geological materials, the first
8 thing you find is very strong downward gradients
9 because the water is pushing to get down to that more
10 permeable zone?

11 A. Well, that is not necessarily the
12 only occasion on which he would have strong vertical
13 gradients, but yes ...

14 Q. That is one occasion?

15 A. That is one occasion.

16 Q. That is the occasion shown on H-
17 481A in the second and third examples?

18 A. Yes.

19 Q. We go from the top example where
20 there is no underlying more permeable zone to the
21 second example where the underlying more permeable zone
22 is only more permeable by a factor of 10, and we can
23 see from the top to the second diagram a great change
24 in terms of the strength of the downward gradients at
25 the right-hand end of the diagram, can we not?



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A. Yes.

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Q. Then we go to the third diagram

where we have a permeability contrast of two orders of magnitude and now the flow lines are almost running together at the right-hand side of the diagram and you get very, very strong downward gradients and you get them because of that permeability contrast; isn't that right?

A. That is correct, yes.

Q. Now, could we jump the next three paragraphs which describe the last three figures on the next page and I don't really want to get into them, but go to the last paragraph on page 197:

"Subsurface stratigraphy and the resulting subsurface variations in hydraulic conductivity can exist in an infinite variety. It should be clear from these few examples that geological heterogeneity can have a profound effect on regional groundwater flow. It can affect the interrelationship between local and regional systems, it can affect the surficial pattern of recharge and discharge areas, and it can affect the quantities of flow that are



1 discharged through the systems."

2 Do you agree with that, Dr. Charlesworth?

3 A. Certainly.

4 Q. "The dramatic effects shown on
5 Figure 6.4 are the result of
6 conductivity contrasts of 2 orders of
7 magnitude or less. In aquifer-aquitard
8 systems with greater contrasts, flow
9 patterns become almost rectilinear, with
10 horizontal flow in the aquifers and
11 vertical flow across the aquitards."

12 Do you agree with that, Dr. Charlesworth?

13 A. I am sure I do, but let me reread
14 it. Yes.

15 Q. Now, let's back to Site F...

16 A. Right.

17 Q. ...and leave H-481A up on the
18 board for a moment. Let's first review what we have
19 discussed in this cross-examination so far and which
20 you have agreed to. With regard to geology, looking
21 only at the results in HC-4, we see there are zones in
22 the shale that are much more fractured and zones in the
23 shale that hardly show fracturing at all, and in fact
24 on Thursday you were kind enough to point out to the
25 Board that there was one five-foot core without a



1 fracture?

2 A. That is correct.

3 Q. So, in the ground at Site F, we
4 have got geological materials that are very
5 heterogeneous, are they not?

6 A. Yes, I think that is a fair
7 statement.

8 Q. Secondly, we have looked at packer
9 test results --

10 A. I am sorry, we have geological
11 materials and the geological materials are not
12 heterogeneous but the fractures within the materials
13 are such that they introduce a heterogeneity, but I
14 wouldn't say the geological materials themselves are
15 very heterogeneous.

16 Q. We wouldn't describe it as a
17 homogeneous flow system?

18 A. I wouldn't describe it as a
19 homogeneous flow system.

20 Q. Secondly we looked at packer test
21 results and Hvorslev test results and pumping test
22 results and you agreed with me that those three methods
23 for testing hydraulic conductivity demonstrated that
24 what we find in the geological materials at Site F are
25 permeability contrasts of at least five orders of



1 magnitude?

2 A. Based on those results, yes, that
3 is correct.

4 Q. Then we looked at the vertical
5 gradients and we found the vertical gradient as high as
6 five and certainly we found in virtually -- we found in
7 every borehole we looked at on Exhibit H-480 some
8 strong vertical gradients, did we not?

9 A. Yes.

10 Q. Some very strong vertical
11 gradients?

12 A.. Yes.

13 Q. In fact, Dr. Charlesworth, we
14 found, looking at H-480, exactly the same kind of
15 strong vertical gradients you would expect to find
16 looking at H-481A that is behind you, did we not?

17 A. I think rather than just answering
18 yes to that, Mr. Chairman...

19 Q. Can you answer yes to that and
20 then give us the explanation so I don't forget?

21 A. Yes, we found strong vertical
22 gradients and you have strong vertical gradients here.
23 However, I am not quite sure where this is actually
24 taking us. This kind of drawing is something that is
25 actually superimposed on a regional kind of system, as



1 I understand it, and it is sort of postulating an
2 aquifer structure at depth beneath the whole system,
3 and that would be equated to this kind of situation
4 here.

5 MR. ESTRIN: You had better clarify for
6 the record what you are saying "this" is?

7 DR. CHARLESWORTH: The kind of system we
8 are looking at on Exhibit ...

9 MR. HODGSON: Q. ...H-481A.

10 DR. CHARLESWORTH: A. On H-481A.

11 Q. Perhaps you had better write it on
12 the document?

13 A. Yes. To me ...

14 MR. ESTRIN: For the record, you are
15 specifically looking at what part of the overhead?

16 DR. CHARLESWORTH: I am looking at (b),
17 for example. This seems to be more in a regional
18 context, but I suppose you could have that kind of
19 situation on a local context. The problem I have had,
20 and I can go back and check these tables you have given
21 me here, but the scenario of vertical gradients I have
22 looked at at Site F does not clearly fit this pattern,
23 but even within -- I did not see a clear pattern of
24 downward gradients and lateral gradients that
25 consistently fit the Trow scenario.



1 I see some instances where within the
2 highly fractured zone we still have downward gradients
3 and I feel it is actually stretching it somewhat to fit
4 that to their scenario. I notice on page 198, one of
5 the diagrams that was not discussed and which is 198(d)
6 might, and I am throwing this in, but if you wanted to
7 postulate a flow system that fit Trow's model, I would
8 be sort of more comfortable with 198(d) where you have
9 a zone of limited extent and some downward gradients
10 into it and you will notice on the right-hand side and
11 then lateral movement within that zone and a more
12 diffuse movement out of that zone. It is very
13 difficult to go from these idealized situations to the
14 real situation at Site F, but ...

15 MR. McQUAID: Could I jump in for a
16 moment. Mr. Estrin asked us to ask what was being
17 compared and I think in July when we are reading this
18 we want to be sure we understand. Earlier, Dr.
19 Charlesworth pointed to either 6(a) or 6(b) and said
20 this relates to that which was H-40-D21 and I would
21 just like to go back, and I think it was 6(a) but it
22 might have been 6(b) which relates to H-40-D21.

23 DR. CHARLESWORTH: I was talking,
24 Mr. Chairman, about this whole concept being presented
25 in the three figures; it seems to me, the three figures



1 on H-481A, whatever the details, you are looking at it
2 in a regional context which is more comparable to the
3 scale of H-40-D21, for example, which is a profile from
4 the site to the lake.

5 MR. HODGSON: Q. Don't you agree that
6 Site F most closely resembles the last figure on H-481?
7 Haven't we got a situation at Site F where we have
8 permeability ...

9 MR. ESTRIN: H-40?

10 MR. HODGSON: H-481A, the overhead.

11 Q. Haven't we got permeability
12 contrasts within the geological materials not of two
13 orders of magnitude but of 5 orders of magnitude, and
14 don't we have very, very strong downward gradients on-
15 site? Don't we, in fact, have that very situation at
16 Site F?

17 DR. CHARLESWORTH: A. I don't think you
18 do. As I say, if anything, I would liken it to 6.4(d)
19 which is a zone that Trow postulated of finite extent.

20 Q. But 6.4 -- the (d) figure you are
21 pointing out on page 198 shows the more permeable zone
22 going halfway across the figure?

23 A. Yes.

24 Q. Can we confine our discussion for
25 the moment to what's going on on the site itself?



1 A. Right.

2 Q. What you are pointing out is a
3 situation where perhaps the more permeable zone doesn't
4 make it all the way to the discharge area, the lake, or
5 whatever. Can't we agree at Site F there is a more
6 permeable zone and in fact, Dr. Charlesworth, you
7 cannot explain the strong vertical gradients at Site F
8 unless you accept that there are more permeable zones
9 in that shale and whether you accept Trow's
10 interpretation of those more permeable zones, doesn't
11 the data force you to the conclusion there are more
12 permeable zones at Site F?

13 A. Yes. That I have no trouble
14 agreeing with. There are more permeable zones.

15 Q. All right. Let's go back. Don't
16 we then have to agree, Dr. Charlesworth, that the
17 geology, the hydrogeology and the topography at Site F
18 all combine to lead us to the conclusion that the flow
19 system has very strong vertical gradients and has
20 horizontal features as well?

21 A. Yes. Just to go back to the point
22 on the more permeable zone, Mr. Chairman, and I don't
23 want the Board to get the wrong impression, but there
24 is still the question about how extensive they are and
25 where they lead and what they are connected to, and



1 that is the point I was trying to make here. I
2 haven't seen evidence there is a continuous zone that
3 has an outlet at either end.

4 Q. And in fact, isn't this really the
5 same theory that is being postulated at Site D, you
6 have a less permeable zone on top and a more permeable
7 zone below which is underdraining the less permeable
8 zone and you get fairly strong downward gradients at
9 Site D as well.

10 A. I don't quite see the connection
11 there. I think there are major differences between the
12 two sites and you can talk in generalities.

13 Q. I agree there are major
14 differences, but the issue is whether they have this in
15 common, that there are substantial permeability
16 contrasts in the geological materials deposited on the
17 sites and those substantial permeability contrasts lead
18 you to the conclusion that you would expect to find
19 strong downward gradients on the sites, and in fact you
20 found strong downward gradients at both Site D and Site
21 F; isn't that right?

22 A. We find downward gradients.

23 Q. They are not as strong at Site D;
24 do you not agree?

25 A. Not as strong as Site D.



1 Q. I am sorry. Site D's downward
2 gradients are not as strong as at Site F?

3 A. They are not as strong, and I
4 would have to check the number, but if you are
5 extending the analogy, then I guess what you are saying
6 is that you have a highly fractured zone and you have
7 an upper granular unit and the two are playing a
8 similar role. I am not clear what you are asking me to
9 agree to.

10 Q. I am asking you to simply agree
11 that on a simple level and to understand the hydro-
12 stratigraphy at either site, we must understand the
13 permeability contrast between the geological materials
14 deposited on the sites and the permeability contrasts
15 leads to there being downward gradients at both sites
16 and, in fact, reflect -- are reflective of the fact
17 that there are more permeable zones at both sites.

18 I don't want to take the comparison any
19 farther than that, but I do want to take it that far.

20 A. It is possible that the downward
21 gradients are due to flow moving down at Site D, for
22 example, because they are moving down into a more
23 permeable zone from which it is then able to flow away.
24 Yes, I can accept that.

25 Q. Let's leave Site D for a moment



1 and go back to Site F.

2 MR. LANCASTER: Would you like to do
3 that a little later ...

4 MR. HODGSON: That would be quite
5 satisfactory and we could go back to it later.

6 DR. KINGHAM: I wonder before we do
7 that, however, Dr. Charlesworth, we are anxious to have
8 your best evidence on this whole situation of
9 gradients, and Mr. Hodgson put to you Exhibit H-480 and
10 you gave your opinions on gradients on H-480. I wonder
11 if when you did that you noticed that the vertical
12 scale, while constant throughout, the horizontal scale
13 varies by as much as 6 to 1 between 480F and 480G. I
14 wonder if you would review that over the coffee break
15 and confirm for us your sense of those gradients, just
16 so we have your answer.

17 DR. CHARLESWORTH: I will certainly do
18 that. As you probably appreciate, it is sometimes
19 difficult to observe everything up here.

20 DR. KINGHAM: It is difficult to check
21 all of those things on the spot, so to speak, but we
22 would like your best evidence.

23 MR. LANCASTER: Mr. Hodgson, are there
24 copies of exhibits that are to be filed, 477, 479, they
25 were both overheads and were there copies made of



1 those?

2 MR. HODGSON: I don't have my list, but
3 is 479 the same as 481? Was 479 an overhead of one
4 element of hydrostratigraphy? 479 is in fact
5 incorporated into the photocopy you have in 481.

6 DR. CHARLESWORTH: 477 is the one I have
7 here.

8 MR. HODGSON: 477 is incorporated into
9 481 and you have a copy of that, and what is 479? That
10 was Mr. Estrin's exhibit.

11 MR. LANCASTER: Yes, 479. All right.
12 15 minutes.

13 ---Recess

14 MR. LANCASTER: Please be seated.

15 MR. ESTRIN: Here are the exhibits. The
16 original overhead of 479.

17 DR. KINGHAM: That is the one that has
18 the A, B and C series.

19 MR. ESTRIN: Do you want the overheads?

20 DR. KINGHAM: We wanted to have at least
21 one of 479, 479A and 479B.

22 MR. ESTRIN: Perhaps we can do these
23 over lunch and sort them out.

24 DR. KINGHAM: Very well.

25 MR. HODGSON: Q. To go back to the



1 point that Dr. Kingham made just before the break, I
2 did want to point out that these head profiles, Exhibit
3 H-480, they were prepared in April -- sorry, August by
4 Mr. Feenstra who was doing it for his own edification
5 and for no other purpose, and it turned out they were
6 useful for this purpose. I apologize for the fact
7 there are changes in the horizontal scale and the
8 vertical scale is always constant, but the only change
9 of any significance is in WAT-5 and if you wouldn't
10 mind now or over lunch simply checking the vertical
11 gradients in WAT-5 and satisfying yourself that when
12 you told us earlier you found strong downward gradients
13 that you don't wish to now change your mind based on
14 what you have calculated.

15 I thought as I took you through the
16 evidence that you were in fact eyeballing the numbers
17 and not looking at the slope, in fact, I am certain I
18 saw you do that?

19 DR. CHARLESWORTH: A. I did intend to
20 do that, but I should add, and I guess this applies to
21 all witnesses, but when you are faced with this kind of
22 thing you may actually agree to something when you are
23 up here and when you subsequently sit down and analyze
24 it you may have second thoughts. So anything I said I
25 would qualify it as I am giving you my first impression



1 on being faced with this data.

2 MR. LANCASTER: Quite understandable.

3 DR. KINGHAM: I wasn't thinking in any
4 way you might change your mind on Figure G, but I
5 wanted to be sure that where you said strong downward
6 gradients you meant it in the context of that different
7 horizontal scale.

8 DR. CHARLESWORTH: I appreciate you
9 pointing that out.

10 MR. HODGSON: Q. Now, if we could go
11 back a minute to what we have been discussing, in the
12 model of the hydrostratigraphy which you made available
13 to Dr. Rowe so he could do his modeling at Site F, you
14 have assumed homogeneous materials with a uniform
15 hydraulic conductivity of 4.5×10^{-6} and a horizontal
16 gradient of .035, is that right?

17 DR. CHARLESWORTH: A. That is right.

18 Q. Would you not agree,
19 Dr. Charlesworth, that that model of the
20 hydrostratigraphy at Site F ignores the geology which
21 is not homogeneous, it ignores the high variability in
22 the hydraulic conductivity of the geological materials,
23 it ignores the strong vertical gradients, or it ignores
24 the vertical gradients altogether, and it ignores the
25 basic flow system which we have looked at which was



1 described by Dr. Cherry and which you have agreed is a
2 flow system which describes the situation at Site F,
3 i.e., a flow system with very strong vertical gradients
4 resulting from high permeability contrasts in the
5 geological materials?

6 MR. ESTRIN: Now we have had a recital
7 of the Bible, perhaps we could take this question by
8 question, and perhaps Mr. Hodgson could put his
9 questions one at a time.

10 MR. HODGSON: Q. I don't have several
11 questions, I have one.

12 Q. Doesn't your model, the model you
13 have provided to Dr. Rowe for modeling Site F ignore,
14 No. 1, the geology, 2, the variability in the hydraulic
15 conductivity, No. 3, the vertical gradients and No. 4
16 the flow system to be expected from those vertical
17 gradients?

18 MR. ESTRIN: How about Dr. Cherry's flow
19 diagrams? Do you want to throw that in?

20 MR. HODGSON: I believe this is my
21 cross-examination and through you I would ask
22 Mr. Estrin not to interrupt. If he wants to object he
23 can stand up on his feet and make an objection, but
24 sitting down and making comments like that I find
25 unacceptable and I would like you to instruct him...



1 MR. LANCASTER: As I understand it, the
2 witness will consider them one at a time, as opposed to
3 as a package.

4 DR. CHARLESWORTH: That is correct. If
5 I don't hang myself with the microphone cord.

6 MR. HODGSON: Q. Let's take it one at a
7 time for Mr. Estrin. Does the model you proposed to
8 Dr. Rowe for modeling Site F ignore the fact there are
9 heterogeneous geological materials at Site F.

10 DR. CHARLESWORTH: A. It simplifies the
11 whole system, for example, in terms of hydraulic
12 conductivity and we have taken a mean value recognizing
13 there are zones within there of higher and lower value.

14 Q. Let's take it one at a time and I
15 will get to hydraulic conductivity next. Does it
16 ignore the fact that there is a lot of variability in
17 the geological materials at Site F, that they are not
18 homogeneous?

19 A. It doesn't consider the geology as
20 such. It considers the hydrogeology just as Trow's
21 model considers the hydrogeology. I am not sure it is
22 valid to say it ignores the geology.

23 Q. Does Dr. Rowe's model -- sorry,
24 does the hydrostratigraphic model which you proposed to
25 Dr. Rowe and which he used in his scenarios A and B,



1 take account of the fact that in the geological
2 materials at Site F there are zones that are highly
3 fractured and zones that show virtually no fracturing
4 at all?

5 A. It does not model the different
6 zones, no.

7 Q. Is it not true that the model
8 which you proposed to Dr. Rowe also ignores variations
9 in permeability of more than 5 orders of magnitude?

10 A. No, I wouldn't say it ignores the
11 variations. It encompasses the variations into a
12 simplified scenario recognizing, and I think I should
13 again preface the answers to these questions with the
14 statement I made earlier. Trow made a detailed --
15 attempted to do this detailed classification and did
16 much more detailed modeling in terms of these different
17 zones, but we were trying an alternative and in some
18 ways a conservative approach. We recognized they went
19 for the detailed stratigraphy and we went for a
20 simplified system, but certainly we encompassed the
21 variation in permeability by taking a mean of a wide
22 range of values.

23 Q. You have ignored -- your evidence
24 is not that you ignored the wide range of values, but
25 you have homogenized them into a single number?



1 A. Yes, that is correct.

2 Q. Dr. Charlesworth, how can it be a
3 valid exercise to simply take measured hydraulic
4 conductivity values from all over a site and average
5 them and say that that is the average value of the
6 materials at that site? Don't you at the very minimum,
7 if you are looking at hydraulic conductivities, have to
8 weight the findings as to hydraulic conductivity with
9 the amount of geological materials carrying that
10 conductivity?

11 A. You have to look at all the values
12 and you have to decide how you will handle it. Even in
13 Trow's detailed model they still took mean values of
14 hydraulic conductivity from different points across the
15 site and even in setting up their classification they
16 looked at some broad pictures. So, it is certainly a
17 reasonable approach as one possible approach to do
18 that.

19 Q. Dr. Charlesworth, didn't Trow
20 attempt to correlate variations in hydraulic
21 conductivity with variations in the geological
22 materials, and while it may be true they assigned mean
23 values to particular strata, they weren't suggesting
24 that all the strata could be put together in one big
25 glump, which is what you have, with one hydraulic



1 conductivity which is simply an average of all the
2 values over the site?

3 A. I have suggested that a shallow
4 zone be taken, and it is not the whole section down to
5 the bottom of the Queenston shale and, yes, they have
6 attempted to do this classification. I had some
7 difficulty going from the step from their geological to
8 their hydrostratigraphic and one of the factors I had
9 difficulty with was, for example, the hydraulic
10 gradients and, you know, the material you handed out
11 this morning, Exhibit H-480, and on that, for example,
12 and I haven't done a detailed analysis, but looking at
13 it on a superficial basis, or almost superficial
14 because this was just done briefly now, I can see where
15 the pattern of variations in gradient, the profile they
16 have shown in HC-6 does not readily fit their
17 hydrostratigraphic cross-section.

18 I think on my first examination it fits
19 better their hydrostratigraphic correlations and the
20 horizontal gradients they have on HC-6 seem, on first
21 look, to correspond more to their fractured zone from
22 the logging than their highly fractured zone from their
23 hydrostratigraphic interpretation.

24 Q. Dr. Charlesworth, Trow have been
25 cross-examined, and now we are dealing with your



1 evidence, and I am not suggesting that your evidence --
2 that you should adopt holus bolus Trow's interpretation
3 of the hydrostratigraphy strata for strata and line for
4 line and dot for dot. I am suggesting that you ignored
5 altogether the hydrostratigraphic variability at Site F
6 and you have homogenized the geological materials and
7 you have homogenized the permeabilities and you have
8 put it all together in one big glump and in fact you
9 have done that for the purpose of modeling?

10 A. We have certainly simplified it
11 and I think I said that at the beginning. This is a
12 simplified approach as an alternative to the Trow
13 scenario. I don't want to lose sight of that, this was
14 an alternative approach.

15 Q. I appreciate that. Thirdly,
16 Dr. Charlesworth, doesn't the model that you propose or
17 the model of the hydrostratigraphy that you propose for
18 Dr. Rowe to model, ignore the strong vertical gradients
19 at Site F?

20 A. Yes, and that as I indicated is
21 one -- it could be looked at as one of the conservative
22 factors. I believe, in fact, what doesn't reappear in
23 the very shallow system up at the surface we have
24 talked about, there will be a component of downward
25 movement down and out of the system we have modelled,



1 but we have assume it all moves laterally, so yes.

2 Q. In fact, in assuming that it all
3 moves laterally, aren't you modeling something other
4 than the flow system that one would expect to find at
5 any site with geological materials with such high
6 permeability contrasts and which we in fact find at
7 Site F with geological materials with such high
8 permeability contrasts. In fact, isn't the flow system
9 you are modeling completely different from the kind of
10 flow system to be expected and which in fact is found
11 at Site F?

12 A. I am not sure. For example, I
13 referred to the Morrison Beatty test pits which show
14 significant flows laterally above dry material in the
15 shale. Once you start to look at it on that scale,
16 then the whole -- there are local variations and it
17 becomes difficult to fit it in detail to a broader
18 picture.

19 Q. I am not suggesting,
20 Dr. Charlesworth, that interpreting the
21 hydrostratigraphy at Site F is simple and so I am not
22 asking you to provide us with a simple two minute
23 interpretation. What I am suggesting is that the
24 interpretation you proposed to Dr. Rowe for modeling,
25 so oversimplifies the situation at Site F that it bears



1 no resemblance to Site F?

2 A. No, I wouldn't agree that it bears
3 no resemblance.

4 Q. Would you put up Exhibit H-481A,
5 please. Just turn on the light.

6 A. The overhead.

7 Q. Would you agree with me that what
8 you propose Dr. Rowe to model more closely
9 resemble the find in the top figure than what we
10 find in the bottom figure on Exhibit H-481A?

11 A. As I indicated earlier, I am
12 having some difficulty following the line of
13 questioning and relating these which are a regional
14 kind of picture to a little piece of what we have
15 modelled which sort of fits in here somewhere.

16 MR. ESTRIN: Perhaps Dr. Charlesworth
17 could mark the overhead.

18 MR. HODGSON: Q. The purposes of
19 the record you are using a red pen on the top figure on
20 H-481A and showing us a portion of that figure which
21 has what, an idealized version of a landfill site?

22 DR. CHARLESWORTH: A. Even now I
23 hesitate to mark this because the whole scale of this
24 cross-section -- well, okay, I will say I could
25 envisage that the landfill would fit in here somewhere



1 and here I am trying to mark and we have modelled the
2 small part in there, but there is no interpretation of
3 that small section, but I am sure other people ...

4 Q. For completeness could you
5 transpose that same sort of drawing down to the third
6 one and show us in roughly the same scale the portion
7 of the diagram we are talking about?

8 A. On the third one it would be there
9 (indicating). I would say then that looking at those
10 two extremely idealized regional schemes, that the Trow
11 model doesn't bear any resemblance on that scale to
12 scenario ...

13 Q. We are not talking about the Trow
14 model but about Site F. Don't you agree that Site F
15 more closely resembles the third figure than the first
16 figure at the right-hand end, and don't we find at Site
17 F a very strong downward vertical gradients and don't
18 we find those strong downward vertical gradients
19 because we have very high permeability contrasts in the
20 geological materials at that site?

21 A. On the regional scale I would not
22 say, and looking at the regional scale, I wouldn't say
23 Site F resembled (b) with a deep more permeable zone
24 extending from the recharge area to the discharge area
25 down here. On a regional scale, no, I wouldn't agree



1 that that figure, figure (b) more closely resembles it
2 and I don't think that anybody has postulated that it
3 does. I haven't seen a scenario which has a high
4 permeability zone.

5 Q. Are you suggesting that higher
6 more permeable zones at Site F don't influence the flow
7 system at Site F?

8 A. No, I am not suggesting that.

9 Q. Would you not agree with me that
10 higher more permeable zones at Site F in fact influence
11 the flow system at Site F in the manner shown on the
12 third diagram on H-481A?

13 A. The way I shown it here, Site F is
14 this small red mark to the right-hand side.

15 Q. What we find below Site F at that
16 small red mark are very strong vertical gradients?

17 A. Yes.

18 Q. That is what we find at Site F in
19 Burlington, don't we?

20 A. We find strong vertical gradients,
21 but I know of now evidence that suggests there is a
22 permeable zone extending over a long distance at depth.

23 Q. Let's assume the permeable zone
24 doesn't extend such a long distance. There is evidence
25 there is a more permeable zone and it extends some



1 distance at Site F, doesn't it not?

2 A. There isn't evidence of a more
3 permeable zone. There is a lack of evidence to suggest
4 how extensive that zone is on a regional scale.

5 Q. But on a local scale there is
6 evidence to suggest there is a more permeable zone, do
7 you agree?

8 A. I would agree there is evidence --
9 yes, I would agree there is some evidence to suggest a
10 more permeable zone and I would also say that there are
11 difficulties in clearly identifying that zone and
12 fitting all the data to that zone. For example, as we
13 move down to the southern end of the site, south of
14 403, and you get into the vicinity of boreholes 14 and
15 15, we have downward gradients and so my thesis has
16 been that Trow may be correct and Trow's interpretation
17 may be correct in some aspects, and there are some
18 aspects I disagree with, but the data does not fit
19 perfectly, and I think you will find with any studies
20 done at this site the data will not fit perfectly, so
21 that is not a serious criticism.

22 Q. Let's go back. In the model of
23 the hydrostratigraphy which you proposed for Dr. Rowe
24 to model, there are no strong downward gradients, in
25 fact there are no downward gradients at all?



1 A. We have assumed poses
2 of that model that lateral flow pred ou must
3 also recognize that there are downwa and
4 there are lateral gradients and we h the
5 permeability values available for th are
6 essentially horizontal permeability the type
7 of testing that was done measures la ent of
8 water in or out of the formation. W these
9 values and have recognized the varia have
10 arrived at a mean value and simulate ly,
11 lateral movement, recognizing there ponent
12 that goes downward.

13 Q. So what you have e model
14 is ignore the vertical gradients and e
15 variability in permeability, you ha e
16 variability in the geological mater as rise
17 to the permeability, and you have ite
18 that has homogeneous geological m form
19 horizontal gradient and a uniform is that
20 right?

21 MR. ESTRIN: That tion
22 that Mr. Hodgson tried to put earl ble
23 being recited. If the witness can one
24 word he can certainly do that, but I
25 think it is important to understand as to



1 get the question down line by line in order to give an
2 accurate answer he is also entitled to do that.

3 MR. HODGSON: It is the same question
4 and we have already had the answers to the individual
5 components, so now we are getting an answer to the
6 whole question. I am sorry you weren't listening.

7 MR. ESTRIN: I wonder if Mr. Hodgson --
8 all I am asking is you to indicate to the witness that
9 he has those opportunities if he feels it necessary.

10 MR. LANCASTER: He gave that evidence
11 and that is the way he approached it, there is one
12 question but there are various parts he must consider.

13 MR. HODGSON: Let me try it a bit
14 differently.

15 Q. What we have from Dr. Rowe are the
16 outputs of his model and we have to ask ourselves the
17 question how reasonable are the outputs and how much do
18 the outputs in fact tell us about Site F? Somewhere
19 between the outputs and the inputs is the magic box and
20 we don't have the magic box or the arithmetic
21 mathematical equations and we don't have the computer
22 into which they are programmed, but we have Dr. Rowe,
23 the inputs and we have the outputs.

24 One of the inputs came from you, or I am
25 told it came from you, and that is the



1 hydrostratigraphic interpretation which is the
2 foundation for the model, is that right?

3 DR. CHARLESWORTH: A. I would hesitate
4 to say the hydrostratigraphic interpretation. Dr. Rowe
5 can obviously address what he has modelled.

6 Q. I will ask Dr. Rowe questions
7 about his models; I am not asking you to defend his
8 model?

9 A. Mr. Chairman, if I might finish
10 what I was saying. We looked or I looked at the
11 scenario and discussed -- Dr. Rowe talked about what he
12 thought might be a mechanism which was leading to
13 attenuation at this site, which was matrix diffusion as
14 you have heard, and we looked at a way that we could
15 test that hypothesis out and one way was to say if we
16 have a landfill, let's assume that any leachate that
17 comes down will move laterally in the groundwater
18 system and we assigned various values, and I am not
19 trying to claim any greater validity for those values
20 than they merit, but we took a mean value, we took a
21 gradient and Dr. Rowe put those into his model.

22 I think that is a fair representation
23 and that sums up what we did. We took mean values to
24 provide an alternative approach to this problem to come
25 up with an explanation or one possible explanation of



1 what mechanisms may be occurring at the existing sites
2 and what may occur at Site F.

3 Q. I know that, and I appreciate
4 that. The question we have to ask is whether or not
5 the results of the modeling exercise reflect anything
6 going on anywhere in the vicinity of Site F, and all we
7 have to look at are the output from the model and
8 inputs to the model, and one input is your input, the
9 hydrostratigraphic interpretation.

10 What I want to know from you,
11 Dr. Charlesworth, is what value is the output of Dr.
12 Rowe's model if what has been modelled at Site F is a
13 hydrostratigraphic regime with homogeneous materials,
14 with a uniform K value and only horizontal gradients.

15 Now, let me finish the question. In
16 fact, what we know about Site F is that it has
17 heterogeneous geological materials with very high
18 vertical gradients and an enormous variability in the
19 hydraulic conductivities of the materials on the site.

20 The question is what good is the output
21 from the model unless we can understand how the input
22 to the model relates to reality? How does your
23 hydrostratigraphic model input relate to Site F and why
24 should this Board accept that that was a suitable input
25 to the model, and that was a suitable



1 hydrostratigraphic regime to model at Site F when that
2 is not what we find at Site F?

3 A. I think we can accept the results
4 as much as we can accept the results of any model,
5 Mr. Chairman, by saying that Dr. Rowe has looked at
6 flow through rock. If a greater component, for
7 example, is moving downward, his results could be
8 transposed and you could look at flow in a different
9 direction, but we are saying let's assume it moves
10 laterally in this case. It is undoubtedly a
11 simplification, but the important point of his model
12 are the processes that take place within that rock and
13 with the water and the leachate as it moves through
14 that rock.

15 I am not claiming that that is an
16 accurate depiction of what happens at the site, but on
17 the same basis, and I think it is relevant to mention
18 this although we are discussing this model, but, for
19 example, Trow's scenario gave me concern because they
20 have water moving down to a great depth and coming up
21 again and you could argue do you really think a
22 particle of water really follows that path at this
23 site? Maybe it does or maybe it doesn't.

24 I believe that this was a reasonable
25 scenario to model as to whether one accepts what



1 actually comes out of the model, and that is a
2 different matter if one accepts what comes out of any
3 model, but I think that this was a reasonable approach
4 as a corollary or a complement to the kind of scenario
5 that Trow had modelled.

6 Q. You would agree that in proposing
7 to model reality the inputs have to relate to reality,
8 do they not?

9 A. Well, certainly that -- one should
10 try and relate to reality, but it depends on how one is
11 approaching modeling the system. If you are going to
12 model flow through a piece of rock or you are trying to
13 simulate the movement of a given particle of water,
14 then you are approaching it in two different ways.

15 Q. At Site F Dr. Rowe has modelled
16 leachate moving horizontally through fractured shale
17 with an average K of 4.5×10^{-6} and an average
18 horizontal gradient of .035. Do you agree?

19 A. He modelled that as one scenario
20 and also modelled the Trow scenario.

21 Q. Talking about scenarios A and B.
22 That is true, is it not?

23 A. Yes.

24 Q. At Site F landfilling will not
25 greatly reduce the vertical gradients, will it?



1 A. No.

2 Q. So at Site F leachate which
3 escapes the leachate collection system goes down
4 through the bottom of the cells and would travel
5 vertically across areas of the site with strong
6 vertical gradients, would it not?

7 A. And it would travel horizontally
8 in zones of horizontal movement. The results where we
9 have horizontal gradients -- in those situations it
10 will travel horizontally. I might add in the zones we
11 have horizontal gradients, they do not necessarily
12 correspond to Trow's highly fractured zones and the
13 zones where we have Trow's highly fractured zones,
14 similarly we do not always get horizontal gradients.

15 Q. Can we agree this far; some of the
16 leachate will flow vertically through vertical
17 fractures and where there aren't vertical fractures and
18 where there are in fact massive units of the shale like
19 the five-foot piece you pointed out to us on Thursday,
20 you won't in fact get fracture flow but intergranular
21 flow. Isn't that right?

22 A. Yes.

23 Q. You will get matrix diffusion in
24 the fracture flow but you won't get matrix diffusion in
25 the intergranular flow, is that right?



1 A. Yes.

2 Q. Once the leachate has travelled
3 vertically some certain distance, some of it fracture
4 flow and some of it intergranular flow, it would appear
5 that it will hit more permeable horizontal layers at
6 Site F; is that not correct?

7 A. Some will move down and will
8 encounter zones where it may well move laterally and
9 other particles of water molecules will continue to
10 move downward, yes.

11 Q. The portions that move laterally
12 through the fractured shale will also -- will also
13 experience matrix diffusion?

14 A. Yes.

15 Q. If we want to model the geological
16 regime and the hydrogeological regime at Site F, do we
17 not have to take into account a combination of fracture
18 flow and intergranular flow through the more massive
19 units of the geological materials that the leachate
20 will in fact have to flow through at Site F?

21 A. That is one approach, but I feel
22 that there are potential weaknesses in that approach
23 and therefore it is reasonable to also, given that that
24 approach has been attempted, I think it is reasonable
25 to attempt an alternative approach.



1 Q. The question is what value the
2 alternative approach has if the alternative approach
3 deviates so much from what we in fact find at Site F?

4 A. Well, it may not deviate so much
5 and if it does deviate on the scale at which Dr. Rowe
6 has modelled it, it probably deviates or could deviate
7 in a conservative way, but it may not deviate.

8 Q. Actually this is the last question
9 I want to ask you at this time on Site F. I am
10 intrigued to understand how it is you can describe, as
11 you have described several times, describe your
12 interpretation of the hydrostratigraphy at Site F which
13 you proposed to Dr. Rowe for the purposes of modeling
14 as conservative, and I want to know how you can depict
15 a hydrostratigraphic regime which ignores the geology,
16 glumps together the hydraulic conductivities and
17 ignores the strong vertical gradients and assumes a
18 uniform lateral flow system and call it conservative,
19 because what is conservative about being totally
20 diametrically wrong about the interpretation of a site?

21 A. I don't accept it is totally
22 geometrically wrong and we don't have water flowing
23 uphill, for example. I have forgotten what the first
24 part of your question was, and perhaps you would like
25 to repeat it.



1 Q. The first part of my question was
2 a preview to the last part of the question and the last
3 part of my question was why was an interpretation that
4 ignores so much of the data we have on the site a
5 conservative interpretation?

6 A. It is conservative in some ways.
7 It is conservative because it assumes that everything
8 will come out of the landfill and move laterally and
9 the data suggests that it in fact will move down into
10 the highly saline water. I was concerned we have this
11 zone of somewhat less saline and let's see what happens
12 if it moves into that zone and it is conservative
13 because, as I say, there undoubtedly will be a portion,
14 maybe a significant portion that moves down into this
15 highly saline water and ceases to be a problem.

16 Q. Thank you. Dr. Rowe, I wonder if
17 I could ask you a few questions.

18 DR. ROWE: A. Certainly.

19 Q. Dr. Rowe, I am sure there is
20 something you want to add to what it is we have already
21 been discussing and I will give you every opportunity
22 to tell this Board whatever you would like it to hear.
23 Let me start by asking you about a few questions about
24 what modeling is all about. I take it a model is a
25 simplified version of reality?



1 A. I would say that that is true.

2 Q. What you are proposing to do when
3 you engage in a modeling exercise is to work from what
4 is known to what is unknown?

5 A. That is one part of it and another
6 part is to try and gain some understanding from what
7 the mechanisms are what the implications of uncertainty
8 regarding the parameters are, and this is true, not
9 only of modeling in this context, but of all modeling
10 and all engineering.

11 Q. Are parameters the same thing as
12 variables because my next question was what you are
13 doing is using variables and our understanding of the
14 relationship of variables to, among other things,
15 possibly made predictions?

16 A. That is correct.

17 Q. Now, the model you in fact use is
18 a set of mathematical equations, is it not?

19 A. That is correct.

20 Q. In order to do this modeling
21 everything has to be capable of being quantified?

22 A. That is correct.

23 Q. What you then develop is a set of
24 mathematical equations that are a kind of mathematical
25 representation of the world around us, or some portion



1 of the world around us?

2 A. Correct, a mathematical model as
3 opposed to a physical model.

4 Q. I think you told us a model is
5 only as good as its inputs?

6 A. That is correct.

7 Q. Would you agree that each of the
8 inputs should fairly represent what you actually
9 believe the reality is, or in the case of what we are
10 doing here, the subsurface conditions?

11 A. They should either fairly
12 represent what reality is or represent what would be a
13 conservative interpretation of reality.

14 Q. Do you want to expand on that?

15 A. Yes. Mr. Chairman, one must
16 recognize that in all life we are dealing with
17 complexities, whether it is dealing with science or
18 whether it is designing a building. If we were trying
19 to analyze a reinforced concrete beam in a building, it
20 is made up of sand particles and gravel and cement
21 paste and it has steel in there and if we attempted to
22 model the details of what is going on at that level, we
23 wouldn't have any time to build structures. We
24 simplify the problem and have a simply mathematical
25 model of concrete beams and it is realistic in the



1 sense that we know we can use it, is conservative and
2 we use that model, and we have an overall idea of what
3 is happening although we aren't precisely saying what's
4 happening at a particular point in space, and the same
5 applies here. One must simplify the real very complex
6 system into a sufficiently tractable system and then
7 look at what the effect of key variables is going to
8 be.

9 Q. Would you mind putting up overhead
10 20 so we can focus on what your variables in fact are?

11 A. Certainly. I have put up overhead
12 20 of Exhibit 444.

13 Q. I guess I want to ask you a few
14 questions and I don't want to belabour this because I
15 did pursue it with Dr. Charlesworth, but I take it that
16 Dr. Charlesworth's contribution to this modeling
17 exercise is in the Darcy Velocities and that is the
18 single input that comes from the hydrostratigraphic
19 interpretation?

20 A. Yes, that is correct.

21 Q. Is that the only input?

22 A. He provided me with opinions
23 regarding fracture spacing, for example, and that is
24 the primary input given the hydrostratigraphic
25 interpretation which he used and I would point out that



1 the numbers you quoted me considering, represents only
2 one of a number of cases I would say.

3 Q. The Darcy Velocity that he has
4 proposed to you, the Darcy Velocity is K times I?

5 A. Yes.

6 Q. Permeability times gradient and he
7 gave you a permeability of 4.5×10^{-6} ?

8 A. Yes.

9 Q. That is uniform?

10 A. Yes.

11 Q. He gave you a uniform horizontal
12 gradient of .035?

13 A. Yes. That is what I modelled. He
14 was aware that this particular model that I was using
15 is a one dimensional model and it does not permit local
16 variations and he gave his best opinion as to what
17 those parameters would be on the scale of the problem I
18 was examining.

19 Q. Now, I think at some point in your
20 evidence you told us that having conducted sensitivity
21 tests on a number of your inputs, that in fact the only
22 input of any real significance in the whole model was
23 the Darcy Velocity and you could vary all kinds of
24 other inputs and not get very great changes in output,
25 but the one thing that made a big difference was the



1 Darcy Velocity?

2 A. Yes, and in the context I was
3 holding that discussion I think I was discussing the
4 effect of parameters such as fracture spacing, fracture
5 aperture size, fracture porosity and that was the
6 conclusion I reached in that context.

7 Q. I want to ask you, and if it is an
8 unfair question tell me it is an unfair question and I
9 can pass on, but I do want to ask it. If the Darcy
10 Velocity which you got from Dr. Charlesworth assumes no
11 variability in the shale and no variation in the
12 hydraulic conductivity of the geological materials in
13 Site F, no strong vertical gradients, a uniform set of
14 fractures and only lateral flow, and if those in fact
15 are not the conditions we find at Site F; how do we
16 then relate the results of your modeling exercise to
17 what we find at Site F?

18 A. I will certainly attempt to answer
19 your question, but I would like to take it a piece at a
20 time.

21 Q. I don't mind at all. If I am
22 right that the Darcy Velocity input to the model which
23 came from Dr. Charlesworth assumed, one, no variability
24 in the shale?

25 A. All right.



1 Q. Let me give you the list because
2 you will write them down anyway and I can give you the
3 whole list so you can have it in front of you. No
4 variability in the shale, no variation in the hydraulic
5 conductivity of the geological materials on-site. No.
6 3 is no strong vertical gradients, in fact no vertical
7 gradients at all. No. 4 is a uniform set of fractures
8 and No. 5 is only lateral flow.

9 Then I want to know if those inputs
10 don't in fact reflect what we find at Site F, how we
11 then relate the outputs of your model to Site F?

12 A. Okay. That's a fair question and
13 I will attempt to respond to it. Firstly, no
14 variability in the shale and no variability in K on-
15 site. What we are focusing on here, and can I take
16 this off for a moment?

17 Q. It is your evidence, Dr. Rowe. So
18 feel free to do whatever you want.

19 A. It might be of assistance if I
20 could put up overhead 18 and then we can come back to
21 overhead 20. This is overhead 18. What we are
22 visualizing or what we are modeling in this particular
23 case, and this is in my scenarios A and B, and as you
24 heard my evidence in scenario C I accepted Trow's
25 interpretation, but if we wish to look at the



1 alternative, I was considering contaminant transport
2 down within the zone of the landfill into a fractured
3 rock zone.

4 I was not specifically modeling
5 hydraulic gradients in that zone, and I think
6 Mr. Tidball touched on this in his questioning.
7 However, I was very aware, as was Dr. Charlesworth in
8 his discussions with me, that there were strong
9 vertical gradients at the site and that is indeed how
10 the contaminant gets from the landfill into this mass
11 of rock beneath the landfill before it moves laterally
12 off-site. Although I am not specifically modeling the
13 gradients, and if you wanted to you could interpret my
14 scenario as being that way, but in my scenario B I was
15 modeling it coming down and moving along, and I think
16 Mr. Tidball asked me a question about that, and the
17 only way that could happen if you did have very strong
18 downward gradients.

19 In scenario A I am assuming there are
20 downward gradients and that is how the stuff gets into
21 the rock beneath the landfill at the site. I am not
22 specifically modelling it in the sense that I am not
23 modeling how long it takes to move down there, but I am
24 modeling it in the sense that it gets there and it is
25 in the rock and then I'm starting my clock if you like



1 as to attenuation once it gets to the down-gradient
2 edge of the site and then looking the lateral movement
3 down-gradient of the site.

4 So, what in essence Dr. Charlesworth, as
5 I understood the information he gave me was not
6 neglecting either down-gradients vertically or the
7 hydraulic conductivity vertically, but we were focusing
8 on the mechanism as it moves laterally off the site and
9 that mechanism is controlled by the lateral Darcy
10 Velocity.

11 If there is further down velocity, and
12 let's assume there are down-gradients off-site, then
13 what are those downward gradients going to do? There
14 is no question there is a lateral component based on my
15 understanding of Dr. Charlesworth's evidence, and there
16 may be an additional vertical component, and it will
17 carry some of these contaminants further down into more
18 rock.

19 What I am considering, I am restricting
20 them in a zone which within the report is 25 metres
21 thick and I am saying they are locked in that zone and
22 any attenuation that will occur will have to occur in
23 that zone. If we had down-gradients which carry some
24 of the contaminant out of that zone, and how can there
25 be downward gradients -- there must be fresh water and



1 that will lead to dilution and lower concentrations and
2 more attenuation.

3 Certainly what I am modeling here is a
4 simplification. You may well have down-gradients off-
5 site, but if you do then the results I have are
6 conservative and I have never made any pretence, and in
7 fact I tried to make it abundantly clear that I am not
8 attempting to predict precisely what is going to happen
9 at a given point at a given time. I am looking at the
10 effect of a number of parameters on what might be
11 expected to happen and I regard these calculations to
12 be design calculations. Things may well be much better
13 than I have simulated. Did I omit any of your points?

14 Q. For starters, Dr. Rowe, if there
15 are zones with high permeability, won't movement be a
16 lot more rapid than the movement you have predicted in
17 scenario A?

18 A. That depends on how extensive
19 those zones of higher permeability are. If they are
20 contained in less permeable material, the answer is no
21 and the only way it could be more is if you have very
22 extensive zones of much higher permeability material at
23 a gradient, and that would give me Darcy Velocities
24 substantially greater, and I can put back up the
25 original overhead you requested, overhead 20, but if



1 they were substantially greater than the values I
2 looked at because then it is a different problem, but I
3 see no evidence of that because if there was, if you
4 have these massive zones there, perhaps I can back up--
5 it seems to me you have two basic ways of looking at
6 the problem and one is the way Trow have done it and I
7 analyze that in scenario C where you have a weakly
8 fractured massive shale unit and we can argue how thick
9 it is, but a zone where it must diffuse down very
10 slowly.

11 Q. Where there is no fracture flow?

12 A. Where there is no fracture flow
13 into a zone where there is fracture flow and
14 particularly if there is water coming from off-site
15 because then you will have high levels of attenuation
16 as contaminants are released from that zone into the
17 fractured zone and plus you will have in addition
18 matrix diffusion as it moves along. That is one way of
19 doing it and that is how I looked at it in scenario C
20 and I am not arguing whether that is or isn't the case.

21 Another way of looking at it is suppose
22 you don't have these big blocks. Suppose it is
23 fractured. Suppose the stuff can get down beneath the
24 site through fractures. Then it will have to off
25 laterally and it still has to go off laterally, but



1 there will be a component going down, but the evidence
2 I have seen indicates that there will be a lateral
3 component.

4 It strikes me as a reasonable question
5 to ask. Let us suppose that Trow isn't right, and I am
6 not saying they aren't but let's suppose they are, then
7 what are the implications and that is what I tried to
8 look at. I don't think you can have -- you have one or
9 the other, but I don't think you can have somewhere in
10 between.

11 Q. Let me turn it around and come at
12 it this way; you would agree with me that all the
13 evidence we have from the Burlington and Bayview
14 landfill sites suggest that as regards leachate
15 migration nothing is going nowhere?

16 A. That is certainly my
17 interpretation. If you take nothing going nowhere as
18 not beyond 25 metres, I would agree.

19 Q. Nothing is going nowhere and it is
20 a fact that it sits out there to be explained by
21 hydrogeologists and geotechnical engineers?

22 A. That is right.

23 Q. The question is what is the
24 explanation for the fact that this leachate doesn't
25 appear to have migrated any great distance for either



1 one of these two by now fairly old landfill sites.

2 That is part of the exercise we are engaged in?

3 A. That's right.

4 Q. Given what we know about the
5 hydrogeological regime at Site F from looking at the
6 cores and examining the hydrogeological data as well as
7 the geological data, what we expect to have happen here
8 is first there will be a lot of shallow flow of the
9 kind Dr. Charlesworth has described which will be
10 recaptured on-site?

11 A. That's right.

12 Q. Secondly we expect some component
13 of deeper flow?

14 A. That is correct.

15 Q. Looking at the geological
16 materials first and only, we expect that there is going
17 to be vertical flow through vertical fractures?

18 A. Correct.

19 Q. We expect, in fact, we can almost
20 say with certainty, that where there are not vertical
21 fractures there is vertical flow, intergranular
22 vertical flow through the more massive units?

23 A. That is correct.

24 Q. Whether or not you define it at
25 Trow defines it as one massive unit or whether or not



1 using your eyes and looking at the core from HC-4 you
2 can see several units of a foot thick or five feet
3 thick or three feet thick, and there are several
4 segments where if the leachate is going to escape the
5 site it will have to move in an intergranular method
6 down through that material. Is that right?

7 A. Certainly in some areas of the
8 site that is definitely true.

9 Q. That material has a very low
10 hydraulic conductivity?

11 A. The intact shale, yes, certainly.

12 Q. And travel is going to be very,
13 very lengthy?

14 A. Through the intact shale, yes.

15 Q. What is suggested by the high
16 gradients is that in fact we know that water is being
17 driven vertically down through that material at Site F
18 and we expect leachate will be driven down through that
19 material at Site F?

20 A. That would be my understanding,
21 yes.

22 Q. The explanation for those high
23 vertical gradients is that what is below that massive
24 tight material, that low permeability material, is some
25 very high permeability material and in fact those high



1 permeabilities have been measured at Site F?

2 A. Yes, there are certainly zones of
3 high permeability, yes.

4 Q. When the leachate reaches those
5 zones of high permeability we expect it to move
6 laterally through those zones of high permeability?

7 A. Yes, with conditions.

8 Q. Now, the contribution you have
9 sought to make to this discussion of why it is that
10 nothing is going nowhere at Site F is that you have
11 tried to introduce into this whole set of equations
12 something Mr. Feenstra told this Board he was unable to
13 do because he didn't have a model to do it, and that is
14 he knew matrix diffusion was occurring but he couldn't
15 model it. Isn't that right, and that is something you
16 have sought to introduce?

17 A. Yes, and I thought it would be of
18 benefit to the Board.

19 Q. Looking at what we know about the
20 hydrostratigraphy, you expect matrix diffusion starting
21 at the bottom of the landfill and you expect matrix
22 diffusion vertically wherever there is travel down
23 vertically through cracks?

24 A. That is correct.

25 Q. Wherever there is intergranular



1 movement there won't be any matrix diffusion?

2 A. Not in the context we are talking
3 about.

4 Q. When the leachate reaches more
5 permeable lateral zones and moves through those more
6 permeable lateral zones there will be matrix diffusion
7 again?

8 A. Yes, that's right.

9 Q. In your scenario C you have
10 modelled leachate flow in a very similar manner to the
11 way in which Trow did it?

12 A. Yes, indeed. I was just trying to
13 complement what they had done in their original report
14 because they obviously didn't have time to do it with
15 their better fit model.

16 Q. What you do in your scenario C and
17 what they did doesn't take into account matrix
18 diffusion?

19 A. That is right.

20 Q. But your scenarios A and B do take
21 account of matrix diffusion?

22 A. That is correct.

23 Q. Now, what I am trying to
24 understand, Dr. Rowe, is how scenario C could have been
25 modelled to take account of matrix diffusion, No. 1,



1 and, No. 2, why is it that you didn't do it that way,
2 and, No. 3, and I can separate these again for
3 Mr. Estrin ...

4 A. Perhaps you could run over them
5 again.

6 Q. Let me get out No. 3 out before I
7 forget and then we will have the Court Reporter tell
8 us. No. 3, since it doesn't appear to be the case the
9 inputs to the model where you get matrix diffusion
10 relate to the actual hydrogeological conditions at Site
11 F, how can this Board be satisfied that they can relate
12 back the modeling of matrix diffusion to the actual
13 flow system we actually find at Site F? Because they
14 have you telling them and they have Mr. Feenstra
15 telling them that matrix diffusion has to be put into
16 the equation, but nobody has put it in to the actual
17 flow system.

18 I know that's a big long question and
19 Mr. Estrin isn't on his feet, so he must think it is a
20 friendly one.

21 MR. ESTRIN: I was just asleep.

22 DR. ROWE: For clarification, what was
23 1 and 2?

24 DR. KINGHAM: How can you model Trow's
25 model to take account of matrix diffusion. That was my



1 recollection.

2 DR. ROWE: Could I have No. 2?

3 DR. KINGHAM: Why didn't you model it?

4 MR. HODGSON: Q. Why didn't you model
5 matrix diffusion in the scenario C type model taking
6 account of the flow system that in fact is assumed for
7 scenario C?

8 DR. ROWE: A. Right. I will certainly
9 address those three questions.

10 Now, can one model matrix diffusion with
11 respect to Trow's interpretation. The answer is, yes,
12 you can. I, in fact, although I didn't go into any
13 detail, I made a very crude attempt to see what might
14 happen. Let me just back up a bit. I do have the
15 overhead. I will try and get what I am going to say as
16 clear as I can.

17 I would like to, for the record, put up
18 overhead No. 4 from Exhibit 440. In scenario C,
19 Mr. Chairman, what I was doing was essentially adopting
20 Trow's concept of a weakly fractured shale unit where
21 contaminant transport would be through the
22 intergranular pore space and then into a highly
23 fractured shale unit. In this particular model as I
24 was using, and as the results have illustrated here, I
25 am not considering matrix diffusion within the highly



1 fractured shale. I am treating this as an equivalent
2 porous medium.

3 Q. To back you up, there is shale
4 above the weakly fractured shale?

5 A. There certainly is.

6 Q. And there would be matrix
7 diffusion there as well?

8 A. Correct.

9 Q. You are not modeling that either?

10 A. That is correct. So, I am
11 concerned with the movement down through the weakly
12 fractured shale and along the highly fractured shale
13 unit, and just considering it as an equivalent porous
14 medium. This was obviously the first step one would do
15 in modeling a situation such as this and the results I
16 got are shown here. There is an impact of about 85
17 milligrams per litre after 550 years, at which point I
18 was tempted to ask do I need go further, because
19 already at the site boundary the impact is very, very
20 small, and certainly much smaller than in any of the
21 other scenarios that I looked at.

22 Now, as Mr. Hodgson points out quite
23 correctly, I did not consider the matrix diffusion as
24 it came down through the weathered shale above it, and
25 if I had that would further reduce the concentrations.



1 Also what this model directly does not consider is
2 matrix diffusion of any contaminants as they came in
3 here and moved along to the edge of the landfill. If I
4 had considered that what it would have done is further
5 reduce this impact.

6 The last part of the question is what
7 happens, I guess, as you come down-gradient through the
8 highly fractured shale. As I said, one view you could
9 take is that 85 milligrams per litre is very small so
10 therefore let's not worry about it, but I was
11 interested probably for my own interest more than
12 anything else, but to see what kind of matrix diffusion
13 you might get, and so I made a very crude assumption
14 and essentially assumed all of the mass got down into
15 here instantaneously, and "here" is into the highly
16 fractured shale, but instantaneously at a concentration
17 of 85 milligrams per litre.

18 Then I modelled the migration down
19 through the highly fractured shale and what I got for
20 that particular calculation was a decrease from 85 to
21 about 60 milligrams per litre over a distance of 800
22 metres. I would point out that this is an extremely
23 conservative calculation, an upper boundary and, in
24 other words, I would expect much more attenuation than
25 that. The reason I would expect much more attenuation



1 is because firstly not all of the mass is getting in
2 there instantaneously, it is getting there much faster
3 than in reality, and, secondly, I have taken a five
4 metre thick unit. I don't think Trow ever suggested it
5 was five metres thick and they had values considerably
6 greater than that, but I noticed when I read the
7 transcript that people kept trying to whittle away and
8 whittle away at the thickness of this highly fractured
9 shale, so I went as low as anybody could go and that
10 was five. I think the lowest I saw was seven.

11 What happens if I decrease the thickness
12 of this layer, it gives you a high Darcy Velocity
13 because there is the same amount of water flowing
14 through, but the thinner it is the higher the Darcy
15 Velocity and as I indicated the higher the Darcy
16 Velocity the less impact we have with matrix diffusion.

17 So, this calculation I have done is very
18 conservative and if I considered a thicker layer, say
19 10 metres, then we would halve the Darcy Velocity for
20 the same total flow and we would get more effect of
21 matrix diffusion. Also, if I went to the trouble, and
22 which I could do, of trying to model movement down here
23 and matrix diffusion as it moved along, and modeling
24 the whole thing in one model instead of putting two
25 models together, then you would get less effect still,



1 but, quite frankly I didn't think it was worth it from
2 an engineering point of view when the impact of the
3 down-gradient is already only 85 milligrams per litre.

4 Q. Looking at scenario C behind you,
5 do you agree if in fact the fairest interpretation of
6 the hydrostratigraphy at Site F is that we have got
7 more permeable zones and less permeable zones, high
8 vertical gradients, substantial changes in the
9 geological materials beneath the site, that is a fairer
10 way to model Site F, to do it on your scenario C, which
11 was really Trow's model as well rather than your
12 scenario A. It is a fairer representation of reality
13 and the input matches better what we find at the site
14 than scenario A?

15 A. Are you asking me to give a
16 hydrogeological opinion?

17 Q. I am not. I am asking you whether
18 or not as a modeler, don't you want your inputs to as
19 closely match reality as possible?

20 A. Yes, as a modeler, one always
21 likes one's inputs to match reality, and I am not
22 arguing, nor have I ever argued with Trow's better fit
23 model as being a reasonable way of representing what is
24 going on at that site. They have, I think, done a very
25 good job and I think they are to be complimented on the



1 efforts they went to to try and model what is going on.

2 However, as Dr. Charlesworth has pointed
3 out to you and as he indeed pointed out to me, it may
4 not be as simple as all of that. Let's suppose ...

5 Q. Let's just ...

6 MR. ESTRIN: Let him give his answer.

7 DR. ROWE: Let's suppose it isn't as
8 simple as all of that. What would happen if the
9 contaminant gets down -- I would like, if I could, to
10 go back to overhead 18, I think it was. What happens
11 if it does get into a fractured zone. To a large
12 extent I don't care, and I shouldn't say I don't care,
13 but it doesn't matter greatly how it gets into the
14 fractured zone. What I am looking at is what happens
15 to it as it moves along the fractured zone. I am sure
16 this would be of interest even with respect to Trow's
17 picture of things in the weathered shale above their
18 weakly fractured massive shale unit because what I am
19 modeling can explain why it is we don't see
20 contaminants massive distances from the landfill when
21 they haven't gone through this postulated weakly
22 fractured massive shale unit.

23 So, if there is a situation over the
24 site where contaminants can get down vertically and
25 where there are enough vertical fractures to get down



1 into a permeable zone and move laterally, then that is
2 what I am considering. It seems to me reasonable to
3 look at the possible ways the site can be viewed. I am
4 not saying Dr. Charlesworth is right and I am not
5 saying Trow is right, because that would be asking me
6 to give a hydrogeologic opinion and I am taking input
7 from the hydrogeologist.

8 Q. I know you are taking input from
9 the hydrogeologist, but as the modeler, I am really
10 trying to understand, because I am sure the Board will
11 want to understand, if they don't know now they will
12 want to understand they certainly will be the end of
13 argument, but your scenario A, just for the sake of
14 argument, doesn't fit the hydro -- the input to your
15 scenario A doesn't fairly represent the
16 hydrostratigraphy at Site F.

17 Now that is the argument and taking that
18 for a second. The question becomes can we relate the
19 output to what will happen at Site F if one of the
20 inputs so greatly skews reality? Why is it that we can
21 accept the output from your scenario A if the model for
22 the hydrostratigraphy that went into scenario A is so
23 grossly inadequate to explain the geological and
24 hydrogeological information generated at Site F?

25 A. Mr. Chairman, I think what is



1 important here is that I am attempting to model a real
2 physical situation with a reasonable interpretation of
3 what is going on at the site. You say it is totally at
4 variance, and the only thing I can understand from your
5 being at variance is because we are neglecting the
6 vertical gradients.

7 I am pointing out to you -- to Mr.
8 Hodgson, Mr. Chairman, that that is a conservative
9 assumption. It may well be that the concentrations I
10 have calculated would exceed what would happen at the
11 site, and I am quite happy to go with that. I don't
12 lose sleep at night about things being safer than I say
13 they are going to be, but I worry about things not
14 being safe and that's what engineering is all about.

15 Science is about certain things, but
16 engineering is about building things safely in the
17 present of uncertainty. Given the uncertainties of
18 this site, and given what is a reasonable idealization,
19 a conservative idealization in my opinion and the
20 consequences of that, a minimal impact, I feel
21 comfortable.

22 It could be that things are as good as
23 Trow says it is and that is even better, but that
24 doesn't alter the fact that it is a reasonable thing to
25 look at what might happen if it isn't as neatly



1 packaged as in the original Trow model.

2 I am not offering an opinion as to which
3 is better, but I am saying if it is as Dr. Charlesworth
4 says it is, then the impact off-site or south of 403 is
5 minimal and if it is as Trow says it is, then the
6 impact south of 403 is even less.

7 Q. I don't want to leave this
8 discussion without asking you if you could put up your
9 model again for scenario C?

10 A. Yes certainly. That was overhead
11 4 you are referring to?

12 Q. Yes. To make sure your evidence
13 is balanced, if it is fair to balance it in this way,
14 you have suggested at various times that when one
15 models one should create an envelope of possibilities
16 and an envelope has two ends, a left and right-hand
17 end, and what we have here is one end of the envelope.

18 My question is your scenario C, if you
19 had used the inputs Trow used in their modeling in
20 scenario C, you would have got roughly the same output
21 they got?

22 A. I would have got very similar
23 which is why I didn't do it, there was no point.

24 Q. So when we are looking at an
25 envelope of possibilities we should vary the inputs so



1 we have an idea of the sensitivity of the output to the
2 various inputs?

3 A. As a general question that is
4 correct.

5 Q. As a question with regard to
6 scenario C?

7 A. With regard to scenario C, are you
8 asking whether we should look at what Trow got from
9 their original contaminant migration model? Is that
10 the question?

11 Q. Yes, I am, and let me be more
12 specific. In scenario C you have used a K value for
13 the massive shale of 10^{-8} ?

14 A. Yes, that's correct. I didn't, I
15 used Trow's flow.

16 Q. Sorry?

17 A. The flows I used -- the downward
18 velocity is what Mr. Sobanski quoted in his statement.
19 I did not personally calculate the flows. I took them
20 based on information provided on Exhibit H-221, I think
21 it was, and in Mr. Sobanski's comments in testimony and
22 those are not my flows.

23 Q. You took a Darcy Velocity of
24 .0023?

25 A. Yes.



1 Q. Implicit in that Darcy Velocity is
2 a hydraulic conductivity and a gradient?

3 A. Yes.

4 Q. That hydraulic conductivity is
5 probably very low?

6 A. Yes, I believe that that is true.

7 Q. If there was a higher hydraulic
8 conductivity and the same gradient we would have a lot
9 more flow across that unit?

10 A. We would.

11 Q. A lot more flow reaching the
12 highly fractured shale?

13 A. Indeed.

14 Q. And a lot more flow through the
15 highly fractured shale?

16 A. Yes, indeed.

17 Q. If you had varied the gradients in
18 the highly fractured shale from .01 to say .001, you
19 would get much faster flow in the highly fractured
20 shale?

21 A. Again I am not giving the flow in
22 the shale, but if you were to go to Trow's original
23 model, and I can put it up ...

24 Q. I am asking if it is possible to
25 vary the inputs on scenario C?



1 A. Of course it is and Trow looked at
2 the other end and I personally have difficulty with it
3 because I think the flows are far too high.

4 Q. I only want your evidence,
5 Dr. Rowe, and am I hearing you correctly that you are
6 saying that there is an envelope of possibilities and
7 Trow are at one end and you are at the other and it is
8 your professional opinion to the Board that you are at
9 the right end and they are at the less likely end?

10 A. I would want to clarify firstly to
11 the Board, or for the Board, that this isn't my model
12 from the perspective of flow, it is Trow's model and
13 based on Exhibit H-221, so I am not quibbling.

14 They have given two ends of a range and
15 gave their original model, which was presented in
16 Exhibit H-40, if I recall the number, and during
17 evidence and perhaps it could be checked, but I think
18 it was in about September H-221 arrived and H-221 was
19 the better fit model, and they had considered
20 anisotropy combined with a more realistic hydraulic
21 conductivity in the highly fractured unit as I
22 understand how that better fit model can develop.

23 When I looked at the results myself, I
24 concluded that they were correct, it looks a much
25 better fit and from the modeling perspective their



1 better fit model makes a lot more sense than their
2 original model, but I gather because they didn't have
3 time they didn't do a contaminant migration model to go
4 with that and I thought there is something lacking. If
5 they didn't have time to do it I have time to do it so
6 I did it and I presented the results to you.

7 In terms of their original model, their
8 original flow parameters, Mr. Feenstra did a
9 contaminant migration analysis on that and he reported
10 them to the Board and I think he concluded the impact
11 would be quite acceptable. I think the better fit
12 model and it is my opinion the better fit model is a
13 much better fit than their original model, and I am
14 telling the Board that if one accepts that better fit
15 model then this is the consequence in terms of
16 contaminant migration.

17 MR. ESTRIN: "This" being ...

18 DR. ROWE: This being the result shown
19 on overhead 4 of Exhibit 444. What I am trying to do
20 in this particular instance is supplement the evidence
21 already given to the Board by Trow. I am not
22 attempting to attack it, but as something ...

23 MR. HODGSON: Q. I am not suggesting
24 you were, but I was trying to define what the
25 appropriate range should be.



1 DR. ROWE: A. On the more conservative
2 side, Dr. Charlesworth's interpretation is more
3 conservative and it has greater potential impact off-
4 site than Trow.

5 MR. HODGSON: Mr. Chairman, this would
6 be a convenient time.

7 MR. LANCASTER: All right, two
8 o'clock.

9 ---Luncheon Adjournment at 12.36 p.m.

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(Page 20763 Follows)



1 ---Upon resuming at 2:00 p.m.

2 MR. LANCASTER: Please be seated.

3 MR. HODGSON: Q. Dr. Rowe, if I could,
4 I would like to go back, although I would only like to
5 go back briefly, to where we were before the lunch
6 break. Before lunch you will recall that I was asking
7 you how the Board could place confidence in the results
8 of scenarios A and B if the model of the
9 hydrostratigraphic regime which is an input to your
10 model is in fact not a hydrostratigraphic model which
11 reflects what is found at Site F and that was the
12 context of the discussion. You will recall I listed a
13 number of what I suggested to first Dr. Charlesworth
14 and then to you were variances in the
15 hydrostratigraphic regime, and I am not asking you to
16 confirm they are variances, but take them as
17 assumptions that they are variations, and listed the
18 variability of the shale, the variation in hydraulic
19 conductivity, the strong hydraulic gradients, the
20 uniform set of fractures and the fact that all flow is
21 lateral.

22 You have explained how your model can
23 avoid any concern about vertical gradients that take
24 account only of horizontal gradients. If I have
25 understood your evidence correctly, and perhaps you



1 could put up the overhead where you described this, but
2 you are saying that I am starting my modeling exercise
3 after any leachate has had its vertical travel and it
4 is now started down along the horizontal path?

5 DR. ROWE: A. I am referring to
6 overhead 18 in Exhibit 444.

7 Q. So the modeling exercise begins at
8 the toe of the landfill -- the southern end of the
9 landfill and all across a 25-metre face, a 25-metre
10 depth face at the south end of the landfill?

11 A. The modeling of attenuation begins
12 at the southern end of the landfill.

13 Q. When you say it is conservative, I
14 guess you are saying that you have made the assumption
15 that flow from the base of the landfill to the face of
16 where your modeling exercise begins is instantaneous?

17 A. That's correct.

18 Q. In fact what we know, or I believe
19 we all know from scenario B and C and Trow's modeling,
20 the vertical flows are quite slow; isn't that right?

21 A. If you have very low hydraulic
22 conductivity you will have very slow ...

23 Q. Assuming the vertical flows are
24 very slow, you have ignored those vertical flows and
25 have started off with horizontal flows. The horizontal



1 flows through a segment of shale is 25 metres in depth?

2 A. That is the value used in the
3 report and I made the point several times that the
4 attenuation would be the same for the same Darcy
5 Velocity and would essentially be the same for the same
6 Darcy Velocity whether it is 5, 10 or 25.

7 Q. My question is what happens if the
8 horizontal flow is not through a unit of shale with a
9 hydraulic conductivity of the 10^{-6} range. What happens
10 if the flow is through a segment of shale with a
11 hydraulic conductivity of, let us say for discussion,
12 10^{-3} ?

13 A. What would happen?

14 Q. I am asking what would happen and
15 I am going to suggest the answer is that the flow in a
16 zone of 10^{-3} will be much faster than in a zone of
17 10^{-6} ?

18 A. If you assume the same gradient,
19 yes.

20 Q. The Darcy Velocity will be much
21 higher and we will have to push a lot more water down
22 through that zone?

23 A. Yes, at which point you have to
24 ask yourself if it has enough to push it downward.

25 Q. We have to ask ourselves that



1 question. If you made the assumption that there was a
2 zone with a hydraulic conductivity of 10^{-3} , wouldn't
3 that be a more conservative assumption than the
4 assumptions you have made?

5 A. Yes. Going from the conservative
6 to the ridiculous.

7 Q. Do we take conservative to the
8 point of ridiculous if what we do is model what in fact
9 we find? Let's assume there are zones of much higher
10 conductivity. If there are zones of much higher
11 hydraulic conductivity and you are modeling based on
12 the fact that the whole area is 10^{-6} when in fact some
13 portion of the area might turn out to be 10^{-3} , are you
14 not modeling something other than the real case at Site
15 F?

16 A. Again it is a question of scale,
17 Mr. Chairman. If what we have, and I am referring to
18 Figure 18, but if we have a zone in here which I will
19 indicate in red, which is material with a K of 10^{-3} and
20 which is surrounded by material with a K much, much
21 lower than that, as I indicated I think in one of my
22 other overheads in my evidence, it is not the K of the
23 highly fractured unit which will control the flow in
24 the system but the hydraulic conductivity and gradients
25 in the less permeable zone surrounding it.



1 The presence of a zone of 10^{-3} such as
2 that is not going to make a great impact on the overall
3 performance of the system and the only way it could
4 make a great impact was if it was of large lateral
5 extent.

6 Q. Let's assume it is of large
7 lateral extent, because what you have shown just now is
8 in effect a kind of lens, isn't it?

9 A. That is correct.

10 Q. Well if it is a layer and not a
11 lens? What if it turns out, and let's assume for the
12 moment that it is as extensive as the 20 hectares or so
13 that Trow found in their pumping test at PW-2. Let's
14 assume we have a zone which we know to be at least 20
15 hectares in horizontal dimension extending hundreds of
16 metres north, to the south to the east and to the west,
17 and let's assume it has a hydraulic conductivity of
18 10^{-3} . That isn't something you have modelled in your
19 scenarios A and B; is it?

20 A. No, it is in essence scenario C.

21 Q. What would happen if you did model
22 it in scenarios A and B?

23 A. If you did model it you would have
24 a high Darcy Velocity and enormous contaminant
25 transport and we wouldn't be here discussing whether or



1 not there is a plume from Burlington or Bayview Park
2 because it would be obvious there is.

3 Q. I want to suggest to you,
4 Dr. Rowe, that there would only be a plume from
5 Burlington or Bayview Park, assuming that leachate had
6 first been transported vertically down to that
7 fractured zone?

8 A. Yes, that's right.

9 Q. What I want to suggest to you is,
10 and see if you agree, the problem with scenario A is
11 that you really need to couple scenario A in effect to
12 scenario C. You want to model matrix diffusion while
13 contaminants are being transported horizontally from
14 Site F, but you haven't coupled it to transport
15 vertically from the landfill down to whatever units are
16 going to in fact transport it. If those units that are
17 going to transport it are in fact more permeable units,
18 then once the vertical transportation has taken place
19 the horizontal transportation takes place at a much
20 different rate than the kind of rate you are describing
21 in your evidence; does it not?

22 A. I think we are really trying to
23 say the same thing, but it doesn't look that way. In
24 my scenario C I am examining a situation where you have
25 the problem as Trow Hydrologist Consultants seem to be



1 convinced as it is. You have a layer of material where
2 it is hard for the contaminant to get down through and
3 then a highly fractured zone. That is an idealization
4 of the real situation and that is one idealization but
5 it is an idealization of the real situation.

6 If I accept that idealization, then we
7 are in my scenario C and my conclusion is the same as
8 your consultants essentially reached, that the
9 contaminant moves down very slowly through the weakly
10 fractured massive shale and it moves much faster in the
11 highly fractured shale, but nevertheless, the impact is
12 very small. That is one way of idealizing the real
13 situation.

14 That is not the only way.

15 Dr. Charlesworth is another qualified hydrogeologist
16 who doesn't see things quite that same way and he has
17 presented an alternative idealization and I have
18 considered that and I came to my conclusions, but you
19 can't take part of Trow's and part of Dr.
20 Charlesworth's and look at them in isolation. I am
21 sure you don't really want me to do that, but that's
22 the impression I get from your question, that that is
23 what you want.

24 Q. All I want to understand,
25 Dr. Rowe, I don't really want you to do anything, I



1 just want to understand and I want your evidence for
2 this Board as to how they are to interpret the results
3 you get with scenarios A and B, given that the hydro-
4 stratigraphic model you are working from doesn't relate
5 to the known field data at Site F.

6 I am trying to explore with you the
7 variations and the significant variation appears to be
8 that once you get the contaminants down to a zone where
9 you can transport them horizontally, you have assumed
10 there are no more permeable zones and they are all
11 being transported through one zone which has a uniform
12 permeability which is relatively low, although not
13 extremely low, somewhere in the order of 10^{-6} .

14 A. I did look at values up to more
15 than an order of magnitude higher as well.

16 Q. All right. Perhaps, since I am
17 not suggesting to you that your modeling of scenario C
18 is inappropriate, could we try a comparison on this
19 basis. If you are modeling in scenario C or Trow's
20 modeling in scenario C corresponds with what in fact we
21 see happening at Burlington and Bayview, and if your
22 modeling in scenarios A and B corresponds to what we
23 see happening at Burlington and Bayview, then in terms
24 of an exercise in modeling to explain what is taking
25 place in the field, don't you think it would be more



1 appropriate to accept the results of scenario C as more
2 likely representative of what is occurring in the field
3 and what will occur at Site F than the results of
4 scenario A and B, given that the inputs to scenario C
5 much more closely match the field conditions found than
6 do the inputs at scenarios A and B?

7 A. Well, to answer the question I
8 really have to go back over what I said. I am prepared
9 to accept Trow's idealization and to model that and I
10 come to a conclusion about the modeling of that. I do
11 not accept your proposition that the proposal that
12 Dr. Charlesworth suggested I model is unrealistic. I
13 recognize it doesn't consider various aspects of that
14 and it doesn't directly model the migration downward
15 into the shale, nor does it directly model any
16 migration downward on this side of the site, and I
17 accept that and recognize that that is not questioned
18 and not disputed.

19 The fact is that if we are concerned
20 about lateral migration in the upper portions of the
21 shale, this is in my opinion a reasonable and
22 conservative design calculation, and in fact I wouldn't
23 even call it a modeling exercise, but a design
24 calculation and I think it is a reasonable way of
25 approaching the problem, and indeed you may find



1 yourself in a situation where you could have both being
2 true. You could have, as Trow visualized, movement
3 down through the weakly fractured massive shale into a
4 more permeable unit and along at the same time as
5 lateral migration in the weathered shale above the
6 weakly fractured shale. So, it may not be an either/or
7 situation.

8 Q. Could we at least agree that
9 scenarios A and B did not model the situation or do not
10 take account of the possibility that the hydro-
11 stratigraphic regime at Site F includes more permeable
12 zones?

13 A. I don't think we can agree with
14 that. I can agree to the point that the model itself
15 is not modeling different units, and that is certainly
16 true, but my understanding is that Dr. Charlesworth
17 considered the fact there could be variability arriving
18 at his hydraulic conductivity and furthermore in my
19 modeling I didn't restrict myself to the value
20 Dr. Charlesworth gave me, I went up to more than an
21 order of magnitude higher in terms of Darcy Velocity.

22 I have tried to consider the range of
23 cases I considered to be reasonable to consider,
24 Mr. Chairman, and from an engineering perspective,
25 quite frankly it doesn't matter to me whether Trow are



1 right or whether Dr. Charlesworth is right, it doesn't
2 matter, because in both cases I have convinced myself
3 as an engineer that the final outcome is okay.

4 Q. On that we are in agreement, so
5 let's pass on to another subject for a moment. Could I
6 ask you to again put up overhead 20?

7 A. Overhead 20 of Exhibit 444.

8 Q. Let me see if I understand how you
9 are using the inputs to the model. What we find on
10 overhead 20 are what you believe are the appropriate
11 inputs; is that right?

12 A. They are the parameters I
13 considered.

14 Q. Not just overhead 20, because
15 there are 21 and 22 as well?

16 A. Yes.

17 Q. You call them parameters and I
18 call them variables, but whichever way you have used
19 them as though they were independent variables; is that
20 correct?

21 A. To a large extent, yes.

22 Q. You would agree with me that it is
23 possible to use these variables by holding all of them
24 constant and carrying given variable over a given range
25 to test, for example, for its sensitivity?



1 A. Correct.

2 Q. In fact you have told us you did
3 test for the sensitivity of at least some of these
4 variables, perhaps all of them?

5 A. Yes, that is right.

6 Q. In fact I think you told us that
7 in doing your sensitivity tests, the only variable that
8 seemed to have a significant impact was the Darcy
9 Velocity?

10 A. Can I put that in context? I said
11 that when I was discussing the effect of fracture
12 spacing, aperture size, fracture porosity. When I was
13 looking at those parameters it didn't matter very much
14 which value I adopted within a given range for a given
15 Darcy Velocity, because I would get, for all practical
16 purposes, the same sort of answer, but if I varied the
17 Darcy Velocity I got different answers. I consider the
18 Darcy Velocity to be the most important of those
19 parameters.

20 Q. The Darcy Velocity, if we can
21 discuss it for a moment, but conceptually we calculate
22 the Darcy Velocity as K times I , with K being the
23 hydraulic conductivity and I being the gradient?

24 A. I agree.

25 Q. Conceptually Darcy Velocity means



1 that a volume of water is moving through a unit area of
2 bedrock in a unit of time?

3 A. That is right.

4 Q. The Darcy Velocity, although it is
5 greatly simplified, it is a cubic metre passing through
6 a square metre per year. Is that what it is?

7 A. Yes, Dr. Charlesworth had an
8 overhead to illustrate that.

9 Q. If we want to understand the
10 linear velocity, we take the Darcy Velocity and divide
11 it by porosity and we will get a calculation as to the
12 speed at which the water will move once it has passed
13 across that given point in one year?

14 A. Yes.

15 Q. The Darcy Velocity is the amount
16 of liquid we are pumping into the system into a given
17 year?

18 A. Yes, indeed, and that is why it is
19 so important because it is carrying the contaminant
20 with it, and so how much contaminant is entering the
21 system is related to how much liquid is entering the
22 system and that is why it is important.

23 Q. You agree with me that in
24 scenarios A and B for each model run, the Darcy
25 Velocity must be specified?



1 A. Yes, that is correct.

2 Q. For each Darcy Velocity specified
3 there is an implicit hydraulic conductivity?

4 A. There is an implicit hydraulic
5 conductivity and gradient which go together to give
6 that Darcy Velocity.

7 Q. In fact because you have selected
8 a particular gradient of .035, and your gradient can
9 only vary over a very small range, it would mean in
10 effect that your hydraulic conductivity could only vary
11 over a very small range, would it not?

12 A. For a given Darcy Velocity, but I
13 must point out that I look at more than an order of
14 magnitude difference.

15 Q. Let me understand. For the Darcy
16 Velocity you have used three Darcy Velocities in this
17 modeling exercise?

18 A. Yes.

19 Q. For .035, you have assumed a
20 hydraulic conductivity of 4.5×10^{-6} ?

21 A. If you couple that with a gradient
22 of .035.

23 Q. I took that off your witness
24 statement and you said that that's the hydraulic
25 conductivity that matches that Darcy Velocity and they



1 can vary over a small range as long as the gradients
2 vary as well?

3 A. That's right.

4 Q. Assuming the gradient at .035, the
5 hydraulic conductivity that matches your Darcy Velocity
6 of 1.25 is 1.1×10^{-5} ...

7 A. That corresponds to the same
8 gradient.

9 Q. The Darcy Velocity -- the
10 hydraulic conductivity that corresponds to the Darcy
11 Velocity of .7 is 6.3×10^{-5} ?

12 A. The same gradient, that is
13 correct.

14 Q. Now, you have already told us that
15 for most values or variables in your model, you can
16 test the sensitivity by varying them over a certain
17 range?

18 A. I can indeed.

19 Q. For example, you can for any
20 particular model run vary only the fracture aperture?

21 A. Well, if I keep the spacing
22 constant and vary the fracture aperture, then I am
23 implicitly varying the fracture porosity.

24 Q. You can vary the fracture aperture
25 and you could also vary the fracture spacing?



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A. I can.

Q. You can vary those independently
of one another?

A. I can.

Q. In fact you have done that in your
model?

A. I have indeed.

Q. Perhaps Dr. Charlesworth could
stand up and I would like to ask you a question. In a
real fractured rock system, would you agree with me
that the hydraulic conductivity is not independent of
the fracture spacing and aperture, and in fact it would
be strictly dependent on the fracture and aperture
spacing?

DR. CHARLESWORTH: A. Yes. The
hydraulic conductivity for fracture flow will be
dependent on a combination of fracture spacing and
fracture frequency, yes.

Q. So for any given combination of
fracture spacing and aperture size, we can match the
corresponding hydraulic conductivity?

A. Yes.

Q. And in fact using the example from
Hoek and Bray on Exhibit H-244, if we know that one --
two of those three values we can calculate the third,



1 is that not right?

2 A. Yes.

3 Q. Now, Dr. Rowe, if I could I would
4 like to show you an overhead.

5 DR. ROWE: A. Should we give this an
6 exhibit number?

7 MR. LANCASTER: H-482.

8 ---EXHIBIT NO. H-482: Chart "Hydraulic
9 Conductivity Based on
10 Fracture Configurations
in Rowe Models"

11 MR. HODGSON: Q. On H-482, first of
12 all, we have taken from your cases 1 through 29, the
13 combinations of fracture spacing and fracture aperture
14 you have used in the various model runs, and the
15 combinations are listed there as 1.2 on the left and 30
16 on the right. Do you see that?

17 DR. ROWE: A. I do.

18 Q. Can you confirm that those six
19 combinations are the six combinations of fracture
20 spacing and fracture aperture that you in fact used in
21 your study?

22 A. If you want me to confirm them
23 right now, I can check. Hold on. Yes, I will confirm
24 that.

25 Q. You would agree with me that using



1 this figure from Hoek and Bray, which is already in
2 evidence, but we have reproduced it for convenience on
3 this page as well, but it is possible for any given
4 combination of fracture spacing and fracture aperture
5 to identify an implicit hydraulic conductivity?

6 A. Are you asking me whether one
7 could use the figure from Hoek and Bray to calculate a
8 permeability for a given opening size?

9 Q. Opening size and spacing.

10 A. If you are asking me whether I can
11 mechanically do that, the answer is yes, but if you
12 want to know if it means anything, then that's a
13 different question because I don't think it does.

14 Q. Do you want to tell us why it
15 doesn't?

16 A. Yes, and you can correct me if I
17 am wrong, but I understand this is for an idealized
18 system of perfectly parallel smooth fractures which I
19 doubt you have in the real situation.

20 Q. As I understand it, and you can
21 confirm this, my understanding that your model is for a
22 set of ideal parallel fractures.

23 A. Oh yes, but what one has to be
24 very careful about is that -- these are two totally
25 different models and you must look at the range of



1 applicability. One of the most difficult things to
2 determine in my view is the fracture opening size in a
3 fractured rock system. I do not believe it consists of
4 a series of parallel, smooth, and smooth is very
5 important here, because how the water flows through the
6 fractures is not only related to how wide they are but
7 it's related to the roughness of those fractures and I
8 do not believe it is meaningful, and I did this
9 exercise myself and I concluded it was not meaningful
10 to do that.

11 Q. Would you mind just doing this
12 exercise with us for a moment?

13 A. Sure, as long as you understand I
14 don't think it is meaningful.

15 Q. In the first selection of fracture
16 spacing and fracture aperture, 1.2 and 30, would you
17 agree that the implicit hydraulic conductivity, and,
18 Mr. Chairman, $2.0E-06$ is Mr. Feenstra's computers way
19 of saying 2×10^{-6} and I understand that is a standard
20 system of notation?

21 A. My computer says it the same way.

22 Q. Would you agree that the implicit
23 hydraulic conductivity in that combination case is $2 \times$
24 10^{-6} ?

25 A. If you go through and multiply



1 those numbers, and I am sure I can check it, and I
2 don't know if I need to.

3 Q. Subject to check, can we agree the
4 implicit hydraulic conductivities for the six choices
5 of fracture aperture you have made use of are the six
6 reflected in this column?

7 A. Yes. Again I would like to
8 caution that I think we are heading down an unrealistic
9 path here. What one should be doing, if one was to be
10 doing anything, would be going the other way and take
11 the hydraulic conductivity as known and try to infer a
12 fracture aperture size, but to go the other way is
13 silliness.

14 Q. Let's just follow the exercise a
15 little further. This is another overhead I would ask
16 you to put up.

17 MR. LANCASTER: Exhibit H-483.

18 ---EXHIBIT NO. H-483: Chart "Hydraulic Conductivity
19 Based on Fracture
20 Configurations in Rowe Models"

21 MR. ESTRIN: I see we now have 29 cases
22 of hydraulic conductivity in column 1 implicit in the
23 Darcy Velocity of Rowe models. We seem to have a
24 continuing series, and I am sure it will continue
25 unless something is done at this point of numbers and
documents being handed out without any advance notice



1 whatsoever to the witness or myself. This is
2 completely contrary to the treatment Mr. Lederer and
3 Mr. Hodgson insisted on with regard to their witnesses
4 in which they uniformly got assistance on.

5 It seems to me, with the greatest of
6 respect, I am not complaining about unfairness, but I
7 am rising because I believe that there is potential for
8 misleading the Board and getting into wasteful areas
9 that are unproductive time. This is headed "Hydraulic
10 Conductivity Based on Fracture Configurations in Rowe
11 Models." Even if it takes Dr. Rowe a few minutes to
12 check these, it is a few minutes of time which could
13 have been more constructively spent at a break.

14 It seems, with the greatest of respect,
15 I am requesting that from now on any further exhibits
16 of this type, that he or any of the other counsel in
17 cross-examination if it is their wish to put figures or
18 calculations to them, they be given to the witness at
19 least a few hours in advance to give him an opportunity
20 of looking them over.

21 Secondly, before we put this in with the
22 title as it is and we have the witness questioned about
23 this, that he have the opportunity of determining
24 whether the various values which supposedly are
25 implicit and are stated to be there, are in fact ones



1 which he ascribes to and before any further
2 questioning. We may be wasting a lot of time.

3 MR. HODGSON: If I can respond. I am
4 not putting new information to this witness. All of
5 this information or virtually all this information is
6 taken from his report and we are just using his
7 information and presenting it in a tabular form. It is
8 true we have added some new information, but the new
9 information we have developed, and it is implicit in
10 the information. That is the first point.

11 The second point is that it is true that
12 before this hearing began there was an idea that
13 documents that would be put to the witness would be
14 shown to the witness ahead of time if that was possible
15 and we are all trying to deal with the fact that it
16 isn't always possible because people don't always think
17 of things a long time ahead. The reality of how this
18 hearing has developed is that my friends have, first of
19 all, all cross-examined the Region's witnesses with
20 their own experts' reports in their back pockets and
21 then produced them after the Region's witnesses have
22 left the witness box.

23 Secondly, they have put, not only one
24 piece of paper with one bit of information summarized
25 to witnesses, they have put whole articles, whole texts



1 to the witness and asked them to explain them.
2 Mr. Sobanski was cross-examined on Miss Hewetson's
3 thesis and cross-examined for quite some time on
4 Miss Hewetson's thesis. Mr. Estrin knows that he has
5 abused this rule more than anybody else. He has
6 shovelled into evidence with Mr. Hiraishi this, M-267,
7 a whole book, and, with the greatest of respect, I am
8 not abusing the privileges of this room or this witness
9 by putting to him information taken from his report and
10 re-organized in a different way.

11 As to whether or not he has had to check
12 it, I have consistently asked that witnesses take
13 information subject to check and we have checked it and
14 they can check it later, and if they find they disagree
15 with it later they can correct it and there is no
16 prejudice to the witness in taking it subject to check.

17 MR. ESTRIN: If I can reply, I don't
18 think the Board needs to hear this, but I would like to
19 make it clear, Mr. Hodgson is confusing the issue I
20 raised with something else. The issue of whether or
21 not documents can be put in in cross-examination is, of
22 course, another matter, but with Mr. Hiraishi this
23 document was given to Mr. Hiraishi several days, if not
24 a week before he testified, as an example of the
25 courtesy and proper behaviour which I understood this



1 Board wanted to have all counsel observe.

2 Here we have a piece of paper with a lot
3 of technical information which may or may not be
4 accurate and Mr. Hodgson intends to spend the next half
5 hour or at least the next few minutes dealing with it,
6 and you can take the implications from there.

7 I don't mind, and it is quite proper,
8 but he could have given it to the witness at lunch time
9 at the very least, and said please check this I will be
10 asking you about this after lunch, just check that the
11 values that I say are implicit in here are ones that
12 are calculated right and whether you will agree they
13 are implicit we can ask in cross-examination and we did
14 that throughout our cross-examination where we gave out
15 documents in advance and we will just get into
16 continual problems with this.

17 So, it is a question of two different
18 issues, not a question of trying to put something -- I
19 am not objecting to anything he wants to put in that is
20 relevant in cross-examination as an exhibit, as he has
21 a right to do it, but it is the way he is putting them
22 in and the timing.

23 MR. LANCASTER: The Board did ask that
24 all documentation be given to the other side as early
25 as possible.



1 MR. HODGSON: I appreciate that. We
2 prepared some new cross-sections we want
3 Dr. Charlesworth to look at and we gave them to him
4 first thing this morning and I told him I wouldn't ask
5 any questions on them until tomorrow and in fact they
6 were just finalized yesterday. To the extent we can
7 comply with the rule, we are trying to comply.

8 MR. LANCASTER: Where did this come
9 from and how long have you had this document.

10 MR. HODGSON: I have had this since
11 Thursday afternoon.

12 MR. ESTRIN: It was in my office on
13 Friday.

14 MR. LANCASTER: Has the witness had it?

15 MR. HODGSON: The witness has not had
16 it.

17 MR. LANCASTER: It is just a question
18 of checking what's said I suppose. However, you may go
19 ahead with that.

20 MR. HODGSON: Thank you, Mr. Chairman.

21 DR. ROWE: Before we move on I haven't
22 quite finished my comment. You said these numbers are
23 implicit in my calculation, but I disagree most
24 strenuously with that comment. They are not implicit
25 at all. You have taken a figure from Hoek and Bray and



1 you are trying to project hydraulic conductivities from
2 that figure for a given opening size and, in my opinion
3 that is an inappropriate thing to do. I would also
4 like to put my results in the correct context for the
5 Board.

6 The thing I feel one can get a
7 reasonable handle on is the Darcy Velocity, as it is a
8 function of a hydraulic conductivity which can be
9 measured and a gradient which can be measured and it is
10 something we have a handle on. Something we have a
11 very poor handle on it is the fracture opening size.
12 We have seen silliness a couple of times about what
13 could happen when you divide a meaningful number like a
14 Darcy Velocity by a porosity which can vary by one or
15 two orders of magnitude.

16 Suddenly the contaminants instead of
17 moving hundreds of metres in years could be moving
18 kilometres or tens of kilometres a year. There is a
19 very great danger in putting too much emphasis on very
20 small numbers that one can't reasonably determine from
21 the field data.

22 So, what my approach was, was that I
23 had the Darcy Velocity from Dr. Charlesworth and I look
24 at an order of magnitude range from that velocity and I
25 recognized there was uncertainty as to the fracture



1 opening size, and I said, okay, we know what the Darcy
2 Velocity is so what is the impact of that uncertainty
3 in terms of contaminant transport? That was the
4 objective of my varying those fracture opening sizes.
5 It was given the Darcy Velocity, what is the
6 implication with respect to matrix diffusion and
7 contaminant transport of uncertainty over an order of
8 magnitude or two, at least two orders of magnitude with
9 respect to the fracture opening size.

10 To then go and say that you looked at
11 this range of fracture opening size, therefore you are
12 saying the hydraulic conductivity of the material is
13 such, is not what I intended to do and is a totally
14 inappropriate way of viewing what I have done.

15 MR. HODGSON: Q. Bear with me, please,
16 Dr. Rowe, because I would like the Board to understand
17 the exercise we have carried out and by all means we
18 will have your evidence on its appropriateness if we
19 don't already have it.

20 In the left-hand margin we have listed--
21 in column one we have listed first of all or second of
22 all after VA the Darcy Velocities that you say you have
23 used in these various cases, 1 through 29. We have
24 listed beside the Darcy Velocities what you have told
25 us are the implicit hydraulic conductivities that go



1 with those Darcy Velocities and they can be taken right
2 out of your witness statement.

3 In column 2 we list the fracture spacing
4 you use for a particular case. In column 3 we list the
5 fracture aperture you have selected for a particular
6 case. In column 4 we have taken the information
7 developed from H-482 and simply asked from Hoek and
8 Bray what fracture configuration -- what hydraulic
9 conductivity is implicit in the fracture configuration
10 that was selected for the particular case.

11 Then what we have asked ourselves is how
12 does the fracture configuration -- how does the
13 hydraulic conductivity implicit in the fracture
14 configuration that you have selected relate to the
15 hydraulic conductivity implicit in the Darcy Velocity
16 which you have used.

17 So, we are comparing in case one, a
18 hydraulic conductivity implicit in the Darcy Velocity
19 of 6.3×10^{-5} and what we find by looking a Hoek and
20 Bray is that the implicit hydraulic conductivity for
21 the fracture configuration used in that case is 2×10^{-6}
22 and column 5 is where we have simply multiplied the
23 difference to give the Board an idea of the range of
24 variance and the range of variance in case one is 32
25 times, 32 times, and in effect the fracture



configuration which comes from the fracture spacing and fracture aperture has implicit in it a hydraulic conductivity that is 32 times lower than the hydraulic conductivity chosen or implicit in your Darcy Velocity.

Going down we find that the variations are in case 2 are 13 times lower, in case 3, 79 times higher, in case 4, 320 times higher ...

DR. KINGHAM: Lower.

MR. HODGSON: Q. Sorry, lower.

In case 6, and I think this is the most extreme case, but in case 6 the implicit hydraulic conductivities mismatch by 3200 times. You will find in slightly bold type in column 5 that we found three occasions, cases 5, 11 and 19, where the hydraulic conductivities implicit in the two values, in the sets of values that were inputs to your model were within an order of magnitude 3 times in 5, 3 times in 11 and 4 times in 19.

Now, first of all, Dr. Rowe, would you agree with me that it would not be wrong to run your model with fracture configurations that reflected a hydraulic conductivity that was in fact reflected in the Darcy Velocity of that particular case; would it not?

DR. ROWE: A. Yes, and I believe the



1 way you are suggesting it would be totally
2 inappropriate. Mr. Chairman, if Mr. Hodgson wants to
3 pursue this line of questioning, what I could have
4 done -- I had Hoek and Bray in our office and it is a
5 standard geotechnical text. I am very familiar with
6 this chart and I easily could have gone to it and said
7 I have a hydraulic conductivity of 6.3×10^{-5} and I
8 could have gone to this chart and looked across to a
9 given fracture spacing and come down and got the
10 fracture aperture size, and I could have run the
11 analysis and it would have saved me a lot of time and I
12 could have reported those results, and somebody would
13 say but you didn't look at the effect of fracture
14 aperture size and this will be really important, and my
15 point in looking at it was to show that it is not
16 really important.

17 I admit the hydraulic conductivity is
18 important, and it is important because it controls the
19 Darcy Velocity, but to go to that figure -- the
20 hydraulic conductivities are based on idealized results
21 from Hoek and Bray which was never intended to be used
22 in the way you are using it, and it is, to me, totally
23 inappropriate and these code numbers you have in column
24 5 don't mean anything.

25 Q. Let me suggest they do mean



1 something. Let's look at the most extreme case, case
2 6. Here we have a situation where the hydraulic
3 conductivity implicit in your Darcy Velocity is $6.3 \times$
4 10^{-5} and the hydraulic conductivity implicit in your
5 fracture configuration is 2×10^{-1} . So 2×10^{-1}
6 suggests a very much more permeable unit than 6.3×10^{-5} .
7 Would you agree? We are talking four orders of
8 magnitude.

9 A. Mr. Chairman, this is, as I said
10 before, a totally inappropriate thing we are doing.
11 You could accuse people of looking at too wide a range
12 of aperture size. If I was wanting to do things the
13 way you are doing them, I would not have looked at how
14 wide a range I look at. If you can draw any conclusion
15 at all from those calculations given on Exhibit H-483,
16 and if you can draw any conclusion at all, it is that
17 the fracture opening size is not likely to be 500
18 microns, but likely to be far less than that.

19 Q. Time and again when you presented
20 the results of your modeling exercise, scenario A, you
21 told us you tested for the sensitivity of various
22 inputs and I have discovered the only input that really
23 made a big difference to the model output was the Darcy
24 Velocity?

25 A. That is correct, and that is my



1 evidence.

2 Q. I am suggesting that explicitly in
3 case 6, the reason why the only input that has any
4 effect on output is a variation in the Darcy Velocity
5 is that if you mismatch the hydraulic conductivities in
6 your inputs as wildly as they appear to be mismatched
7 in case 6, conceptually what is happening is that you
8 are not stuffing enough water into the system to get
9 any effect at all. You are stuffing water in based on
10 a hydraulic conductivity four orders of magnitude
11 higher than the unit into which you are stuffing the
12 water, so you have a unit that has an implicit
13 hydraulic conductivity based on its fracture
14 configuration of 10^{-1} and you are stuffing water in as
15 though it was 10^{-6} and you don't have enough water?

16 A. Is that a statement or a question?

17 MR. ESTRIN: What is the question?

18 DR. ROWE: A. If the question is is
19 that true, the answer is no, it is not true.

20 MR. HODGSON: Q. Go ahead.

21 DR. ROWE: A. I guess I should wait
22 for the question. Are we finished with this?

23 Q. We are not finished with it. I
24 want to show you a few more overheads.

25 A. Will this be Exhibit 484?



1 MR. LANCASTER: Yes, H-484.

2 ---EXHIBIT NO. H-484: Chart "Fracture Spacing
3 Based on Apertures and
4 Hydraulic Conductivity in
Rowe Models"

5 MR. HODGSON: Q. We have your evidence
6 that all of this means absolutely nothing?

7 DR. ROWE: A. I should qualify what all
8 this means.

9 Q. I wanted to show you what happens
10 -- sorry, I wanted to show you what happens if you hold
11 the fracture aperture constant and change your fracture
12 spacing to match so that the hydraulic conductivity
13 implicit in the resulting fracture configuration is as
14 close a match as possible to the hydraulic conductivity
15 implicit in the Darcy Velocity, and that is all we have
16 carried out -- that is the only exercise we have
17 carried out on this document and then I will show you
18 the next document.

19 MR. LANCASTER: H-485.

20 ---EXHIBIT NO. H-485: Chart "Fracture Spacing
21 Based on Apertures and
22 Hydraulic Conductivity in
Rowe Models"

23 DR. ROWE: Would you like me to put
24 H-485 up?

25 MR. HODGSON: Q. Yes, please.

DR. ROWE: A. It is amazing what you



1 can do with computers.

2 Q. Pardon?

3 A. Just an aside.

4 Q. To explain, Dr. Rowe, to show what
5 we have done and taking the information from H-484 and
6 putting it on H-485, in column 1 we have your Darcy
7 Velocity and the K implicit in your Darcy Velocity and
8 column 2 is your chosen fracture aperture, column 3 is
9 the fracture spacing you used and in column 4 the
10 fracture spacing that if it was matched with the
11 fracture aperture would give a hydraulic conductivity
12 the same as or virtually the same as the implicit
13 hydraulic conductivity implicit in the Darcy Velocity
14 you used as an input.

15 You can see the variation, the fracture
16 spacing goes from 1.2 in case one to .03 and the
17 fracture spacing in case 2 goes from .3 to .03 and then
18 to show you some of the wildly mismatched one, in case
19 6, keeping your fracture aperture of 500, in order to
20 get a hydraulic conductivity that matches the hydraulic
21 conductivity implicit in your Darcy Velocity, you have
22 to go to one spacing at greater than 100 metres?

23 A. I think that tells you something
24 about what you are doing.

25 Q. It either tells us something about



1 what we are doing or it tells us something about what
2 you are doing, one or the other.

3 MR. ESTRIN: Mr. Chairman, first of all
4 could Mr. Hodgson clarify that the velocities he is
5 implying in figure 1 or column 1 of Exhibit H-485 is
6 again something he has asked Dr. Rowe to assume,
7 because I think his evidence was he wouldn't agree that
8 it was proper, or something to imply that it's
9 improper, but I would like to know so that we know on
10 what basis we are hearing the evidence.

11 DR. KINGHAM: Perhaps we could do it in
12 steps. The numbers you gave us as Darcy Velocities,
13 were those the numbers you used as the Darcy Velocities
14 in column one on any of the charts, as they are the
15 same numbers.

16 DR. ROWE: The Darcy Velocities are the
17 Darcy Velocities.

18 DR. KINGHAM: Do those numbers
19 correspond to the hydraulic conductivities and, if so,
20 are the ones listed there the same ones in your view?

21 DR. ROWE: They appear to be correct.

22 DR. KINGHAM: Is that your question,
23 Mr. Estrin, with regard to column 1?

24 MR. ESTRIN: If I understood a previous
25 answer of his, it was to say that it wasn't something



1 in his view that ought to be done to imply a velocity,
2 a hydraulic conductivity from the Darcy Velocity in the
3 way it was being done in the first column. I may have
4 misunderstood him, but he said that in response to the
5 first of these and if that was his answer then I think
6 it is appropriate to know whether that same comment
7 follows on with the other two documents.

8 DR. KINGHAM: Perhaps he should have a
9 chance to explain, but I thought he was expressing the
10 Darcy Velocities and the hydraulic conductivities
11 associated.

12 MR. ESTRIN: Not the Darcy Velocities
13 but what was the K implicit in the Darcy Velocities.

14 DR. ROWE: Perhaps if I could clarify
15 this for everybody. The Darcy Velocities I used of
16 .05, .125 and .7 are given and for a given hydraulic
17 gradient of .035 you can infer the hydraulic
18 conductivities given in these exhibits from it, and I
19 do not dispute that.

20 Where I am having a great deal of
21 difficulty is that I am then asked to accept that one
22 could take a figure from Hoek and Bray, and I wonder
23 how much investigation has gone into the applicability
24 of this figure and how much data on which it is based,
25 and I think you will find the answer not very good when



1 you look at that, and then to say that you used a
2 fracture opening size which is the most uncertain
3 parameter in the whole system, and of all of the
4 parameters the fracture opening size is the most
5 difficult to get a handle on, but then say you used a
6 certain fracture opening size and therefore this is
7 what your hydraulic conductivity is. That in my view
8 is totally inappropriate; you do not work from the
9 thing you least understand, or the thing you are least
10 certain of and then go backward and try to deduce a
11 concrete quantity.

12 What makes more sense if you want to use
13 this chart at all, and I don't think it is appropriate,
14 but if one did, it would be to go the other way and say
15 okay Dr. Rowe you used a hydraulic conductivity of
16 whatever one you wish to pick, say 1×10^{-5} , and for a
17 given fracture spacing that means your fracture opening
18 size should be such and such and I would say, okay I
19 have looked at that number and you don't have a major
20 impact.

21 I have gone beyond that and have said
22 given it's uncertain, from the point of view of
23 contaminant transport, what is the effect of that
24 uncertainty and that is what I tried to look at and
25 indicate to the Board. All of my results are for a



1 given Darcy Velocity and that is a given input
2 permeability, if you like, for a given gradient and if
3 you want to use this chart and pursue this line of
4 reasoning, then perhaps you can work this way and say
5 doesn't your results suggest a fracture opening size
6 corresponds to such and such.

7 I don't believe it is appropriate to do,
8 but at lest it is not nonsensical, but try and work
9 from a thing you least know about, and that is why
10 there is a wide range, because we know the least about
11 it and I wanted to know myself what is the impact on
12 contaminant transport of that parameter and I looked at
13 it, and I looked at a very wide range, because in the
14 literature a very wide range is reported. We saw in
15 Dr. Cherry's text a range very similar to that which I
16 looked at, and that from an engineering perspective is
17 a sensible thing to do, but when you start working this
18 way it just doesn't make sense.

19 Q. Could I take you first of all to
20 overhead 23?

21 A. Certainly.

22 Q. Comparing cases 1 and 2. In case
23 1 you used a fracture spacing of 1.2 and an aperture
24 spacing of 30 microns?

25 A. That is correct.



1 Q. In case 2 you hold constant at 30
2 microns and use a fracture spacing of .3, and so all
3 you are varying between cases 1 and 2 is the fracture
4 spacing?

5 A. That is correct, yes.

6 Q. What we see as a result of varying
7 the fracture spacing is that in case 2 the results are
8 quite substantially different from case 1. Do we
9 agree?

10 A. Yes, and I indicated in my
11 evidence that at short times, at short times the
12 fracture spacing is of importance and at larger times
13 it is of decreasing significance, and you can see there
14 is also a significant difference in the curves from
15 cases 2 and 4 where there is a difference in fracture
16 spacing. In my later evidence when you look at 300
17 metres or 800 metres down-gradient, it was hardly
18 plottable or not plottable, but it was a question of
19 time scale.

20 Q. Concentrating on cases 1 and 2 you
21 haven't varied the Darcy Velocity in those cases; have
22 you?

23 A. They have the same Darcy Velocity,
24 that is correct.

25 Q. Are you telling us that you can



1 vary the fracture spacing four times from 1.2 to .3 and
2 is that four times?

3 A. Yes.

4 Q. You can vary the fracture spacing
5 four times and hold the aperture constant and maintain
6 the same hydraulic conductivity in the materials into
7 which you are pumping water?

8 A. I am not saying the fracture
9 spacing is specifically those values. You will
10 find ...

11 Q. But you are using those values
12 in your model. You are not saying it is specific to
13 those values, but you are running the model with those
14 values and you held one model at one element constant,
15 and you varied one, and now we can see looking at cases
16 1 and 2 what happens when you vary one input and that
17 one input is fracture spacing. First of all, you agree
18 with me there has to be some reasonable match between
19 hydraulic conductivity implicit in a Darcy Velocity
20 input and hydraulic conductivity implicit in fracture
21 spacing and fracture aperture; do you not?

22 A. I agree.

23 Q. If they are wildly mismatched your
24 model won't tell us anything about anything?

25 A. I disagree most totally. If I can



1 again make the point I made before, we are looking at
2 the primary parameter which is the Darcy Velocity and
3 the secondary parameter is the fracture spacing, and we
4 can look at the cause, and yesterday when we looked at
5 the cause, or last Thursday or whenever it was, we saw
6 one area of the spacing was about 30 centimetres and
7 another was about 10 centimetres, and we went through
8 all that and that is essentially we established. This
9 is something we can get a handle on. The thing we can
10 least well get a handle on is the fracture aperture
11 size, and there is a relationship between the two, but
12 I don't know precisely what the fracture aperture size
13 is.

14 Given that I don't know it and given
15 that it is the most difficult thing to determine, I
16 decided what was a prudent and reasonable engineering
17 approach was to look at the sensitivity of the
18 contaminant transport processes for a range of values
19 and in cases 4, 5 and 6, you can see I am changing it
20 by two orders of magnitude and for the given flow
21 through the system there is no significant effect.
22 There is a little effect but no significant effect.

23 All I would say is that for a given
24 hydraulic conductivity and given spacing, if you wish
25 to infer from Hoek and Bray what is the fracture



1 opening size, then look up and see what it is, and
2 let's suppose for argument sake -- we could look at the
3 charts and see what Trow said, but let's for argument
4 sake assume it was 200. We could say I have looked at
5 that range and the effect is not significant and that's
6 as far as you can go with Hoek and Bray and to try and
7 work it the other way is not sensible.

8 I have tried to look at a reasonable
9 range, a very wide range in fact and perhaps
10 unreasonably wide, a range of aperture sizes to see if
11 that had an impact on contaminant transport, but to say
12 you looked at a very wide range, therefore you are
13 saying the hydraulic conductivity is something else is
14 not an appropriate way of interpreting what I have
15 done.

16 Q. I would just like to have your
17 evidence. If the hydraulic conductivity which is
18 implicit in your selection of fracture aperture and
19 fracture spacing is wildly out of line with the
20 hydraulic conductivity implicit in your Darcy Velocity,
21 then aren't you in effect pumping a little bit of water
22 into a great big space? Isn't that conceptually what
23 is going on? You are not going to agree with me you
24 did this, so answer the question without agreeing you
25 did this. Agree with me conceptually that I am right?



1 You can't pump a little bit of water into a great big
2 space and expect a whole lot to happen in a groundwater
3 system. You have got to match the amount of water you
4 are pumping into the cracks to the fracture
5 configuration.

6 It is a bit like having a dry sponge in
7 the bottom of a bathtub and putting one drop of water
8 on it and waiting to see what happens to the bathtub,
9 and nothing happens so you put on two drops and nothing
10 happens, and then you put on three drops and nothing
11 happens and you come here and say I have put three
12 drops of water on a dry sponge in a bathtub and the
13 bathtub stayed dry. You didn't put enough water on it.

14 I am suggesting that that is in fact
15 what happened here. You haven't pumped enough water
16 into the system to make something happen and we can see
17 in cases 1 and 2 what happens. You haven't had to
18 change the Darcy Velocity but you did reduce the
19 fracture spacing or increase the fracture spacing,
20 which is it, you reduced it for 1 to 2?

21 A. I reduced it.

22 Q. And you get quite a different
23 effect between 1 and 2?

24 A. That is the effect of fracture
25 spacing and they have the same Darcy Velocity and we



1 are pumping the same amount of water through the system
2 in both cases. If one wants to make any conclusion
3 from all of this, the only thing you can conclude is
4 that-- or can we say we can use Hoek and Bray to get
5 some idea of what the true aperture size is. I don't
6 think it is appropriate and I don't think Hoek and
7 Bray's charts were ever intended to be used in that
8 way, but if you were going to do that, then you could
9 attempt it and you could say instead of being somewhere
10 between 5 and 500 for that Darcy Velocity, an
11 appropriate fracture opening size would be 200 and I
12 could say I would accept that, but it doesn't alter the
13 results because you can see the results are insensitive
14 to it.

15 Q. You used Hoek and Bray on page 30
16 of your Site F report?

17 A. That's correct.

18 Q. You haven't used it for any
19 different purpose than we have used it for on this
20 cross-examination?

21 A. I used it to get some idea of what
22 the probable range of fracture opening size is, and
23 based on my interpretation of their work it was 10 to
24 50 microns. I was also aware that this is not site-
25 specific but a textbook based on very idealized



1 situations, and I was afraid if I came in here only
2 having looked at 5 to 50, somebody in cross-examination
3 would say it could be 500 and that will have an
4 enormous effect on your results and I am saying I
5 looked at that and, no, it doesn't.

6 Q. I am not trying to have an
7 enormous effect on your results. I am trying to
8 understand your modeling exercise. We have your
9 outputs and we have a list of your inputs and we don't
10 have your mathematical equations and don't have your
11 computer but we have you. All we can do is examine
12 those inputs and ask ourselves whether or not those
13 inputs are closely enough related to reality that we
14 can expect a reasonable output.

15 I am suggesting to you that your
16 fracture configurations are so wildly mismatched with
17 the implicit hydraulic conductivities in your Darcy
18 Velocity, that your model, as it is currently
19 configured, can't be expected to produce any meaningful
20 results in scenario A and scenario B?

21 A. Is that the question?

22 Q. That's the question.

23 A. The answer to the question is, no,
24 that's not true. Again I would point out that for a
25 given hydraulic conductivity you can, if you wish,



1 relate it to a fracture opening size. If you want to
2 restrict your interest to the fracture opening size you
3 deduce from Hoek and Bray, that is fine, and I am
4 telling you that the impact on scenario A is minimal
5 impact south of 403, but I am also telling you that
6 there is nothing magic about Hoek and Bray and you are
7 putting a great deal of faith on this, but you are
8 working in the wrong direction, you are working from
9 the thing we know least well and trying to work
10 backward to the thing we know well and we should be
11 working the other way.

12 MR. HODGSON: Mr. Chairman if you are
13 going to take an afternoon break, this would be an
14 appropriate time.

15 MR. LANCASTER: All right.

16 ---Recess

17 MR. LANCASTER: Please be seated.

18 MR. HODGSON: Q. If we could I would
19 like to turn to Site D and I wonder if you could take
20 out your report, M-442 and turn to page 27.

21 DR. ROWE: A. Which page?

22 Q. Page 27, Table 2. I don't believe
23 it was reproduced as an overhead?

24 A. I think I do have one of it, but I
25 didn't show it at the time.



- 1 Q. What I propose to do is take you
2 through one example, one of the cases you did at Site D
3 so we can look together at the assumptions, and the
4 case I propose to examine carefully is case 8. Before
5 we deal with case 8 it might useful if we reminded
6 ourselves and the members of the panel of what the
7 results in case 8 were. Is this microphone working?
8 I wonder if you could put up your
9 overhead No. 57?
10 A. Certainly.
11 Q. Can you confirm for the Board that
12 what case 8 shows is that you will have an impact at
13 the site boundary shown on this overhead as ten years?
14 A. That is correct.
15 Q. The chloride concentration at the
16 site boundary would be 1206 milligrams per litre of
17 chlorides?
18 A. Yes. This case is the worst case
19 I examined, the most extreme case I examined.
20 Q. You described the cases you have
21 examined as envelope of cases?
22 A. Yes.
23 Q. This is one end of the envelope
24 and as the days move along no doubt we will be moving
25 across to the other end of the envelope?



1 A. That is correct. This is one end
2 of the envelope.

3 Q. Just so we understand because
4 these time periods are important, but the way in which
5 we should understand the ten years shown on overhead 57
6 is that that ten years is from when?

7 A. A good question. That ten years is
8 from when -- in terms of the model I am specifically
9 dealing with here in overhead 57, that ten years is
10 from when the mound is developed. I think it might be
11 useful if I could put up overhead 58.

12 Q. So ten years for the time at which
13 we get a 15 metre head in the landfill and you will
14 have that kind of impact, 1260 milligrams per litre at
15 the site boundary?

16 A. That is correct.

17 Q. Then, looking at overhead 58...

18 A. 58.

19 Q. Looking at overhead 58 for case 8,
20 I take it if the hydraulic trap fails and the
21 assumption of this particular scenario 8 is that it
22 fails on the day the cell closes, is it not it?

23 A. Not necessarily. The assumption
24 is that the clock starts when it fails.

25 Q. The clock start when it fails. We



1 will come back to when the clock starts. The clock
2 starts when the hydraulic trap fails?

3 A. That is in essence -- perhaps if I
4 can clarify; in terms of the analysis that I did and
5 reported in my Site F report, I started the contaminant
6 migration from the time the mound was developed and I
7 summarized ...

8 Q. You are talking about Site D. You
9 said Site F?

10 A. I meant Site D. I started it from
11 the time the mound was developed and I summarized on
12 overhead 58 the times to first impact off-site. In
13 case 8 which Mr. Hodgson drew out, it was 6 years to
14 first impact and 10 years to peak impact. If one
15 assumes there is no migration until the mound is
16 developed fully, and if we assume the mound develops at
17 about a metre a year which seems a reasonable a number
18 as any, then 14 plus 6 would give you 20 years from the
19 time the trap fails.

20 I also did another simple calculation
21 which tried in a very crude way to simulate some
22 contaminant movement down as soon as the trap started
23 to fail and of course an increasing rate of movement as
24 the mound built up and that gave me 14 years. Based
25 on this, I would expect somewhere between 14 and 20



1 years between after the trap fails you would be getting
2 off-site impact.

3 Q. But the way we should read the ten
4 years from the previous overhead was that we would add
5 the ten to the 14?

6 A. That is correct.

7 Q. If 1990 is the year in which the
8 hydraulic trap fails on this scenario you won't
9 experience off-site impacts at the level of 1260
10 milligrams per litre until the year 2014 or it will
11 take 24 years, would it not?

12 A. Approximately that. Maybe a little
13 less, but approximately.

14 Q. So we add the 10 to the 14?

15 A. Approximately, yes.

16 Q. If we are interested not in the
17 maximum impact at the site boundary but the impact at
18 25 milligrams per litre, then the time is six years
19 after the mound builds up to the height which is 14
20 years, so we are talking about a 20 year period?

21 A. That's correct.

22 Q. Twenty years to first impact and
23 24 years to most significant impact?

24 A. That is correct.

25 Q. That's on the assumption that



1 nothing is leaking out the bottom while the mound is
2 built up, but if something is leaking out the bottom
3 while the mound is building, then the first impact
4 comes in the 14th year after failure?

5 A. That is correct.

6 Q. Two things are happening in the
7 first 14 years because, number one, the mound is
8 building at the rate of a metre a year and, number two,
9 leachate is escaping out the bottom?

10 A. That's right. Leachate is
11 escaping during the period when the mound is
12 developing, but in the modeling as I reported it in my
13 Site D report, I did not consider that as occurring and
14 I considered the migration beginning after the mound
15 was fully developed, so the results may not be
16 conservative in terms of time.

17 Q. So the 14 years in column four is
18 the situation where leachate is escaping while the
19 mound is building?

20 A. Yes.

21 Q. So really you have given us a kind
22 of range?

23 A. I tried to.

24 Q. Between and 14 and 20 years for
25 first impact at the site boundary?



1 A. That is my best estimate for that
2 case.

3 Q. I take it you regard this
4 particular scenario, your case 8, to be a reasonable
5 scenario?

6 A. I think I indicated it was on the
7 bounds of my envelope. I think it is possible but not
8 as likely as some of the others.

9 Q. Can I take you to page 27 in
10 Exhibit 442?

11 A. That is where we are, isn't it?

12 Q. That is where we are and everyone
13 else can go there as well. If we could just focus on
14 case 8, perhaps it might be convenient -- I have a
15 drawn a red line above and below case 8 so the eyes
16 don't wander off to other less relevant cases for the
17 purpose of this cross-examination. However, you don't
18 have to do that, perhaps you are more focused in your
19 attention than I am.

20 May I also suggest that it would be
21 easier to discuss case 8 if we numbered the columns
22 across the top of the page, and I have numbered the
23 column entitled Comments as column 1 and the others
24 then, hydraulic conductivity as No. 2, et cetera,
25 across to column 9.



1 First of all I would like to review
2 quickly the information contained in each one of these
3 columns as it relates to case 8 and then I would like
4 to go back and discuss both with you and
5 Dr. Charlesworth the contents, as it were. Just so
6 everyone is focused together on what goes into case 8,
7 these are in essence the kind of inputs or the sort of
8 inputs we were discussing at Site F; are they not?

9 A. That is correct, yes.

10 Q. The first input is that there is a
11 total failure of all the collection tiles in cells 3
12 and 4?

13 A. 4 and 5.

14 Q. Sorry, cells 4 and 5?

15 A. Yes.

16 Q. The total area of failure is 575
17 metres by 390 metres?

18 A. Yes.

19 Q. Which I have calculated for the
20 sake of calculating it as .224 of a square kilometre or
21 about a fifth of a square kilometre, and you have
22 assumed that the underdrains will fail in cells 4 and 5
23 but the subheaders continue to function; is that right?

24 A. That is correct.

25 Q. In column 2, you have assumed that



1 the hydraulic conductivity of the waste lies somewhere
2 between 1×10^{-5} and 1×10^{-4} ?

3 A. Yes.

4 Q. And the .1 means $.1 \times 10^{-4}$ is the
5 same thing as saying 1×10^{-5} ?

6 A. It is indeed.

7 Q. The second thing you have imputed
8 into this model is the average piezometric head in the
9 waste is 194 metres?

10 A. Correct.

11 Q. Given that the base of the
12 landfill is taken to be 179 metres, we are talking here
13 about a mound of leachate in the waste of 15 metres?

14 A. Yes, average height.

15 Q. Average height. Then in the
16 fourth column the hydraulic conductivity of the upper
17 till, you have taken in this case to be 4×10^{-7} ?

18 A. That is correct.

19 Q. That was not the highest value you
20 modeled?

21 A. No.

22 Q. It was your intermediate value, as
23 it were?

24 A. That is correct.

25 Q. You modelled in a couple of cases,



1 three cases, Trow's 8×10^{-8} and in some of your other
2 runs you modelled 8×10^{-7} which would be a much more
3 permeable upper till?

4 A. Much more permeable than what?

5 Q. Pardon?

6 A. Much more permeable than what?

7 Q. Than 4×10^{-7} .

8 A. Twice as permeable.

9 Q. In column 5, the next column the
10 boundary head case. You have assumed that the head in
11 the upper granular unit is at 181.5 metres. Is that
12 right?

13 A. I believe that that is so, but I
14 can double-check. That is my recollection. That is
15 correct.

16 Q. Perhaps it might be convenient if
17 everyone write in 181.5 beside the Roman Numerals (ii).
18 As I understand this table, where it says (i) the
19 boundary head case is 181.25 and where it is (ii) it is
20 181.5 and except for cases 2 and 3 you have modelled
21 all the rest of your cases at 181.5?

22 A. That is correct. That is the
23 boundary head in the upper granular unit.

24 Q. Then, in the next column we find
25 the calculated Darcy Velocity?



1 A. Correct.

2 Q. And the calculated Darcy Velocity
3 we have been discussing in other contexts is the amount
4 of water you can shove into the system depending on
5 the head you have got and the hydraulic conductivity
6 you have got?

7 A. Yes.

8 Q. In this particular example, the
9 Darcy Velocity is substantially greater than the Darcy
10 velocity we would find in any of the other model runs
11 you have proposed?

12 A. This is the worst case I examined
13 and that is substantially higher than any of the other
14 cases.

15 Q. And the next column is the
16 calculated proportion of flow to the shale and you have
17 calculated or assumed, I am not sure I understand
18 which, that of that total amount of water that will be
19 pushed out the bottom of the landfill by this
20 particular head, the total amount of the water is .275
21 metres per annum?

22 A. Yes.

23 Q. And 58 per cent of that quantity
24 of water will continue on its merry way to the bedrock
25 and 42 per cent will exit in the upper granular unit?



1 A. In the upper and lower granular
2 units.

3 Q. Will most of it go out the upper
4 granular unit?

5 A. Yes, most of it will go out the
6 upper granular unit.

7 Q. We can come back to that. Then,
8 in column 8 is the calculated horizontal Darcy Velocity
9 in the upper granular unit and you have 62.2 metres per
10 annum?

11 A. Correct.

12 Q. If we were interested to know, for
13 example, the horizontal velocity in the upper granular
14 unit, we could divide 62.2 by the porosity of the upper
15 granular unit which you have taken to be .3?

16 A. Correct.

17 Q. That would give us a horizontal
18 velocity in the upper granular unit of 200 metres per
19 annum?

20 A. Approximately, yes.

21 Q. In fact, just focusing on that for
22 a moment and looking at the overhead which you have up,
23 when you calculate the time for a contaminant to move
24 100 metres once it reaches the upper granular unit, you
25 are looking at the linear velocity for contaminants in



1 the upper granular unit based upon this Darcy Velocity
2 are you not, and so 200 metres per annum as the linear
3 velocity, in the upper granular unit, and if the
4 boundary of the landfill is 100 metres wide, we are
5 talking a period of one-half a year?

6 A. Correct.

7 Q. Finally, the equivalent height of
8 leachate is the amount of contaminant which you propose
9 to pump into the system and in fact the contaminant
10 curve which you have used here is your intermediate
11 case curve?

12 A. That is correct.

13 Q. We'll come back to that. I
14 wonder, Dr. Charlesworth, if I could ask you a few
15 questions about the first assumption in this worst
16 case? What I am interested in looking at very quickly,
17 Dr. Charlesworth, is just the reasonableness of these
18 various assumptions and what these various assumptions
19 in fact mean in the broader terms of landfilling. I
20 don't think you were here for Mr. Hiraishi's evidence?

21 DR. CHARLESWORTH: A. No.

22 Q. But you do say you have read it?

23 A. I have read at least parts of it,
24 yes.

25 Q. You will recall that Mr. Hiraishi



1 is proposing to landfill from north to south?

2 A. Yes, I think that is correct.

3 Q. He is proposing that landfilling
4 begin in cell 1 and commence on down to cell 2, cell 3,
5 cell 4 and cell 5?

6 A. I believe so.

7 Q. From his exhibits and from his
8 evidence he has estimated that because cells 1, 2 and 3
9 are smaller than cells 4 and 5, that landfilling in
10 cell 1 will be completed in about 3½ years?

11 A. I don't recall the number, but I
12 can take your word for it.

13 Q. You will take my word for it.
14 Landfilling in cell 2 will be completed in about 7
15 years?

16 A. Again I will take your word for
17 it.

18 Q. I want you to assume that this
19 Board requires as a condition of approval that reliable
20 and appropriate monitoring of the leachate levels in
21 these cells commence immediately upon closure, and that
22 means that during the 3½ years that landfilling is
23 taking place at cell 2, leachate levels in cell 1 are
24 being monitored. Can you make that assumption with me?

25 A. Yes.



1 Q. Let's look at the appropriate
2 methods for doing that. One method would be to check
3 the leachate levels in the manholes, would it not?

4 A. Yes. That was the method I had
5 some concerns about.

6 Q. But you would agree that it is one
7 method that should be used?

8 A. It certainly should be done, yes.

9 Q. The second possibility is that one
10 could install a meter on the header and measure the
11 leachate through the header?

12 A. Yes.

13 Q. That in fact is done at various
14 landfills?

15 A. Yes.

16 Q. A third possibility is that one
17 could install pressure transducers during construction?

18 A. That is an alternative.

19 Q. In fact while landfilling is
20 occurring in cell 1 it would be useful to have those
21 pressure transducers, would it not, because it would
22 tell you with regard to those parts of cell 1 that had
23 already been completed, how much leachate is building
24 up in the cell?

25 A. You should have some method and,



1 as I indicated, I have some concerns about how reliable
2 pressure transducers would be in the long-term, but
3 certainly in the short-term.

4 Q. In the short-term they would be
5 useful?

6 A. They would be useful, I would
7 venture, yes.

8 Q. Do I have it it is your evidence
9 that you are recommending to this Board that pressure
10 transducers be suggested for use at Site D?

11 A. I haven't recommended that. I
12 have recommended -- I would recommend that some form of
13 monitoring of leachate buildup be instigated and
14 pressure transducers would be one possibility, at least
15 for the short-term, but I would like to see them
16 combined with some other method, certainly for the
17 long-term.

18 Q. Focusing on the short-term, it
19 would be useful to know the leachate levels in cell 1
20 while cell 1 is being landfilled and realistically the
21 only way to do that would be to put in pressure
22 transducers and read them for at least the 3½ years you
23 are landfilling in that first cell?

24 A. Yes, if they lasted for 3½ years.

25 Q. Are you aware that they are being



1 installed at Keele Valley?

2 A. I understand they are, yes.

3 Q. Have you any understanding as to
4 how long they have lasted so far as Keele Valley?

5 A. I know they have continued to
6 operate, but I don't know what kind of failure
7 percentage there has been.

8 Q. You are just speculating as to how
9 long these things will last?

10 A. I am just speculating based on
11 using transducers in different but less difficult
12 environments, my own personal use.

13 Q. A fourth method for checking
14 leachate levels in cell 1 would be that upon closure
15 and while landfilling is occurring in cell 2, one could
16 install piezometers in the waste in cell 1?

17 A. That would be a fourth method and
18 a simpler method.

19 Q. And a reliable method?

20 A. I would think a reliable method,
21 yes.

22 Q. In fact that is a method that you
23 would recommend?

24 A. Yes, I would recommend that.

25 Q. If you are recommending that



1 piezometers be installed in cell 1, would you also give
2 this Board your evidence as to how many piezometers you
3 would install in the waste in cell 1?

4 A. I would want to see, maybe, and
5 this is sort of off the top of my head, but maybe three
6 or four to allow for the problems that one may not be
7 representative of the overall system, and you may be
8 getting some perching or some local anomalies because
9 the refuse is not homogeneous, and so off the top of my
10 head maybe three or four would be a reasonable number.

11 Q. Of these methods we have
12 discussed, checking the levels in the manholes, putting
13 a meter in the header and installing pressure
14 transducers and installing piezometers, you agree all
15 of those methods should be used to monitor the leachate
16 levels in cell one as soon as it is closed?

17 A. That would be a sound practice, to
18 use all those methods.

19 Q. As long as you are boring a hole
20 into cell 1 to install a piezometer in the waste, would
21 it also be possible to drill down a bit deeper and
22 install a piezometer in the upper till?

23 A. Yes. There are problems in doing
24 that in that you may be creating a preferential
25 flowpath. I know the ministry has some concerns about



1 that kind of situation, but it is possible, yes.

2 Q. Is it something you would
3 recommend?

4 A. Yes, I think it would be with
5 appropriate caution being taken to monitor the till.

6 Q. To monitor the head levels in the
7 till?

8 A. I am not sure if that would be all
9 that useful. I would have to think about it,
10 Mr. Chairman. It is certainly a possibility.

11 Q. Perhaps you could think about it
12 and we could return to it.

13 A. Okay.

14 Q. If we are going to monitor the
15 levels of the leachate in cell 1, do you agree it would
16 also be useful to install piezometers in the till
17 adjacent to cell 1 to monitor the piezometric pressure
18 in the upper till and any granular units that were
19 discovered in any of the boreholes placed near cell 1?

20 A. Yes.

21 Q. In fact the information as to the
22 piezometric pressure in the leachate in the cells would
23 not be that useful in and of itself. One would also
24 want to compare pressures within the landfill and
25 pressures outside the landfill to know whether or not



1 the hydraulic trap was working?

2 A. Yes.

3 Q. Although we have discussed it in
4 this hearing, it is not like reading a road map and
5 when you get to above 181.6 you have the hydraulic trap
6 reversed and the reality in the field might be a bit
7 different than that?

8 A. Certainly.

9 Q. If you had, for example, higher
10 head unit pressures in the upper granular unit,
11 assuming it is below cell 1, that makes it possible to
12 have a higher head within cell 1 and still have the
13 hydraulic trap operate?

14 A. Yes, it would if the head were
15 higher there. I would be concerned about monitoring
16 in the upper granular unit beneath the cell if you were
17 to monitor that.

18 Q. I was not suggesting it be done
19 beneath the cell but I was suggesting it be done
20 adjacent to the cell in the buffer zone?

21 A. Certainly, okay. I would
22 recommend that once you have established where the
23 upper granular unit is.

24 Q. With regard to cell 1, where would
25 you suggest that monitors be placed around cell 1 in



1 the buffer so we can compare piezometric pressure in
2 the various hydrostratigraphic units identified in
3 those holes with the pressures that are being
4 experienced in cell 1?

5 A. Essentially you would ring the
6 cell, but I wouldn't venture at this time to be more
7 specific about the locations because I don't believe
8 the hydrogeology of the site has been defined to the
9 extent where I could make those recommendations at this
10 point. But, essentially, I would want to encircle the
11 cell.

12 Q. Let's make the assumption that the
13 hydrogeologic regime has been identified and defined to
14 your satisfaction and let's assume for the purposes of
15 this next question that the upper granular unit
16 underlies a small portion of cell 1 and the lower
17 granular unit underlies a different small portion of
18 cell 1 and that the rest of cell 1 in fact sits above
19 the upper till and the lower till without a granular
20 unit beneath it.

21 In those circumstances, how would you go
22 about installing your monitors so that you could define
23 what was happening within the landfill and outside the
24 landfill? Perhaps if you like, we could draw it on a
25 freehand sketch so you could in an idealized version



1 describe for the Board how one would go about
2 monitoring in that situation. Do you want me to
3 describe what I am suggesting? Would you like me to
4 draw what I am suggesting? I hesitate to get up there
5 having criticized Mr. Estrin for doing it so many
6 times.

7 A. I don't know what you are
8 suggesting and I would say I would encircle the site
9 and monitor...

10 Q. I want you to suppose that having
11 defined the hydrostratigraphic regime you discovered
12 that the upper granular unit overlaps with cell 1 in
13 the red dotted line and the lower granular unit
14 overlaps cell 1 in the purple dotted line. I want you
15 to suggest for the Board how you would propose
16 monitoring in the buffer zone around cell 1, so you
17 could have a good handle on what was happening within
18 and outside that cell?

19 A. Well, Mr. Chairman, recognizing
20 that this is a totally hypothetical situation, we would
21 also have to make assumptions about flow directions.
22 If we assume that the flow is away from the cell, I
23 would be particularly concerned with monitoring within
24 these two units obviously and we would be faced with a
25 problem here as the next cell would overlap, so I would



1 want to monitor down this area here and when I say
2 "here" I am referring to the east side, but we would
3 also be interested in monitoring even where the
4 granular units were absent, particularly for heads in
5 order to see if the hydraulic trap was functioning, and
6 so I would see some monitors around the side of the
7 site, around the northern side of the site, and I
8 suppose one may monitor to fill in here.

9 But, I must emphasize, it could be very
10 much dependent on the conditions I found when I did the
11 initial drilling which I believe is necessary at this
12 site. I feel it is of limited to value to hypothesize
13 about, or theorize about hypothetical occurrence of the
14 units.

15 Q. I am trying to get your evidence
16 right now and not as to the feasibility of Site D, but
17 as to the feasibility of monitoring of cell 1. I
18 wonder if you would mind putting an X through each one
19 of the monitoring points you are recommended and
20 perhaps we could also number this as the next exhibit
21 so we can refer back to it later.

22 A. I would like to go on record that
23 these are not my recommendations at this time, but
24 these are what would seem to be for a hypothetical
25 situation postulated by Mr. Hodgson areas where I would



1 be looking to install monitors.

2 Q. That is understood,
3 Dr. Charlesworth.

4 A. And the depth, and the closeness
5 of them, et cetera, would depend upon conditions
6 encountered and it would depend upon conditions
7 encountered when you drilled each hole, and one may
8 decide that less or more were required. Certainly the
9 more complex it proved, the more holes you would
10 require in order to adequately monitor it.

11 Q. Continuing on with this
12 hypothetical situation, do I understand that when you
13 drill in the areas you have marked with an X, and could
14 we mark this?

15 MR. LANCASTER: H-486.

16 ---EXHIBIT NO. H-486: Chart - hypothetical cell 1
17 with hypothetical monitoring
18 well locations

19 MR. ESTRIN: Shall we mark it
20 hypothetical cell 1 as advanced by Mr. Hodgson,
21 hypothetical monitoring locations?

22 MR. HODGSON: Q. In drilling the
23 boreholes you have suggested on H-486 would you agree
24 that wherever you found a more permeable unit you would
25 screen and install a piezometer in that unit?



1 DR. CHARLESWORTH: A. Yes.

2 Q. And by measuring water levels in
3 your more permeable units and, in fact, measuring water
4 levels in all of your units and measuring water levels
5 in your monitoring wells in cell 1, it should be
6 possible to tell whether or not the leachate system or
7 the hydraulic trap is operating in cell 1?

8 A. It would give you a fair degree of
9 comfort if you had enough holes and enough monitors in
10 there and you would have some degree of comfort that it
11 was operating. It is always conceivable there may be
12 some unexpected scenario which develops, but that is
13 why you would prefer the site with less complexity and
14 it is always difficult...

15 Q. We know your site preferences,
16 Dr. Charlesworth, but the issue is the feasibility of
17 landfilling at Site D, given that for the moment the
18 assumption is that Site D has been landfilled and you
19 are the hydrogeologist being retained to design a
20 monitoring program. The issue is can a monitoring
21 program work?

22 A. Let's extend the hypothetical
23 situation. If I had a number of wells, water supply
24 wells here, in this hypothetical upper granular unit,
25 then I may well decide that these number of holes were



1 not adequate and perhaps they may be a first line, but
2 I would be concerned about possibly missing them,
3 missing the movement of leachate off the site, and I
4 may well recommend a more comprehensive program in that
5 area, but again that would depend upon what we had
6 found and if we are extending the hypothetical
7 situation and if indeed the contours in this
8 hypothetical upper granular unit extended in that
9 direction, then my hypothetical monitoring scenario
10 would probably be even more comprehensive. It would
11 very much be a case of expanding it to fit the
12 circumstances you encountered.

13 Q. I accept that, Dr. Charlesworth.

14 Now, going back to Dr. Rowe's case 8 or
15 the hypothesis for case 8. First of all, how likely is
16 it that the underdrains would all plug off in any one
17 cell without the subheaders also plugging off?

18 A. I don't know. I would be
19 reluctant to give an opinion on that matter,
20 Mr. Chairman.

21 Q. They are all made out of the same
22 materials, are they not?

23 A. Presumably.

24 Q. So there is nothing magic about
25 the plugging of underdrains without plugging of



1 subheaders?

2 A. It is certainly a worst case
3 scenario, as I think Dr. Rowe indicated a few moments
4 ago.

5 Q. But would you agree it is unlikely
6 if the underdrains plug off the subheaders would plug
7 off as well?

8 A. I don't know. It is an area -- it
9 is not an area I feel comfortable in getting too
10 specific on, but I think partly because there is not a
11 lot of documentation of how they do behave, and it is a
12 worst case scenario.

13 Q. Assuming for the moment that the
14 underdrains and the subheaders plugged off, you would
15 expect leachate to start collecting in cell 1?

16 A. That is correct.

17 Q. You would expect through the four
18 different monitoring methods you have put in place in
19 cell 1, that you would be able in a very short period
20 of time to detect that something different was
21 happening in cell 1?

22 A. If it was all being correctly
23 monitored, I think you have also got to allow for human
24 failure in these situations. I think the monitoring of
25 the manholes is probably not of a lot of use and I



1 think the monitoring of the flows is not of a lot of
2 use because the evidence is that flows vary quite
3 substantially from year to year so you are down to your
4 piezometers and your standpipes.

5 Q. If they varied down to nothing in
6 one year, that would be significant; would it not?

7 A. Certainly that would be
8 significant.

9 Q. Unless it was a year in which
10 there was no rainfall, then that would suggest to any
11 reasonable person that they had a problem in cell 1?

12 A. If they had nothing coming out.

13 Q. So you would agree that the
14 piezometers at least you have installed in the waste
15 would give you a ready indication as to whether the
16 leachate was building up in the waste?

17 A. That should give you a good
18 indication, yes.

19 Q. Allowing for the fact there is
20 always the possibility of human failure and we can't
21 imagine the Ministry of the Environment would fail in
22 insisting that Site D be monitored adequately ...

23 A. Oh, no.

24 Q. And in fact the Ministry of the
25 Environment require an annual monitoring report for



1 every operating landfill do they not?

2 A. Yes.

3 Q. Usually as a condition of
4 approval, some firm of hydrogeologists, often yourself,
5 Dr. Charlesworth, are retained to design, install and
6 oversee a monitoring program at a given landfill site?

7 A. That is correct.

8 Q. And in fact it might even happen
9 in the wildest of all possible worlds that you may be
10 retained as a very competent hydrogeologist to design
11 and make sure this monitoring program would work. We
12 can't imagine you failing in picking up a change in the
13 leachate levels in cell 1; can we?

14 A. I don't know. I don't know what
15 you can imagine, Mr. Hodgson.

16 Q. Assuming then that there has been
17 massive failure and the leachate levels are building
18 up. Wouldn't it be appropriate as an engineering
19 response that first of all one attempted to clean the
20 underdrains to the extent that one could?

21 A. Yes.

22 Q. Secondly, if cleaning the
23 underdrains did not have the necessary effect of
24 reducing the leachate levels and the leachate was
25 strong enough that one wasn't prepared to simply let it



1 go out the bottom, the next engineering response would
2 be to install wells in cell 1 and pump the leachate out
3 directly?

4 A. That would be my recommendation.

5 Q. And that could be done?

6 A. That could be done. There are
7 some problems in doing it on a sustained basis, but it
8 can be done.

9 Q. There would be no excuse for not
10 doing that if the underdrain system could not be
11 revived and brought back to life?

12 A. No, there would be no excuse for
13 not doing it.

14 Q. The only circumstance in which we
15 could imagine no engineering response to a massive
16 failure would be the circumstance where cell 1 was so
17 old and the leachate so weak that it would be difficult
18 for any off-site impacts to be experienced. Is that
19 right?

20 A. I could imagine that scenario
21 somewhere a number of years down the road where perhaps
22 the monitoring became less rigorous. I could conceive
23 of that scenario, but you are right in making the
24 point.

25 What gave me concern at the time I was



1 reviewing the proposals here was that it appeared that
2 a number of these had not been addressed at the time
3 the proposal was put before us all, but certainly a
4 number of the concerns can be dealt with just like the
5 uncertainties in the hydrogeology can be addressed.

6 Q. You have said that you can imagine
7 a point down the road a number of years where the
8 monitoring was not quite as rigorous. You have been in
9 this business in Ontario now for 10 or 15 years?

10 A. Yes, 13 years.

11 Q. Am I right that it used to be
12 possible in Ontario to close a landfill and walk away
13 from it?

14 A. Certainly.

15 Q. Is that possibly any longer?

16 A. No.

17 Q. In fact closed landfills are as
18 closely monitored as operating landfills, are they not?

19 A. Yes.

20 Q. So what we are hypothesizing is a
21 complete failure of the regulatory scheme in Ontario in
22 order for this particular landfill not to be monitored
23 after it has been...

24 A. Not all closed landfills are
25 necessarily monitored as rigorously as existing ones or



1 active ones, but the likelihood is that all new sites
2 once they close will be monitored fairly rigorously.

3 Q. On whatever failure scenario we
4 hypothesize, isn't it reasonable to assume that the
5 oldest cell will fail first?

6 A. Well, that's rather speculative.
7 I don't think that's necessarily so.

8 Q. That is where you would look for
9 the first failure isn't it?

10 A. Yes. That is maybe where you may
11 be caught by surprise, I suppose.

12 Q. Do you think it would be
13 appropriate as we complete landfilling in cell 2, 3, 4
14 and 5 to put in the same monitoring program suggested
15 for cell 1?

16 A. Well, obviously, what is required
17 for one cell is required for the other cells.

18 Q. What I am trying to suggest,
19 Dr. Charlesworth, is that if landfilling begins here
20 let's say in 1990 and it takes 3 1/2 years to landfill
21 the first cell and 3 1/2 years to landfill the second
22 cell and 3 1/2 years to landfill the third cell, and if
23 you monitor the performance of each one of those cells,
24 would you agree with me that it would not be
25 appropriate to landfill in cells 4 and 5 unless cells



1 1, 2 and 3 are operating satisfactorily at the time you
2 start landfilling in cells 4 and 5?

3 A. Yes, certainly I would agree.

4 Q. Would you therefore agree with me,
5 Dr. Charlesworth, that if there was going to be massive
6 failure at this site, we are most likely to experience
7 it first in the first cells to be constructed?

8 A. No, I can't say. I don't see any
9 reason why you shouldn't have a massive failure in the
10 last cells to be constructed because, for example, the
11 geology varies beneath the site and for whatever reason
12 which creates the scenario, and the failure scenarios
13 are not my concept, but whatever reason precipitates
14 these, it may not necessarily happen in every cell in a
15 similar fashion. So I don't think it is reasonable to
16 assume that the failure would be in the first cell,
17 whatever the failure scenario is. I think it is quite
18 conceivable that cells 1, 2 and 3 would work okay and
19 you may get failure somewhere down the road in cells 4
20 and 5.

21 Q. But wouldn't the performance of
22 cells 1, 2 and 3 over the course of the first 10½ years
23 of landfilling give you a very good indication as to
24 whether or not landfilling could be carried on
25 reasonably safely on this site?



1 A. It would, if the geology beneath
2 the site in terms of, for example, the units, the
3 likely flowpaths was the same beneath each cell, and
4 once that is demonstrated then I would go along with
5 your concept to some extent, but I can't agree with you
6 until that has been demonstrated.

7 Q. Will you agree with me this far,
8 Dr. Charlesworth. In order to have a massive failure
9 in any cell at Site D with all the underdrains sealing
10 off, but not on, the hypothesis, the subheaders, and in
11 order for the leachate to build up to a height of 15
12 metres over a period of 14 years, it would take an
13 unconscionable amount of disregard to not observe that
14 that kind of a failure was taking place?

15 A. That is doubtless Dr. Rowe's worst
16 case, the end of his spectrum.

17 Q. Can you imagine in Ontario in
18 1988, never mind in the year 2000, that it would be
19 possible to ignore leachate buildup in one cell of a
20 landfill for 14 years while it builds up to 15 metres?

21 A. I would -- I think I would -- I
22 would like to think that that would not happen, and I
23 would also say, Mr. Chairman, with the monitoring as I
24 interpret it that was presented in the reports, it is
25 conceivable that that could have happened and whether



1 we now improve the monitoring system and go to
2 monitoring in the cells ...

3 Q. But we are improving the
4 monitoring system because you are designing it and we
5 have already improved the monitoring system and you
6 have agreed we can monitor the leachate levels in the
7 cell and we can monitor what is happening outside the
8 cell and we can tell whether or not the cell is
9 performing adequately. If that is the monitoring
10 program designed and implemented at this site, and you
11 are here as an expert hydrogeologist and you can make
12 your recommendations to this Board, and I would like
13 you to keep that in mind, but if that is the monitoring
14 program that is installed at this site, how is it
15 conceivable that the leachate in cell 1 could ever
16 build up to 15 metres undetected?

17 A. It is unlikely.

18 Q. It is inconceivable, is it not?

19 A. I am always reluctant to say
20 anything is impossible, but it is certainly unlikely.

21 Q. There is a very, very remote
22 possibility, don't you agree?

23 A. I would agree that with adequate
24 monitoring they should certainly be alerted and be able
25 to act upon the warnings they get from the monitoring



1 system and I would hope that the regulatory authorities
2 would ensure that they did that.

3 Q. If the hypothesis is that
4 underdrains fail because they plug off, you would agree
5 with me that they are more likely to plug off in the
6 old cells before they plug off in the new cells,
7 wouldn't you?

8 A. I would agree they are more likely
9 to plug off in the old cells than the new cells, but
10 that isn't quite how the question was phrased earlier.

11 Q. That's how it is phrased now, and
12 is that the answer?

13 A. But with regard to where a failure
14 occurs, if it occurs, it could happen in any of the
15 cells.

16 Q. But it is more likely to happen in
17 cell 1 first?

18 A. If it is going to happen in the
19 early stages, it is more likely to happen in cell 1
20 first because that has been around longer.

21 Q. And it just happens that cell 1 is
22 not adjacent to the three overburden wells of greatest
23 concern to you and Dr. Rowe, is that not right?

24 A. It is the most distant cell from
25 those and I don't know if it just happens or if it is



1 designed.

2 Q. In fact the closest cells to those
3 three wells is cells 4 and 5?

4 A. Correct.

5 Q. It would have been possible to
6 hypothesize failure in cells 1 and 2 but in fact it has
7 been hypothesized it will happen in cells 4 and 5?

8 A. Is that a question?

9 Q. That is a question.

10 A. I am sorry, could you repeat it?

11 Q. You have hypothesized failure
12 won't happen in cells 1 and 2 or 3 first, it will
13 happen in 4 and 5?

14 A. I haven't hypothesized.

15 Q. Dr. Rowe has hypothesized that.
16 You would agree that cells 4 and 5 are closest to the
17 Pompa, Chlon and Chaput wells?

18 DR. ROWE: A. Yes.

19 Q. If failure occurs it is more
20 likely to impact those wells if it occurs in cells 4 or
21 5 than it does if it occurs in cell 1?

22 A. Are you asking Dr. Charlesworth?

23 Q. Dr. Charlesworth.

24 DR. CHARLESWORTH: A. Yes. The
25 evidence we have in terms of where the granular unit



1 may be indicates that that is where it may be which is
2 the reason for being concerned if it extends off-site.

3 Q. But you would agree it wouldn't be
4 responsible for the region to landfill in cells 4 and 5
5 unless monitoring in cells 1, 2 and 3 demonstrated, No.
6 1, that cells 1, 2 and 3 could be monitored and, No. 2,
7 that monitoring in fact showed that the landfill was
8 operating properly?

9 A. I think it wouldn't be responsible
10 for the Region to landfill in cells 4 and 5 until they
11 defined the extent of the granular units.

12 Q. Please answer the question.

13 You would agree it would not be
14 responsible to construct cells 4 and 5 unless testing
15 had demonstrated that landfilling at cells 1, 2 and
16 3 ...

17 A. I am sorry, yes, I agree.

18 MR. HODGSON: Mr. Chairman, this would
19 be a convenient time.

20 MR. LANCASTER: I have a little extra
21 chore in the morning, so we will meet tomorrow morning
22 at ten.

23 DR. CHARLESWORTH: Someone is telling me
24 we are expecting 6 inches of snow after midnight and do
25 we have somewhere we can phone to find out if everybody



1 has made it?

2 MR. LANCASTER: That's a thought.

3 MR. HODGSON: Dr. Rowe is the only
4 person who doesn't go home at night. If he lives in
5 Oakville perhaps he could make himself action central
6 at a phone number and we can all phone him and tell him
7 what happened?

8 MR. LANCASTER: Most people are from
9 Toronto and the Board office is in Toronto.

10 DR. KINGHAM: I think we could manage
11 any such alert from the Environmental Assessment Board
12 Registrar, Yvonne Lane, and I will give you her number
13 and she has done this before, so I am sure she would be
14 prepared to do it again. 323-4814. If there is some
15 disaster that strikes you can call that number and
16 Ms. Yvonne Lane will take the call and hopefully will
17 alert all the other parties as to what the disaster is.

18 MR. LANCASTER: Please don't put
19 yourself at risk.

20 DR. CHARLESWORTH: I think I might call
21 from Montego Bay and say I can't make it.

22 MR. HODGSON: Disguise your voice.

23 ---Adjournment at 4:30 p.m.

24 Certified Correct

25 C. F. Nethercut, C.V.R.

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