

CH 88 02
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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-Q208-A01;

— and —

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;

— and —

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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185 RICHMOND ST. W.,

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TEL: 593-4802



I N D E X

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CHARLESWORTH, Dr. David Leonard Charlesworth
(resumed)

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THE CONSOLIDATED HEARINGS BOARD

- 1 IN THE MATTER OF Sections 2 and 3 and 6(3) of the
2 Consolidated Hearings Act, 1981, S.O. 1981, c. 20;
3 - and -
4 IN THE MATTER OF Sections 12(2) of the Environmental
5 Assessment Act, R.S.O. 1980, c.140;
6 - and -
7 IN THE MATTER OF Sections 30, 35 and 38 of the
8 Environmental Protection Act, R.S.O. 1980, c.141, as
9 amended;
10 - and -
11 IN THE MATTER OF Sections 24 and 61(2) of the Ontario
12 Water Resources Act, R.S.O. 1980, c.361, as amended;
13 - and -
14 IN THE MATTER OF Section 28(3) of, and Regulation 164
15 under, the Conservation Authorities Act, R.S.O. 1980,
16 c.85, as amended;
17 - and -
18 IN THE MATTER OF Section 40(12) of the Planning Act,
19 S.O. 1983, c.1, as amended; in connection with site
20 plan control of the sanitary landfill site;
21 - and -
22 IN THE MATTER OF Section 22(1) of the Planning Act,
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24 Honourable Bernard Grandmaitre, Minister of Municipal
25 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;
- and -
IN THE MATTER OF Section 34(11) of the Planning Act,
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Regional Municipality of Halton for an order directing
an amendment to By-law 61-85 of the Town of Milton to
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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
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BEFORE: H. H. Lancaster, Q.C. - Chairman
Dr. D.J. Kingham - Member



Hearing conducted at The Oakville
Granary Commercial Centre, 105 Robinson
Street, Oakville, Ontario, on Monday,
February 1, 1988.

VOLUME 83

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



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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		
7		
8		
9		
10		
11		
12	J.H. Olah	for the Halton Region
13		Conservation Authority
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185 Richmond St. W.
Toronto, Ontario
M5V 1V3

Per: P.D. McQueen



Oakville, Ontario
February 1, 1988

1 --- Upon commencing at 11:30 a.m.

2 MR. LANCASTER: Good morning. Please be
3 seated. Mr. Estrin, there were a few exhibits to come,
4 five or six of them I believe.

5 DR. RONALD KERRY ROWE, (resumed):

6 DR. DAVID LEONARD CHARLESWORTH, (resumed):

7 EXAMINATION IN CHIEF BY MR. ESTRIN, (continued):

8 MR. ESTRIN: Yes. First of all, I have
9 a copy of M-444-OH-38A and 43A.

10 MR. LANCASTER: They have been marked
11 already.

12 MR. ESTRIN: Then there was what I think
13 is Exhibit M-459, piezometer HC-2-86, hydrograph with
14 the rain or precipitation data superimposed on it for
15 August and September, 1987. There is another one of a
16 similar nature which has the number M-461 marked on it
17 which I hope is the appropriate number for HC-2-85.

18 MR. LANCASTER: That is correct.

19 MR. ESTRIN: Finally, a copy of an
20 overhead that Dr. Charlesworth showed you with respect
21 to Site D borehole locations and the location of what
22 were upgradients, horizontal gradients and downward
23 gradients. There is a key on here. Looking at it it
24 may not be that easy to read and I am going to ask
25 Dr. Charlesworth to perhaps at some time or someone



1 from our staff colour those in in an appropriate
2 manner.

3 MR. LANCASTER: That was M-460.

4 MR. ESTRIN: Then if we can continue,
5 Dr. Rowe was discussing ...

6 MR. HODGSON: Excuse me, Mr. Chairman,
7 can we wait until we all have copies of these?

8 MR. ESTRIN: As you will recall,
9 Dr. Rowe was reviewing the important findings of his
10 Site D report. I think I will leave it to Dr. Rowe to
11 pick up on where we were and take it -- tell us where
12 he would like to proceed with that report with
13 reference to overheads and the witness statement.

14 DR. KINGHAM: We have an errata sheet
15 here.

16 MR. ESTRIN: That was previously
17 distributed to the parties. I don't believe it needs
18 to be made an exhibit.

19 DR. KINGHAM: It is both for M-437 and
20 438?

21 MR. ESTRIN: Yes.

22 DR. ROWE: Mr. Chairman, at the end of
23 the session on Thursday I was establishing the basic
24 parameters and methodology that I adopted in this
25 study. I would like to refer, for a few moments, to



1 overhead 42 which is attached to the witness statement,
2 Exhibit M-444.

3 For the purposes of this examination and
4 the primary cases I considered I actually modelled, as
5 I indicated, the thin bed of silt, the upper granular
6 unit, the lower granular unit as well as the till units
7 shown on that overhead. For the purposes of modelling
8 I essentially adopted Trow's hydrostratigraphy. I
9 would just like to refer very briefly to my Site D
10 report which is Exhibit M-442 and specifically to the
11 paragraph on the bottom of page 3. To make the
12 situation quite clear I would like to read that
13 paragraph, if I could:

14 "For the purposes of this study, THCL's
15 assumption that the upper granular unit
16 was the major conduit for rapid
17 contaminant transport off-site was
18 adopted and attention was focused on the
19 increase in the concentration of
20 chloride in this unit at a point 100
21 metres from the landfill, (i.e. at the
22 site boundary). If further
23 investigations were to identify THCL's
24 'thin bed of silt' as being of more
25 hydrogeological significance than



1 indicated by THCL, then the impact of
2 the landfill on groundwater quality at
3 the site boundary could be greater than
4 indicated in the analysis reported
5 herein."

6 I read that to put my comments in context with respect
7 to this thin bed of silt. In my analysis I did not
8 find significant impact off-site for the parameters
9 that I assumed. Dr. Charlesworth raised some question
10 about the significance of this unit in his evidence and
11 his comments do not conflict with what I have said. I
12 am assuming that is of little significance, that may or
13 may not be true.

14 The other point that I would like to
15 mention before we move on is that when one is looking
16 at water balance in the local system one has to make
17 some assumption about over what distance the water is
18 flowing down and off to the left. In this case "off to
19 the left" means off to the west of the site in the
20 local frame of reference. To provide some background
21 for this parameter I would like to, just for a moment,
22 show overhead No. 37 which shows the landfills
23 schematically superimposed on Dr. Charlesworth's
24 indication or Dr. Charlesworth's plot of the minimum
25 and maximum extent of the upper granular unit. The



1 dimension from west to east is approximately 575
2 metres. One can visualize two situations occurring or
3 at least two situations if there was not a significant
4 unit over to the east. When mounding occurred in the
5 landfill, one can visualize the flow moving westward in
6 the upper granular unit over the width of the landfill,
7 i.e., about 575 metres.

8 On the other hand, if this upper
9 granular unit extends in both directions then one can
10 visualize a situation where some of the flow, probably
11 about half of it, would head in the westerly direction
12 and flow would head in the easterly direction. So one
13 can see two possible scenarios that warrant some
14 thought; the possibility that it all flows to the west
15 or it goes down and flows to both west and east. This
16 is where this length L that I am talking about comes
17 in. Is it the full width or is it the half width or in
18 the case of a partial failure it may be just the width
19 of the zone where the partial failure has occurred, or
20 in fact, half of that because there is potential if we
21 consider failure of a number of tiles in that location
22 there, one can consider the potential for lateral flow
23 in this direction as well as in that direction.

24 MR. ESTRIN: Q. Dr. Rowe, you have just
25 marked the overhead with three green lines.



1 DR. ROWE: A. Three green lines in the
2 location I submitted the three tiles failing in my
3 scenario C. Would you like me to mark that as an
4 exhibit?

5 Q. I think we can. We don't ...

6 A. Essentially it is shown on another
7 overhead. If you like I can put that up if it saves
8 anyone any confusion. I had my reference to that with
9 regard to my different scenarios so that if one was to
10 look at Exhibit M-444-OH-43A on scenario C I am talking
11 about these three tiles failing here. What I was
12 indicating on overhead 37 was the potential for flow
13 both to the west and to the east in the event something
14 like that occurred.

15 MR. LANCASTER: You could mark that
16 M-444-OH-37A.

17 --- EXHIBIT NO. M-444-OH-37A: Overhead showing
18 landfill site with
19 cells 4 and 5
delineated

20 DR. KINGHAM: We never had that one with
21 the cross-hatching on before, did we?

22 MR. ESTRIN: I believe that is correct.

23 DR. KINGHAM: I guess that will be as
24 marked.

25 DR. ROWE: I raise this point,
Mr. Chairman, because as I go through these results I



1 will be referring to one-way and two-way flow. When I
2 am referring to one-way flow I am visualizing the flow
3 all moving across to the west and when I talk about
4 two-way flow I will be visualizing half the flow moving
5 to the west and the other half moving to the east. In
6 terms of a parameter, that is represented in terms of
7 the distance L which I refer to in my report and which
8 is referenced in table 2 on page 27 of my Site D
9 report, Exhibit M-442.

10 I am now going to refer to overhead 48
11 in the witness statement which has the title
12 "Differences in Analyses Conducted for Site D."
13 Mr. Chairman, I would like to put this discussion in
14 context. Trow did their analyses in 1986. The theory
15 that I used, the method of analysis or model if you
16 like that I used was published in 1986 so I am not
17 intending to reflect in any way on Trow for not using
18 this type of model. However, what I think is useful is
19 simply for the Board to understand the differences in
20 the two approaches that were adopted.

21 The Trow approach in terms of modelling
22 the variation in concentration with time in the
23 landfill used an assumed concentration profile, assumed
24 variation in concentration with time which they had
25 based on some data and they produced an exhibit to



1 illustrate that. As I have indicated, I approached the
2 same situation from a slightly different aspect. I
3 actually modelled the mass of contaminant in the
4 landfill and let the concentration vary as it would, as
5 the analysis dictated. As it turns out you will see
6 the results are not too different from what Trow used.

7 They then used a one-dimensional
8 solution which is commonly or often referred to as the
9 Ogata-Banks solution. It is actually an analytic
10 solution for a half space, that is for a soil deposit
11 that extends to infinity. This clearly isn't the
12 situation at Site D and therefore if one attempts to
13 use that solution clearly one is involving
14 approximations. What I used was a semi-analytic
15 solution which models the two-dimensional situation
16 which allows us to consider mass actually moving down
17 as well as laterally. It also allows one to consider
18 the influence of flow in the upper granular unit upon
19 transport through the till units.

20 Because they had a one-dimensional model
21 of the Ogata-Banks form they were forced to only match
22 the concentrations at the boundaries between different
23 layers. Now, I would like to, if I could, to just
24 define in general terms the three terms I am going to
25 talk about. One is concentration.



1 If we go back to our airport analogy,
2 concentration is related to how many people are in a
3 given area. The flux is how much is moving. So in our
4 airport analogy the flux is how many people pass a
5 given point per unit area per unit time. If one is
6 talking about conservation of mass, what we are talking
7 about is the number of people who leave the holding
8 ground doesn't change. They might distribute
9 themselves around different holding bays but the number
10 of people doesn't change. That is what we say
11 conservation of mass is. If there was not
12 concentration of mass then people would disappear or
13 appear from nowhere.

14 When one simply enforces concentration
15 at the boundary between different units, one is not
16 saying anything about continuity of flux. Therefore,
17 one has no control on ensuring conservation of mass.
18 This, I think, as a primary difference between the
19 approaches that have been taken is that they have not
20 ensured continuity of flux. It's not their fault, you
21 just can't have continuity of concentration and
22 continuity of flux if you are going to use this model.

23 MR. ESTRIN: Q. Which model?

24 DR. ROWE: A. The Ogata-Banks model.
25 If one is using a two-dimensional model, that allows



1 you to ensure or should I say the two-dimensional model
2 of the nature I have used, that allows one to ensure
3 not only continuity of concentration but continuity of
4 flux. So, it satisfies conservation of mass.

5 The other point, and this is not a big
6 issue, but when you are coupling one-dimensional
7 solutions there is no way of taking account of the
8 effect of contaminants migrating in the upper unit upon
9 what might be happening in the lower unit. You can
10 visualize it, contaminants are coming down and also
11 being carried along this unit. There is the potential
12 for them to move down in terms of this diagram towards
13 the left and also impact on the lower granular unit
14 even outside the landfill.

15 Now, one again cannot readily model this
16 if you are using one-dimensional solutions, although
17 that is not as important an issue as this one, as the
18 question of conservation of mass.

19 Now, in terms of results I am going to
20 report to you, Mr. Chairman, the results of a number of
21 cases which as I have said are listed in table 2 of my
22 report. There are a total of 12 cases in that table.
23 Eleven of them, if you like, my cases -- one of them
24 was a simple attempt by myself to model what Trow had
25 done using their parameters but using two dimensions as



1 silt in this particular analysis. In every other case
2 I did, in this case I didn't nor did I model lateral
3 migration in the lower granular unit in this particular
4 case. What one sees is not terribly dramatic. One
5 sees that the concentration that I calculated is a
6 little higher. The peak concentration I calculated is
7 about 430 milligrams per litre but it takes a little
8 longer for that contaminant to get there.

9 I would also point out that in these
10 calculations, if you look at the way that Trow modelled
11 it and the parameters they used, they are in essence
12 saying that 30 per cent of the recharge from the
13 landfill is going down to the shale. That is my
14 interpretation of their numbers for this particular
15 case. So, I put that up just to illustrate the
16 comparison between their calculation and my
17 calculation. I would however caution that because
18 Trow's approach does not satisfy conservation of mass
19 when you couple the different one-dimensional
20 solutions, one cannot generalize as to how the results
21 of that approach would compare with the results of the
22 two-dimensional approach which does satisfy
23 conservation of contaminant mass. So, one should be
24 careful in generalizing. How the two compare will
25 depend on the parameters used in that comparison.



1 I would now like to leave Trow's
2 scenario and move on to the first of three different
3 scenarios which I considered in my Site D report. I am
4 going to begin by looking at overhead No. 44 which is a
5 summary relating to collection scenario A.

6 MR. ESTRIN: Q. Before we move, you
7 have added some things that are not on our copy of
8 overhead 49.

9 DR. ROWE: A. So this will be Exhibit
10 M-444-OH-49A.

11 --- EXHIBIT NO. M-444-OH-49A: Overhead showing
12 chloride concentration
13 at site boundary in
14 granular units

15 MR. ESTRIN: Q. While we are still on
16 that can you tell us, please, does the curve that you
17 have produced from Trow's report in this exhibit, what
18 can you tell us about it as to how that corresponds to
19 Trow's worst case?

20 DR. ROWE: A. Yes, Mr. Chairman, the
21 curve that I have reproduced here corresponds to the
22 worst case considered by Trow. That represents a
23 situation which I think they referred to as no leachate
24 collection system in operation. That is their worst
25 case scenario.

So, referring to overhead 44 this is
relating to collection scenario A and that scenario,



1 Mr. Chairman, is a scenario where I am assuming all the
2 collection tiles are functioning but that the hydraulic
3 conductivity of the waste, instead of being 10^{-4} has a
4 nominal value of 10^{-5} cm/s. What that does is for the
5 spacing that they have adopted in their design of
6 approximately 30 metres, it gives you an average height
7 of mounding of 182.7 metres. Now, if the original head
8 in the upper granular unit is somewhere around 181.6
9 then this will reverse the hydraulic trap and you will
10 get flow going down into the upper granular unit.

11 Now, there are a number of cases I have
12 examined with respect to this scenario. The case No. 2
13 involves one-way flow; in other words, I am assuming it
14 is all going off to the west, the hydraulic
15 conductivity of the upper till of 4×10^{-7} . You will
16 recall, Mr. Chairman, that Trow indicated a hydraulic
17 conductivity of the upper till of 8×10^{-8} .

18 Dr. Charlesworth and I both spoke to the fact that we
19 don't believe that it is 8×10^{-8} and I feel it is
20 prudent to consider a range of hydraulic conductivities
21 in the upper till. The upper end of the range I
22 considered corresponds to case 3 here which is a
23 hydraulic conductivity of 8×10^{-7} .

24 If I can work my way through this
25 summary, if we -- looking at case No. 2, the first



1 column indicates the direction I am assuming flow. The
2 second column is the hydraulic conductivity of the
3 till, of the upper till. The third column is the Darcy
4 velocity in the upper granular unit that one calculates
5 from the flow modelling, from the consideration of
6 water balance and hydraulic conductivity. So, in this
7 case, case No. 2, we would have a Darcy velocity of
8 about nine metres per annum moving off to the west.
9 Even though I am saying that contaminant is getting
10 down through the upper till, and it will in this
11 scenario, the collection tiles would still be
12 collecting about 90 per cent of the leachate and for
13 the boundary conditions I considered in this particular
14 case, the flow to the shale would be about 44 per cent.
15 I will come back to the summary of results a little
16 later.

17 Cases 2 and 3 considered the boundary
18 head conditions which I denoted boundary head
19 conditions 1 in my preliminary discussion. This is the
20 more critical case; that is with the lower heads at the
21 boundary of the property but these heads are consistent
22 with the data provided by Trow.

23 Cases 4 through 12 were performed using
24 what I have denoted as boundary head case No. 2. As I
25 discussed, this is a less conservative unit; that is to



1 say it will give less impact than boundary conditions
2 1. So my calculations for cases 4 through 12 may not
3 be conservative, they may not be a worst case. You
4 will see in case 4 I have sub-cases a, b and c. These
5 have all the same flow conditions. All that I am
6 varying in these three cases is the mass of contaminant
7 I assumed in the landfill. My purpose here,
8 Mr. Chairman, is to illustrate the implications of
9 bearing that particular parameter. Case 4a is what I
10 considered to be a reasonable case. It corresponds to
11 a mass of 4,400 tonnes. Case 4b corresponds to a
12 lesser value of 3,360 tonnes and case c is what I
13 considered to be a conservative case; that is I don't
14 expect the mass will be this high and that was 7,700
15 tonnes.

16 I would again point out that in all
17 these calculations of mass I have not considered any
18 chloride coming in from the till. It is all coming
19 from the landfill.

20 The fifth case is for very similar
21 parameters to case 4a. The only difference between
22 those two cases is that in case 4a I have assumed one-
23 way flow and in case 5 I have assumed two-way flow.

24 DR. KINGHAM: I wonder if you can
25 clarify two things for us at that very point. You just



1 told us the difference between 4a, b and c was in the
2 mass of contaminants you expect to flow?

3 DR. ROWE: The mass of contaminant I
4 assumed was in the landfill.

5 DR. KINGHAM: On your table 2, page 27,
6 is an equivalent height of leachate which seems to have
7 to do -- are you going to explain that to us?

8 DR. ROWE: I wasn't going to go into
9 that. The mass is a parameter that goes in. If the
10 Board wishes I will be happy to go into it but the
11 equivalent height of leachate is the actual parameter I
12 used in the analysis and one of the key components of
13 that is the mass of contaminant.

14 DR. KINGHAM: So you are saying the mass
15 of contaminant is proportional to the equivalent height
16 of the leachate?

17 DR. ROWE: Yes, it is.

18 DR. KINGHAM: The second question I have
19 for you is that in these cases you told us you assumed
20 a hydraulic conductivity of waste of 10^{-5} . Your table
21 shows a range, are we to understand that is a range of
22 hydraulic conductivities of 0.85, 0.86, presumably
23 times 10^{-6} up to 1×10^{-5} ? Is that how we are to
24 assume it?

25 DR. ROWE: That is 0.85×10^{-5} to $1 \times$



1 10⁻⁵. Were you asking me to clarify why that is a
2 range there?

3 DR. KINGHAM: I just wanted to make sure
4 what you meant by 0.86 to 1. Thank you

5 DR. ROWE: I would now like to refer to
6 overhead No. 51 which is a reproduction ...

7 MR. ESTRIN: Q. Did you add anything to
8 the last one that we didn't have already? No, sorry,
9 this collection, scenario A.

10 DR. ROWE: A. You are quite right,
11 Mr. Estrin.

12 Q. You have added something at the
13 bottom?

14 A. Yes. All that information is
15 contained in tables 1 through 4. I am just bringing it
16 together. So this would be M-444-OH-44A.

17 --- EXHIBIT NO. M-444-OH-44A: Overhead containing
18 information from tables
19 1 to 4

20 MR. ESTRIN: Q. Just before you put
21 that one down, you mentioned something in passing which
22 is not clear in your notes. You said something about
23 case 4a and the mass of chloride considered there with
24 -- what did you say about that in terms of your opinion
25 as to whether that mass was or was not a reasonable
one.



1 DR. ROWE: A. Based on the evidence
2 available to me I think that a mass of about 4,400
3 tonnes seems reasonable. If I could again put up
4 overhead No. 51 from my witness statement, Exhibit 444,
5 and this is a reproduction of figure 7 of my Site D
6 report showing results for cases 2 and 3 where the
7 leachate collection system is working. We are looking
8 at additional mounding due to the hydraulic
9 conductivity of the waste. One can see a trend that
10 you are going to see in all of these curves,
11 Mr. Chairman. That is a trend where when you are
12 plotting concentration versus time at a particular
13 point and our point here is in the upper granular unit
14 100 metres downgradient, the concentration at that
15 point increases with time, will reach a peak value and
16 will subsequently decrease.

17 In case No. 2 which has a hydraulic
18 conductivity in the upper till of 4×10^{-7} , you can say
19 that the concentration had not reached a peak by the
20 time I reached 80 years which is where I stopped the
21 analysis. Even though it hadn't peaked, the
22 concentration at that time was already 530 milligrams
23 per litre for assuming an initial concentration in the
24 landfill of 1,500 which is the same value that Trow
25 used. So the maximum concentration in this case occurs



1 at some time greater than 80 years but at 80 years it
2 is 530 milligrams per litre. This is despite the fact
3 that 90 per cent of the leachate is being collected and
4 44 per cent is going down to the shale.

5 The first arrival in all of these
6 figures, I have defined first arrival as the time when
7 the concentration at the boundary reaches 25 milligrams
8 per litre. That first arrival in case No. 2 is about
9 46 years. In case 3 which is the same conditions
10 except I am looking at a hydraulic conductivity of the
11 upper till of 8×10^{-7} ; in other words, twice as large.
12 In this case you can say the peak arrives at about 56
13 years and the magnitude of the peak is about 730
14 milligrams per litre despite the fact that in this case
15 85 per cent of the leachate is collected locally and 45
16 per cent of the recharge goes to the shale. Those are,
17 I believe, Mr. Chairman, fairly significant impacts.

18 I would now, if I could, like to move on
19 to overhead 52 which is a reproduction of figure 8 from
20 my Site D report. The purpose of this overhead is to
21 illustrate the effect of the mass of contaminant within
22 the landfill. So I would like to just focus results on
23 curves 4a, b and c which I have highlighted in marker
24 pen. If we look at the worst situation here, if we
25 assume the mass of chloride is 7,700 tonnes, then the



1 peak occurs at about 66 years at a value of about 760
2 milligrams per litre. If you have a smaller mass of
3 contaminant you will have a smaller impact. So, if the
4 mass were, say, 4,400 tonnes then the peak occurs
5 somewhere around 62 years and the maximum impact is
6 about 570 milligrams per litre. This is the mass I
7 will be using in all the subsequent calculations. If
8 one was to use a mass of 3,360 tonnes then the peak
9 would be somewhere about 62 years again at a value of
10 about 490 milligrams per litre. Irrespective of which
11 mass we use there is clearly a significant off-site
12 impact.

13 To go with this plot of what is
14 happening at the boundary of the site in the upper
15 granular unit I would next like to show you,
16 Mr. Chairman, some plots of how the concentration would
17 vary with time within the landfill. So, I am going now
18 to refer to overhead 53 which is a reproduction of
19 figure 9 from my Site D report. This again shows
20 variation in concentration with time. In this case
21 though we are referring to the leachate concentration;
22 in other words, the concentration within the landfill.

23 I have shown marked or highlighted in
24 red the concentration profile which Trow assumed in
25 their modelling and, as you will recall, Mr. Chairman,



1 they had data, certainly in the early periods of time
2 which guided them in the selection of this curve but
3 after about 45 years they, as I interpreted,
4 conservatively postulated that the concentration would
5 remain constant at 100 milligrams per litre at least
6 for 200 years. So, this is Trow's curve in red. If I
7 was to perform the analysis, when I performed the
8 analysis for case 4b using a mass of 3,360 tonnes which
9 corresponds to integrating the area, which corresponds
10 to the area under this curve up to about 45 years and
11 the amount of leachate equal to the assumed
12 infiltration, then in fact one finds one gets a very
13 good match up to certainly about 45 years. This curve
14 trails off as indeed one would expect it to. If one
15 looks at the situation which is dealt with in case 4a
16 and also in all the other cases, 2 through 12, 4,400
17 tonnes, then the variation is highlighted in what I
18 would call purple and it is a little bit higher than
19 Trow's values up until about 50 years and then of
20 course it levels off to very low values as one would
21 expect.

22 Finally, if we adopt the most
23 conservative interpretation, 7,700 tonnes, which is
24 including this postulated area up to 200 years then
25 this is much higher than the concentrations Trow



1 deduced from their data, their field data. So this is
2 quite a conservative curve, certainly up to 80 years.

3 DR. KINGHAM: Dr. Rowe, I have the same
4 difficulty understanding this that I had last week.
5 The mass of chloride in the waste is the mass of
6 chloride in the waste, is it not? What leads you to
7 assumptions that in one case the mass of chloride is
8 3,000 metric tonnes and in another case it is almost
9 8,000 metric tonnes?

10 DR. ROWE: That is a good question,
11 Dr. Kingham. One has difficulty in knowing precisely
12 what the mass is going to be there. Some people have
13 tried to estimate it. For example in a paper by
14 Hughes, et al, in the 1970's they had estimated the
15 mass of chloride would be in the order of 0.1 per cent
16 of the total mass. That is one way you can go at it.
17 Another way to go at it is to say we have data showing
18 how the concentration varies with time as we bring
19 about a collection system. If it is coming out of the
20 leachate collection system then we know what the
21 concentration is at the point in time. If we were to
22 integrate the amount of flow that is coming out of the
23 collection system times the concentration then that
24 gives us another way of coming at the mass of
25 contaminant. Of course, that is related to two things.



1 One is the concentration and the other is how much flow
2 you have got. So, mass, if you are going to adopt that
3 way of working out the mass, then you have not only the
4 concentration variation but you have to say something
5 about how much, what volume of leachate is being
6 collected and it is that issue that really results in
7 these different issues.

8 For example, in case 4b I have said that
9 they are collecting leachate at this concentration and
10 that the volume they are collecting is 310 litres per
11 minute. That is what you would expect or what one
12 infers from their reports if the source of the
13 leachate, or water being collected as leachate is
14 purely infiltration. So, if we are just considering
15 the infiltration coming down, washing through the
16 landfill, picking up chloride, taking it out through a
17 pipe, enlarging the mass with time, 310 litres per
18 minute over 45 years, the mass we would collect, based
19 on Trow's curve, is 3,360 tonnes.

20 Now, Trow indicate that if their
21 hydraulic trap is working then they will get additional
22 flow because there will be water coming up from
23 underneath in the upper till. That would give them a
24 volume of leachate being collected of the order of 400
25 litres per minute. Now, if one -- on assuming that



1 there is no chloride coming in with that water but that
2 when it mixes with the water coming down from the
3 infiltration there is a dilution going on, so that by
4 the time you measure it at your collection point you
5 have a larger volume of water at this concentration.
6 When you perform that integration you come up with
7 4,400 tonnes if you integrate it over nought to 45
8 years.

9 Now, the third situation is assuming
10 exactly the same flow but integrating it over 200
11 years, that is assuming one can project for 200 years
12 which is doubtful. The evidence would suggest that
13 this sort of thing is more likely to happen. If one
14 wants to be very conservative then one could assume
15 this flow over 200 years and that is the mass we would
16 come up with.

17 Now, in terms of the original number I
18 gave you, I mentioned that Hughes, et al, had quoted a
19 value which if I recall correctly is about 0.1 per cent
20 of the total mass. This 4,400 tonnes coincidentally
21 works out to be in the order of 0.1 per cent. The
22 7,700 tonnes is in the order of 0.2 per cent of the
23 total mass in the landfill.

24 DR. KINGHAM: Let us just see if I have
25 got this right. If the waste contained, let us say,



1 4,400 tonnes and you are collecting leachate at the
2 lower rate and not counting on collecting any leachate
3 and surrounding groundwater it would be more
4 concentrated coming down through the waste. Your
5 assumption in the middle of the two cases there is that
6 you are collecting some pure water and some leachate
7 and the concentration is still high enough that when
8 you integrate it it would lead you to conclude that
9 there must have been more chloride in the waste? If
10 that is correct then I understand.

11 DR. ROWE: That is correct, doctor.
12 This is correct if -- I think I mentioned the other day
13 that if I was making a prediction as opposed to a
14 design calculation then that is the number I think is a
15 reasonable number to use. In a design calculation, it
16 is better to err on the conservative side but not
17 unreasonably so.

18 DR. KINGHAM: This you are referring to
19 is the 4,400 tonnes and leachate collection of 400
20 litres per minute.

21 MR. HODGSON: Can we just have, for the
22 record, I think the witness was circling 3,360 tonnes
23 and saying that was reasonable.

24 DR. ROWE: I would have no difficulty
25 with 3,360 tonnes. If I was doing a prediction



1 exercise as opposed to a design exercise that would be
2 a reasonable number to use. For design calculation I
3 have chosen 4,400 tonnes which I think, based on the
4 evidence available to me appears to be a reasonable, if
5 not excessively conservative number.

6 MR. ESTRIN: Q. Perhaps for our benefit
7 now and later you had better explain what the
8 difference in your view is between the prediction and
9 the design calculation.

10 DR. ROWE: A. Well, a prediction is
11 when, if one is in a competition for example and these
12 things happen from time to time in geotechnical
13 engineering when you are asked to predict a quantity,
14 for example what the concentrations would be at a given
15 point or how high could you build an embankment before
16 it falls down. You use all the parameters you think
17 are the most likely parameters because you are trying
18 to predict as near as possible what is going to happen.
19 That is a prediction exercise. We rarely do it.
20 Sometimes we do it but we rarely do it in engineering.
21 Normally we are doing a design calculation.

22 In a prediction calculation in the case
23 of things falling down, you were expecting it to fall
24 down so everything is set up because you want it to
25 fall down. You want to know who can best predict when



1 it is going to fall down. In a design calculation we
2 don't want things to fall down and therefore we don't
3 design based on our expected values. We don't design
4 in the case of a building using what we expect to be
5 the strength of the soil. We apply a factor to it so
6 that we have, in our terminology, a factor of safety
7 because we know there is always uncertainty regarding
8 parameters. What you expect to be the case is rarely
9 precisely what the case is. It could be a bit bigger,
10 it could be a little bit smaller. Therefore one tries
11 to be conservative to err on the side of safety but at
12 the same time not being ridiculously so.

13 Q. When you have described the design
14 calculation as being conservative, you are still
15 comparing that to a more conservative case?

16 A. I believe that 7,700 tonnes is
17 certainly more conservative than 4,400 tonnes, yes.

18 The next overhead I would like to ...

19 Q. You've added some things and
20 numbers on the right-hand side of that diagram. I
21 don't know whether it is necessary to explain it or
22 not.

23 A. These here? That is just
24 integrating from nought to 200 years, nought to 45
25 years and nought to 45 years. Would you like me to



1 make that as an exhibit?

2 Q. I don't know if that's necessary.
3 We can all write that I think.

4 A. I would like now to refer to
5 overhead No. 54 in my witness statement which is a
6 reproduction of figure 8 in my report, curves shown in
7 figure 8 of my report. In fact I have eliminated some
8 of the curves just to clarify the point I want to make
9 here. I have eliminated all the curves from figure 8
10 except figure 4a -- curve 4a and curve 5. Once again
11 we are dealing with the scenario where the leachate
12 collection tiles are working. This is the escape of
13 contaminant if the hydraulic conductivity of the waste
14 is having a nominal value of 10^{-5} cm/s. What I am
15 looking at here is in this particular case the effect
16 of one-way versus two-way flow. All other parameters
17 are the same. So, if we were to look at the curve
18 which is dotted and I have highlighted in brown which
19 is curve No. 5, this curve corresponds to two-way flow;
20 that is some of the contaminant moving to the east and
21 some of it to the west. We have a peak concentration
22 of about 590 milligrams per litre after about 58 years.
23 In the case of one-way flow which is shown by curve 4a
24 we have about 570 milligrams per litre after 62 years.
25 If one just compares these numbers I would say for all



1 practical purposes they are the same. From an
2 engineering perspective there is not a big difference
3 between those numbers. In both cases you have a
4 significant off-site impact in the order of 60 years.
5 The difference between one-way and two-way flow, as you
6 can see in this particular case, does not significantly
7 affect the final result in terms of what is happening
8 in the upper granular unit, although it does affect how
9 much is going to the shale. With two-way flow we had
10 48 per cent going to the shale. With one-way flow we
11 end up with 64 per cent going to the shale. This is
12 because the ability to have flow down through the
13 system is controlled by the capacity of the upper
14 granular unit to transmit water off-site. If you
15 change the flow direction from one way to two way you
16 influence the capacity for the granular unit to
17 transmit water off-site.

18 We will come back to that in some of the
19 other examples. In this case whether it is one way or
20 whether it is two way the net effect is significant
21 impact off-site in the order of 60 years.

22 Q. I believe you mentioned this in
23 the last overhead and at that time you said we are now
24 on, including this scenario you are assuming a mass of
25 leachate, chloride of what?



1 A. Four thousand, four hundred tonnes
2 from here on in.

3 Having gone through those results I
4 would like to go back to overhead 44 which is our
5 summary and simply summarize the results that one can
6 draw, conclusions one can draw from those results. So,
7 now I am going to be looking in particular at the
8 right-hand side of overhead 44. The column second from
9 the right has the time to reach the boundary; that is
10 the time it takes for contaminant to move down through
11 the upper till, the lower till and along the upper
12 granular unit to the boundary of the site at the 25-
13 milligram-per-litre level. You can see that the range
14 of times is between 32 to 46 years. Obviously, you can
15 see the fact I have looked at different cases and got
16 different numbers. One must not place too much
17 emphasis on the number of significant digits. What is
18 important here is we are looking at the order of 30 to
19 45 to 46 years as to the time for off-site impact if
20 they persist with this design they have for Site D.

21 The peak chloride concentration at the
22 boundary arrives a little after first arrival. We have
23 looked at some of those times. The peak concentration
24 for case 2, we didn't actually get to the peak. I
25 stopped it at 80 years, I stopped the analysis at 80



1 years but at that time it was 530 milligrams per litre.
2 Looking at the range, for 4,400 tonnes it ranges
3 between something in excess of 530 milligrams per litre
4 and 730 milligrams per litre for the range of cases
5 considered.

6 The effect of the mass of contaminant is
7 illustrated by the results given in cases 4a, b and c.
8 This summarizes the peak values for different masses
9 for case 4b which is the minimum mass, we have a peak
10 value of 490. For 570 which is my mass of 4,400
11 tonnes, case 4a which is my mass of 4,400 tonnes, we
12 have a peak of 570 milligrams per litre. If we go to
13 what I am saying is a conservative value of 7,700
14 tonnes then the peak is 760. This gives you some idea
15 at least of the implications in this particular case,
16 this particular scenario of different masses.

17 In all cases we have, in my opinion,
18 significant impact at the site boundary.

19 I would now like to move on,
20 Mr. Chairman, to overhead 55. I am jumping a bit
21 forward and will come back again. This is overhead 55
22 of the witness statement which is again a summary of
23 situations relating to scenario A. It is elaborating
24 on some of the things we have seen. I have got, in
25 this particular table, Mr. Chairman, the cases



1 indicated on the left, cases 2, 3, 4 and 5. I have
2 tried to give some idea of how long it might take until
3 we get off-site impact doing a very crude estimate of
4 how long it might take the mound to build up.
5 Essentially what I have assumed is that the mound is
6 being developed at one metre per annum. In this
7 particular case I am talking about a mound of 3.7
8 metres. If one believed this number warranted
9 preciseness, that would give you 3.7 years. I have
10 actually written it down as three years. If you wanted
11 to, one could obviously write down four and everything
12 would be increased by one. Let us suppose for
13 argument's sake it takes three years to build up this
14 mound, 46 years after mound development for contaminant
15 to go down through the units and move off-site, giving
16 a total of 49 years. So, one goes through this
17 exercise for all of these cases including the
18 development of the mound. For our scenario A, that is
19 leachate collection tiles working. We are looking at
20 somewhere between 35 and 49 years. Certainly I hope,
21 Mr. Chairman, that that is within my lifetime. So,
22 this is not, in my opinion, an excessively long period
23 of time.

24 The final column of this table is a
25 summary of how long it takes contaminant to move 100



1 metres once it reaches the upper granular unit. In
2 other words, supposing it is getting down to the upper
3 granular unit and you don't detect it. Once it gets in
4 the upper granular unit how much time do you have
5 before it gets 100 metres off-site? The answer is, in
6 these cases we are looking at somewhere between two and
7 five years.

8 That completes the results that I would
9 like to show you, Mr. Chairman, regarding my scenario
10 A. I would now like to move on to scenario B. I am
11 actually going to go back to overhead 45.

12 MR. ESTRIN: Just before you proceed,
13 Mr. Chairman, what was your intention with respect to
14 how we proceed? Are we going to take a lunch break
15 and, if so, when would you desire to do that?

16 MR. LANCASTER: It will be about 1:00
17 o'clock until a quarter after 2:00. Wherever it is
18 convenient for you.

19 DR. ROWE: Mr. Chairman, then I will put
20 up overhead 45 which has the title "Collection Scenario
21 B." This is my worst case situation, the event where
22 all of the collection tiles fail in cells 4 and 5. I
23 am still assuming that the leachate subheaders are
24 functioning. So leachate is still being collected by
25 the subheaders and perhaps it might be useful if I put



1 up Exhibit H-41-D-2. The subheaders which I am saying
2 are still working are the ones at the north of cell 4
3 and the south of cell 5. I am saying these subheaders
4 are working and the tiles have failed, clogged.

5 Leachate is moving to the west and in some cases I am
6 looking at it moving as well to the east.

7 The height of mounding which one will
8 get of course, as we have seen, depends on the
9 hydraulic conductivity of the waste. I have examined
10 three different hydraulic conductivities of the waste.
11 I have examined a K of 10^{-4} cm/s which is the value
12 Trow have quoted in their report. I have examined 2.35
13 $\times 10^{-4}$ which is a higher hydraulic conductivity and I
14 have examined 10^{-3} . The higher the value of the
15 hydraulic conductivity, the lower the mounding. So, in
16 case 6 where I am examining a hydraulic conductivity of
17 the waste of 10^{-3} the average mound height is 183.5.
18 In case 10 where I am looking at a hydraulic
19 conductivity of the waste with a nominal value of 2.35
20 $\times 10^{-4}$ the height is 188.8 metres. In cases 7, 8 and 9
21 using the hydraulic conductivity of the waste given by
22 Trow the height of the mound is -- the average height
23 is 194 metres.

24 The cases that I have looked at with
25 respect to this scenario are summarized in the lower



1 part of the overhead. Again the case number is shown
2 at the extreme left. The flow condition considered is
3 shown in the next column. Then the hydraulic
4 conductivity of the upper till that I used and as a
5 result of these conditions combined with the hydraulic
6 conductivity of the waste or the mounding that results
7 from that one can deduce, using continuity and Darcy's
8 law, a Darcy velocity within the upper granular unit.
9 In this particular case it ranges from a low value of
10 about 11 up to a high value of about 62 metres per
11 annum. All of those are fairly large flows in my
12 opinion. The leachate collected, we are talking here
13 about the local collection, in other words within cells
14 4 and 5, how much of the leachate that is coming into
15 the cell from infiltration is actually being collected
16 from those two cells. The answer ranges with the case.
17 You can see for case 6 it is 74 per cent, case 10 is 44
18 per cent, 7, 76 per cent. Case 8 is where we have a
19 very leaky system so only ten per cent is collected and
20 case 9 is 76 per cent.

21 The flow to the shale. I am assuming in
22 this particular calculation that the shale acts as a
23 drain. That may not be conservative but it is
24 consistent with the picture that Trow had of how the
25 site was working. So these results are going to show



1 the impact, even though in this calculation, somewhere
2 between 42 and 61 per cent of the leachate is flowing
3 to the shale; that is the leachate that passes into the
4 upper till.

5 I am going to come back to the actual
6 results shortly. Before I do I would like to go
7 through the results themselves. So, I would like to
8 refer, if I can, Mr. Chairman, to overhead 56 which is
9 a reproduction of figure 10 of my Site D report. This
10 is a figure from the case where we have failure of the
11 collection tiles in cells 4 and 5 and is illustrating
12 the effect of considering one-way versus two-way flow.
13 All of these -- both of these analyses, Mr. Chairman,
14 are performed using the values of hydraulic
15 conductivity for the till and the waste which Trow have
16 indicated in their report. This is using Trow's
17 parameters.

18 The curves follow the same trend as we
19 have discussed and one can see once again that whether
20 it is moving one way or two way has not had a terribly
21 significant effect on the final outcome at the site
22 boundary. We have got a peak concentration of between
23 810 and 840 milligrams per litre arriving somewhere
24 about 37 to 38 years.

25 DR. KINGHAM: Can you explain that to



1 us? If the contaminant goes down to the gravel layer
2 and goes both ways the concentration it reaches at a
3 point in time is essentially the same as if it all
4 comes down and all goes one way. It sounds as though
5 there should be a difference.

6 DR. ROWE: There is in fact a difference
7 but it is not terribly significant. What is happening
8 is that the amount, the rate at which it can flow down
9 through the upper till is related to how fast it can
10 get out the lateral units as well as to how much can go
11 down. This upper granular unit is providing the
12 greatest means of contaminant getting off-site or the
13 fastest means of directing it off-site. If it can only
14 flow one way, if it all has to go down and flow one way
15 you end up getting a higher flow in the upper granular
16 unit. Because of the capacity of that unit to actually
17 transmit the flow, it reduces the amount of flow coming
18 down through the upper till. Perhaps if I can try and
19 think of an analogy it is like having a cylinder full
20 of water and you put a pin hole in it. The amount of
21 water or the rate at which it is dropping is related to
22 the size of that pin hole. It is a very poor analogy.

23 DR. KINGHAM: I would understand your
24 analogy flipped around. You are telling us the gravel
25 layer is a conduit and it is a pin hole allowing water



1 into that conduit.

2 DR. ROWE: It's over a very large area.
3 We have got to keep in mind here that we are talking
4 about hundreds of metres of landfill and a one-metre-
5 thick upper granular unit and that is where the scale
6 problem comes in.

7 DR. KINGHAM: I understand your point
8 now. One other related question. Are all of the
9 models that you are giving us now based on the
10 assumptions that the extent of that sand and gravel
11 layer is the maximum from your previous exhibits; that
12 is to say it's not the minimum under the site?

13 DR. ROWE: That's right, in all of these
14 cases I am assuming it extends to the west. In some of
15 the cases where I am considering one way I am assuming
16 it is not going to the east and therefore the water has
17 to flow to the west. I think I had finished on that
18 one.

19 So, I would now like to refer to
20 overhead 57 which is a reproduction of figure 10 of my
21 report, again with different curves highlighted. In
22 this case, the cases we are looking at, specifically at
23 cases 6, 8 and 10, they involve different heights of
24 mound and two different values of hydraulic
25 conductivity of the upper till. The worst case which



1 is case 8 corresponds to a hydraulic conductivity of
2 the waste with a nominal value of 10^{-4} and a hydraulic
3 conductivity of the upper till of 4×10^{-7} . This
4 represents the worst case of all the scenarios that I
5 have examined, Mr. Chairman, and in my view marks the
6 boundary of the envelope which I discussed at the
7 beginning of my evidence.

8 The peak in that particular case is
9 1,260 milligrams of chloride in approximately ten
10 years. The next curve which is curve 10 corresponds to
11 a lower mound because it is based on a higher hydraulic
12 conductivity of the waste but using exactly the same
13 hydraulic conductivity of the upper till. So, in this
14 case here the effect is less pronounced but still very
15 significant. We have got a peak impact of about 1,100
16 milligrams per litre after approximately 16 years.

17 The third situation shown there, case 6,
18 corresponds to a hydraulic conductivity of the waste of
19 1×10^{-3} . That is one order of magnitude higher than
20 Trow indicated in their report. This may be possibly
21 unrealistically high but let us see what happens if it
22 were that high. Then we are looking here at the
23 hydraulic conductivity of the upper till of 8×10^{-7}
24 centimetres per second. The peak impact of about 870
25 milligrams per litre occurs in this case in about 35



1 years. So, all cases involve significant impact. That
2 brings us then, Mr. Chairman, to a summary of these
3 results for scenario B so I am going to again refer to
4 overhead 45 which on the right-hand two columns shows
5 the time to reach the boundary and the peak chloride
6 concentration in milligrams per litre.

7 Now, clearly the time to reach the
8 boundary depends on which case we are looking at. You
9 can see that for the range of cases examined it lies
10 between six and 21 years. As before, when I say time
11 to reach the boundary, Mr. Chairman, I am talking about
12 a concentration of 25 milligrams per litre arriving at
13 the boundary. The peak concentration arrives a little
14 after that and the peak values, the cases considered,
15 ranges between 810 and 1,260 milligrams per litre.
16 Again I point out that cases 7 and 9 were performed
17 using the same parameters that Trow give in their
18 report.

19 To complete the summary, Mr. Chairman, I
20 would now like to refer to overhead 58 which is similar
21 to an overhead we saw a short while ago for scenario A
22 in that it summarizes a number of times that are of
23 interest. Again, the overhead lists the reference
24 number of the cases being discussed and again I have
25 assumed for the purposes of argument that the mound is



1 being developed at a rate of one metre per annum. This
2 gives us, depending on the case, between four and 14
3 years for the mound to develop. If one assumes that no
4 contaminant escapes until the mound is fully developed,
5 if one makes that assumption then one can add this time
6 to the times that we looked at a moment ago for
7 contaminant to move down through the upper till and
8 off-site. So, we can add columns one and two to give
9 us an upper estimate of the time to impact. The sum of
10 those two numbers varies between 19 years and 34 years.

11 Now, I mentioned, Mr. Chairman, that
12 this gives us an upper bound. The reason for that,
13 that calculation assumes that no contaminant gets into
14 the system until the landfill has developed a leachate
15 mound to the full amount. Of course, as that mound
16 builds up, as soon as we reach the point where the
17 hydraulic trap reverses, contaminant is going to start
18 to move down through the system. So in fact,
19 contaminant is going to be moving faster than this
20 calculation would suggest. To try and just give a very
21 crude estimate of how fast it might move I did a
22 different calculation. This is a separate hand
23 calculation basically that I performed, assuming that
24 the flow into the unit was linearly related to the
25 height of the mound above the value at which reversal



1 would occur. So I knew where I was going from my flow
2 calculations. I then tried to calculate what would
3 happen to a particle of contaminant as it entered the
4 system. I tried to trace it through very crudely
5 through the upper till, the lower till and along the
6 upper granular unit as the head was building up, as the
7 mound was building up at one metre per annum.

8 The conclusions or the numbers that I
9 reached are indicated in column No. 4. As I point out,
10 it is a rough calculation to give you some idea of the
11 order of number we are dealing with. The order of
12 number is somewhere between 14 and 33 years. I would
13 expect, Mr. Chairman, that the actual time is going to
14 be less than the number indicated in column three and
15 probably on the order of the time given in column four.
16 In many cases there is not a significant difference
17 between those numbers.

18 The last column, column No. 5 again
19 indicates the calculated time that one has after the
20 contaminant reaches the upper granular unit and before
21 it whips 100 metres off-site. In this case it
22 certainly can move off-site. We are talking about
23 times between half a year, say six months and in the
24 biggest case there, 2.7 years. So we are looking at
25 between six months and a little less than three years



1 for it to move off-site, given this scenario; that is
2 once it has reached the upper granular unit.

3 MR. ESTRIN: Q. Now, if we could turn
4 back to your witness statement, Dr. Rowe, paragraph 31
5 of Exhibit 444. I believe that a couple of your last
6 points are perhaps summarized there in paragraphs 31
7 and 32.

8 DR. ROWE: A. That is correct.
9 Mr. Chairman, two of the points I have raised are
10 highlighted in the witness statement in paragraphs 31
11 and 32.

12 Q. Those refer, paragraphs 31 and 32
13 refer to what we have earlier described as scenario B?

14 A. That is right, they refer to
15 scenario B where there is a failure of the collection
16 tiles in cells 4 and 5 and as we have seen the worst
17 case has contaminant impacting off-site in 14 years.
18 That is highlighted in the witness statement. As you
19 can see here we are looking at a range in the 14 to
20 around 30-year range depending on which of the cases
21 one looks at.

22 In paragraph 32, Mr. Chairman,
23 indicating what you can see from the column on the
24 right of this overhead, that is once the contaminant
25 gets into the unit, the travel time is relatively short



1 and in this case of scenario B we are looking at times
2 of less than three years. When we look at scenario C
3 in a moment we will see the time could be as much as 12
4 years for scenario C. In any case we don't in general
5 have a lot of time.

6 Q. Dr. Rowe, look at paragraph 32 of
7 the witness statement. Is there an error in the range
8 set out there or not having regard to your right-hand
9 column?

10 A. This paragraph refers not only to
11 the overhead you see here but one you will see shortly
12 where you will see 12 years. I promise you.

13 That completes my discussion of scenario
14 B, Mr. Chairman.

15 MR. ESTRIN: Mr. Chairman, I see it is
16 virtually 1:00 o'clock. The time has gone so fast I am
17 oblivious to noticing. Perhaps we could stop at this
18 point for lunch.

19 MR. LANCASTER: Yes, we will. A quarter
20 after 2:00.

21 --- Luncheon recess at 12:57 p.m.

22 --- Upon resuming at 2:17 p.m.

23 MR. LANCASTER: Please be seated.

24 MR. ESTRIN: We have now got the stereo
25 pairs labelled with I think the numbers that were



1 assigned to them. We haven't at this point made Xerox
2 copies but I guess any party who would want to do that
3 could certainly borrow them from the Board for that.
4 So, I think they have already been numbered. For the
5 purposes of getting it right Exhibit 449A consists of
6 three sheets, each of which is labelled 1 of 3, 2 of 3
7 and 3 of 3 and refers to October, 1934. Exhibit 450A
8 and it's three sheets is June, 1950. Exhibit M-451A is
9 three sheets, April, 1959 and Exhibit M-452A is three
10 sheets, the summer of 1972.

11 Q. All right, Dr. Rowe, please resume
12 then. As we indicated before, Mr. Chairman, if the
13 Board wishes to have a stereo viewing machine we are
14 quite happy to provide one.

15 MR. LANCASTER: They told me if you
16 cross your eyes you can do it as well.

17 MR. ESTRIN: I am still trying to answer
18 the question why there are three different pages to a
19 stereo pair but I have just been told it deals with the
20 overlap.

21 DR. KINGHAM: I have been looking at
22 them and haven't found a stereo pair yet. My
23 understanding of a stereo pair was that there were two
24 images taken from slightly different perspectives so
25 that when combined they reveal a topography. I don't



1 see in any of these sets any which are of the same
2 piece of land and therefore can be compared.

3 DR. CHARLESWORTH: Each set overlaps so
4 you can look at two of them and then move over and look
5 at one of them and then look at the third one.

6 DR. KINGHAM: I see. Okay, fine.

7 MR. ESTRIN: We will be happy to have a
8 demonstration.

9 DR. KINGHAM: We will try to work it out
10 and if we need help we will let you know.

11 DR. CHARLESWORTH: The technique is not
12 to cross your eyes!

13 MR. ESTRIN: Q. Dr. Rowe, I think you
14 had come to the point where you wished to describe the
15 details of scenario C.

16 DR. ROWE: A. Looking now to the third
17 of the three scenarios I considered, this involves the
18 failure of three of the collection tiles and to be
19 specific what I am looking at is the failure of three
20 tiles to the western side of cell No. 4 and I am
21 pointing here to Exhibit H-41-D2.

22 I considered two cases for this
23 particular scenario. I adopted a hydraulic
24 conductivity of the waste of 10^{-4} which is the same as
25 Trow used in their calculations. I got from that an



1 average head of 183.6 metres. Again we have two cases
2 corresponding to two different values of the hydraulic
3 conductivity of the upper till. Both cases model two-
4 way flow. Case 11 is for a hydraulic conductivity of 4
5 $\times 10^{-7}$, case 12 is 8×10^{-7} . The flow in the upper
6 granular unit that one calculates for these two cases
7 is 2.5 metres per annum for case 11 and 4.5 in case 12.
8 These numbers are smaller than the numbers we saw
9 before because we have much less of the landfill
10 failing and forcing water in the upper granular unit
11 than in scenario B. The proportion of leachate
12 collected locally, that is within this zone between the
13 collection tiles that are still functioning, varies
14 between 82 per cent for case 11 and 69 per cent for
15 case 12. The flow to the shale in these cases is 25
16 and 17 per cent respectively.

17 I would like to turn to the results for
18 this particular case and then we will come back to the
19 summary on the right-hand side of overhead 46. The
20 results are shown on overhead 59 which is a
21 reproduction of figure 11 of my Site D report. In this
22 case as we have seen it is for three collection tiles
23 failing. In case No. 12 which has a hydraulic
24 conductivity in the upper till of 8×10^{-7} the peak
25 concentration of contaminant was calculated to be about
590 milligrams per litre. This occurred at a time of
about 35 years. In case No. 11 we have a lower



1 hydraulic conductivity of the upper till. In this case
2 it is 4×10^{-7} and as a consequence we get some more
3 attenuation. There is here a maximum concentration of
4 390 milligrams per litre which occurs at a time about
5 58 years. As we mentioned before, case 12 involves
6 approximately 69 per cent of the leachate being
7 collected and case 11 is 82 per cent being collected.

8 So, this then brings us back to our
9 summary, overhead 46, which indicates that the time for
10 contaminant to reach off-site based on case 11 is about
11 36 years and the peak concentration would be 390
12 milligrams per litre in this case. In case 12 the time
13 to reach the boundary is about 20 years and the peak
14 590 milligrams per litre.

15 The last overhead I have relating to the
16 case, scenario C, is overhead 61. This is similar to a
17 number of tables we have seen previously. The left-
18 hand side again has the case numbers and in column one
19 we have the time to develop the mound. Because we had
20 only three tiles failing, it takes about three years to
21 develop the mound above the height that Trow expected
22 to be under working conditions. We add to that the
23 time calculated to move down through the upper till and
24 across through the upper granular unit and we get
25 somewhere in the 28 to 39 or in round numbers, 30 to 40



1 years time period. We have spoken before about how
2 long it might take for contaminants to move off-site
3 after they have moved into the upper granular unit. In
4 this case we are talking of seven to 12 years to move
5 off-site. Again, because it is a much smaller failure,
6 the impact is less but nevertheless quite significant
7 as you can see from the concentration levels that I
8 reported earlier.

9 Q. Now, there is a table in your
10 report at page 41, table 3 I think it is that might be
11 relevant to refer to at this point and to explain.

12 A. Yes, Mr. Chairman, table 3 on page
13 41 has the cases marked down the left-hand column and
14 then it has two columns of numbers. If you move to the
15 right-hand column the numbers given -- this is on page
16 41 of my Site D report, Exhibit M-442. The right-hand
17 column summarizes the time for first arrival that we
18 have just been discussing calculated using the
19 contaminant migration model that we have talked about.

20 The numbers to the left of that based on
21 advection alone. This is a very simplistic
22 calculation, neglecting diffusion, neglecting
23 dispersion, just calculating how fast it would take if
24 you consider purely flood flow, velocity down through
25 the upper till, down through the lower till and across



1 through the upper granular unit. Because this is not
2 considering the diffusion and dispersion mechanisms,
3 the times to calculate from this very simple
4 calculation exceed the times calculated from more
5 sophisticated contaminant migration models. However,
6 you can see that we are dealing with the same order of
7 magnitude of the numbers. This is a very simple check
8 on the magnitude of the numbers that we have been
9 dealing with.

10 The other point I think I would like to
11 raise, Mr. Chairman, I alluded earlier in my testimony
12 to the fact that in my modelling at Site F I assumed
13 that the shale would act as a drain. As much fluid as
14 wanted to go down there could go down there. I
15 subsequently repeated my flow calculations modelling
16 the capacity of the shale to transmit water if one
17 assumes a five-metre fractured zone and if one assumes
18 the hydraulic conductivity of that zone given by Trow
19 in their report. The consequences of doing that would
20 be to increase the times of travel to the boundary of
21 the property. To give you some idea of what effect
22 that would have we consider scenario A; that is the
23 situation where the tiles are working but the hydraulic
24 trap fails because the hydraulic conductivity of the
25 waste is less than 10^{-4} . Considering the capacity of



1 the shale to transmit water increases the time of
2 arrival based on this very simple advective or flood
3 flow calculation by between six and 19 years, depending
4 on the case. In scenario B which is the complete
5 failure scenario, in one case it increases the time by
6 about 11 years and in all the other cases only by about
7 one year. In scenario C which we have just discussed,
8 it doesn't have a significant effect. The time is
9 essentially the same plus or minus a year what I have
10 already indicated.

11 So that gives you some idea of what the
12 effect of whether that shale can transmit water or
13 whether it can't is likely to have on the times of
14 arrival we have talked about. When I say I modelled
15 the flow to the shale, the amount of flow going to the
16 shale, but all cases I considered was less than one-
17 and-a-half per cent and typically only about 0.7 per
18 cent of what was entering the system. So, if you
19 assume Trow's hydraulic conductivity and thickness,
20 then that shale is not going to transmit very much of
21 the flow entering the system.

22 Q. Now, turning to another aspect of
23 the general topic ...

24 A. Yes. I would like if I could,
25 Mr. Chairman, to refer to overhead 60 of Exhibit 440.



1 This is a table which has the title "Length of Time the
2 Leachate Collection System must Function." From the
3 information contained in my Site F report -- sorry --
4 my Site D report, Mr. Chairman, from the information
5 contained in my Site D report one can make an estimate
6 of how long the leachate collection system must work
7 before one of the failure scenarios I have considered
8 comes into play given certain constraints on the
9 concentration one is going to accept at the boundary.
10 Dr. Charlesworth in his evidence spoke to the chloride
11 levels at Site D and the Reasonable Use Policy. What I
12 would like to do here, Mr. Chairman, is to give you
13 some feel for how long the leachate collection system
14 would have to operate before one of the failure
15 scenarios I have considered comes into play; in the
16 first instance, if we considered it unacceptable for an
17 increase in chloride at the boundary of 25 milligrams
18 per litre and in the second case if we consider it
19 unacceptable at the ten milligrams per litre level.

20 The cases I have split into two groups.
21 There is the complete failure of the tiles and for the
22 purposes of illustration I have looked at three cases
23 there. The first case, case 9, uses the same hydraulic
24 conductivity of the waste and the upper till as quoted
25 in Trow's report. I have already reported to you,



1 Mr. Chairman, that in this situation about 76 per cent
2 of the leachate would be collected locally; that is in
3 the area of cells 4 and 5 and I am pointing at the
4 moment to Exhibit H-41-D2. In areas 4 and 5 based on
5 this failure scenario, 76 per cent of the leachate
6 would be going to the leachate subheaders at the south
7 and north of cells 4 and 5, the remainder going down
8 into the upper till.

9 As you can appreciate, this is a fairly
10 large failure but nevertheless still 76 per cent is
11 being collected locally. If we ask ourselves what we
12 would observe in the manholes if these cells were still
13 operating as they are expected to be and these ones had
14 failed, so we look at the total leachate collected
15 compared with what Trow expected to collect.
16 Approximately 80 per cent of the leachate is being
17 collected over the entire site given this complete
18 failure of the tiles in cells 4 and 5. Now, if we
19 assume that the initial concentration of chloride in
20 the landfill is 1,500 milligrams per litre and based on
21 this calculation one would want the leachate collection
22 tiles to function for 65 years before the contaminant
23 started entering the system due to this failure. If
24 one was not prepared to accept the 25-milligram level
25 and wanted it down to ten, then you are looking at



1 something in the order of in excess of 80 years.

2 I have two other failure scenarios that
3 we have discussed. The worst of these is case No. 8.
4 This is the out of bound of the envelope I have
5 referred to. In this case ten per cent is being
6 collected locally. The other 90 per cent is going down
7 into the till beneath cells 4 and 5. Nevertheless when
8 you look at the site as a whole, one has still got 58
9 per cent being collected. In this case if you have an
10 initial concentration of 1,500 milligrams per litre
11 then you need the system to function for something in
12 the order of 75 to 80 years to get down to the 25-
13 milligram-per-litre impact at the site boundary after
14 failure. If you are concerned at the ten-milligram
15 level then it is in excess of 80 years. Case 10 is
16 intermediate between these two cases and here we have
17 44 per cent being collected locally, 70 per cent being
18 collected on the site and we are looking at 70 to 75
19 years. Those are the situations if the initial
20 concentration is 1,500 milligrams per litre. In the
21 event of 3,000 milligrams per litre then the times
22 would increase to the order of 75 to more than 80
23 years. So, that is the length of time the tiles must
24 operate before you can have a complete failure of the
25 system.



1 If we just ask ourselves what about the
2 failure of just a few tiles, for example these tiles
3 over to the west of cell No. 4, the three tiles I
4 considered in my scenario C, then in these two cases
5 locally for case No. 11 we are looking at 82 per cent
6 being collected, that is directly beneath the zone
7 where the failure has occurred. If we look at it in
8 terms of the overall site perspective 98 per cent is
9 being collected. In this case we have got 1,500
10 milligrams. You would want those tiles to operate for
11 50 to 55 years to get down to a 25-milligram-per-litre
12 impact off-site and 65 to 70 years to get down to the
13 ten-milligram-per-litre impact.

14 Case 12 is 69 per cent collected
15 locally, again 98 per cent is collected over the entire
16 site. Those two numbers are for all practical purposes
17 the same because we are talking about a very small area
18 of the total site. At the 1,500-milligram level we are
19 looking at 60 to 65 years to get down to an off-site
20 impact of 25 milligrams per litre and 75 to 80 years to
21 get down to ten. Of course if the initial
22 concentration were worse than the 1,500 I have assumed,
23 if it were 3,000, then the leachate collection system
24 has to operate longer, somewhere in the order of 60 to
25 80 or more years.



1 Q. Dr. Rowe, there is a little bit
2 more different information on that than the one that
3 was distributed as No. 60 so perhaps we had better mark
4 that one M-444-OH-60A.

5 --- EXHIBIT NO. M-444-OH-60A: Overhead showing length
6 of time leachate
collection system must
function

7 MR. ESTRIN: Q. Could you please read
8 out the writing you have added on?

9 DR. ROWE: A. The writing I have added
10 on here?

11 Q. Yes.

12 A. I've written Exhibit H-41, page 54
13 and the quantity of leachate they are expecting to
14 collect from that figure is about 400 litres per
15 minute.

16 Q. Can you read the bottom line?

17 A. This refers to case 9 and it
18 indicates that case 9 uses THCL's values for waste and
19 upper till. It uses the same K for the waste and the
20 upper till they used in their report.

21 Q. Can you also read the third
22 asterisk line there which is not on our copy, the line
23 that begins with three asterisks?

24 A. It says:

25 "Time leachate collection system must



1 function to reduce boundary impact to
2 the value stated."

3 Q. That pertains to?

4 A. That pertains to the times I am
5 talking about here.

6 Q. Dr. Rowe, I believe in your
7 witness statement you address this topic in the
8 narrative form. Is that basically beginning around
9 paragraph 33?

10 A. That is correct, yes.

11 Q. Through paragraphs 34 and 35?

12 A. That is correct.

13 Q. I wonder if we could just go over
14 that. In paragraph 33 it is stated that you would
15 indicate that having regard to the chloride values
16 already present in adjoining wells which are in excess
17 of Ministry of the Environment drinking water
18 objectives and having regard to the Ministry of the
19 Environment Reasonable Use Policy which is quoted as
20 saying no decrease in water quality will be acceptable
21 due to the sanitary landfill, the statement is made:

22 "Accordingly the leachate collection
23 system must continuously function as
24 designed for more than 80 years to
25 reduce an assumed initial chloride



1 concentration of 1,500 milligrams per
2 litre in the landfill to ten milligrams
3 per litre at the south boundary."

4 A. That is for example here. I am
5 talking to overhead 60 to, for example, the right-hand
6 column showing the time that the leachate collection
7 system must function to reduce boundary impact to a
8 value of ten milligrams per litre.

9 Q. Now, can you -- have you some
10 other narrative which I think you have already
11 discussed what it would be assuming 25 milligrams when
12 it was acceptable and how long it would take and then
13 beginning in paragraph 4 if the initial concentration
14 was 3,000 and I think you've already outlined that
15 scenario.

16 A. Yes, I've discussed that.

17 Q. Let us go to paragraph 35. Could
18 you just elaborate on what you have said there and you
19 might read it and then elaborate?

20 A. Paragraph 35 is in fact making
21 reference to the previous paragraphs and it says:

22 "The time periods given above do not
23 reflect a worst case situation..."

24 Those time periods, Mr. Chairman, in the previous
25 paragraph relate to case No. 9 and it says here:



1 "The time periods given above do not
2 reflect a worst case situation in terms
3 of the length of time required to reduce
4 initial chloride concentrations to the
5 levels specified. The times referred to
6 were calculated assuming a hydraulic
7 conductivity of the upper till given by
8 THCL, i.e., 8×10^{-8} cm/s. The time the
9 hydraulic trap would be required to
10 operate to achieve the reductions
11 contemplated would be longer if the
12 hydraulic conductivity of the upper till
13 was greater.

14 For example assuming the hydraulic
15 conductivity of the upper till was $4 \times$
16 10^{-7} cm/s and assuming the initial
17 chloride concentration was 1,500 mg/L it
18 would take approximately 70-75 years for
19 that initial concentration to be reduced
20 to the point where the off-site impact
21 would be less than 25 mg/L and more than
22 80 years to reduce it to less than 10
23 mg/L."

24 Q. All of that, that narrative, is
25 directly related to the last overhead?



1 A. That is correct, Mr. Chairman.

2 Q. Now, I wonder then if you could go
3 to another but perhaps related topic and this is found
4 at paragraph 49 of your witness statement. Perhaps you
5 can introduce the topic that is actually discussed
6 there.

7 A. Well, paragraph 49 is discussing
8 the question of whether there is a redundancy with
9 respect to possible off-site impact. When one looks at
10 the spacing of the collection tiles as proposed and as
11 indicated on Exhibit H-41-D2 by THCL for a landfill at
12 Site D, it addresses the question of what would happen
13 if only one of the leachate collection tiles failed and
14 the point I am making is that even if only one fails
15 locally there is likely to be a reversal of the
16 hydraulic trap. If one accepts Trow's hydraulic
17 conductivity of the waste, then the calculations they
18 perform indicate that the maximum height of mounding
19 would be approximately 1.5 metres and I agree that if
20 that is the height of mounding you would have, you
21 would not have reversal of the trap. The trap should
22 work based on the information we have available to us.
23 However, if one tile failed then the spacing between
24 tiles would be 60 metres and that means the maximum
25 mound under those same conditions would be three metres



1 and that would be enough to locally reverse the trap.

2 Q. So you reached a certain
3 conclusion if in fact there was a redundancy, if there
4 was a significant safety factor?

5 A. Yes, I conclude that there is not
6 a significant safety factor, Mr. Chairman.

7 Q. In paragraph 50 you address
8 something that came out in re-examination of
9 Mr. Hiraishi by Mr. Hodgson as to whether or not
10 because the leachate collection system would collect
11 leachate without a slope it was suggested that
12 therefore any degree of slope at D would be a
13 redundancy. Could you comment on that?

14 A. Mr. Chairman, I agree that the
15 leachate collection system could collect leachate even
16 if there were no slope but we have discussed, I think,
17 that mounding is going to occur and that if that
18 mounding is more than about 2.6 metres then there is
19 going to be a reversal of the hydraulic trap locally.
20 The higher that mound gets the more problem one is
21 going to have at this particular site.

22 Q. You say at the top of page 29
23 that:

24 "It is not conservative to assume
25 mounding can occur without having



1 negative implications for reversing the
2 hydraulic trap."

3 A. When I say that I am referring to
4 mounding in excess of 2.6 metres. Once mounding
5 exceeds 2.6 metres, based on the information available,
6 one would expect the trap to reverse locally.
7 Therefore one does not wish to be relying on mounding
8 to drive the leachate into the leachate collection
9 subheaders.

10 Q. Then again I think in paragraph 51
11 if I could direct your attention to that in the witness
12 statement again, Dr. Rowe, it was suggested to
13 Mr. Hiraishi that by providing access to leachate
14 collection pipes it was suggested another redundancy.
15 Could you comment?

16 A. I think he was referring to
17 Exhibit H-41-D2. If I understand, correctly marked,
18 the zone in yellow here that you couldn't get to and,
19 Mr. Chairman, I believe, it is my opinion that when one
20 has a site where the impact on the local residents off-
21 site is dependent on an engineered system such as a
22 hydraulic trap working then one should take all
23 precautions possible to make sure that you can clean
24 that system and to minimize the impact if it fails.

25 In this case here some attempt has been



1 made to clean the system. There are some manholes.
2 You can see there are also a lot of tiles that can't be
3 accessed and readily cleaned. I do not think that this
4 is a desirable or satisfactory situation.

5 Q. Dr. Rowe, just to refresh our
6 memories, you reviewed the transcript of Mr. Hiraishi's
7 testimony with respect to these yellow markings?

8 A. Yes, that is correct.

9 Q. In the witness statement you say
10 you will review that drawing where Mr. Hiraishi himself
11 indicated that approximately one-third of the site
12 where garbage would be deposited would not be
13 accessible by way of manholes.

14 A. My understanding of Mr. Hiraishi's
15 testimony was that even if he were to try and put more
16 manholes, given this design, he may be able to put some
17 more manholes, for example, Mr. Chairman, over here to
18 the west but towards the centre, my understanding was
19 that he didn't feel that one could adequately put
20 manholes down even if he wished to be able to clean the
21 system out. My understanding of his testimony was that
22 this was an area where he couldn't practically put
23 manholes down to clean out those tiles given the design
24 as shown on Exhibit H-41-D2.

25 Q. Could you just point that area out



1 again? Stand back a bit if you can.

2 A. The area that I am referring to,
3 and my understanding from reading the transcript, I
4 wasn't personally here, was that Mr. Hiraishi marked
5 the area shown in yellow as a zone where he couldn't
6 readily put manholes.

7 Q. You have indicated in your witness
8 statement that that seems to cover approximately one-
9 third of the area where waste will be deposited. Is
10 that about the right ratio?

11 A. I didn't measure it precisely, no.
12 It is of that order.

13 Q. Now, on the same general area of
14 the leachate collection system Mr. Hiraishi's comment
15 from the transcript is paraphrased looking at paragraph
16 52, that there was a need to provide proper quality
17 assurance and quality control as well as construction
18 techniques that will limit and minimize problems with
19 pipe breakage and premature clogging. Do you agree
20 with that?

21 A. Yes, I agree with that.

22 Q. Have you formed an opinion as to
23 whether or not this is a concern which is or is not
24 more crucial at one of the sites?

25 A. Mr. Chairman, I think as a matter



1 of policy one should have good construction quality
2 control. It is a bit like motherhood. It is something
3 one should do, one should believe in. In terms of
4 these two particular sites it is far more critical at
5 Site D than at Site F because we have people using
6 water 100 metres off-site at Site D. Trow have
7 indicated themselves in their own report, and I'm not
8 quarreling with this, that if the hydraulic trap were
9 to fail then there is potential off-site impact. If
10 they don't detect it with their monitoring and stop it
11 moving with their proposed purge wells there is going
12 to be an off-site impact. I believe therefore that the
13 maintenance of the collection system as indicated on
14 Exhibit H-41-D2 is more critical than the maintenance
15 of the collection system at Site F. Clearly they
16 should try and maintain Site F as well.

17 Q. Continuing in your witness
18 statement at paragraph 53, again Mr. Hiraishi's comment
19 here is with respect to regular preventative
20 maintenance that is required in such a program "may
21 include cleaning" of that system. Can you comment on
22 that?

23 A. Yes. Again I have no quarrel with
24 his suggestion that he should clean the pipe. Again I
25 think he is absolutely correct. What I am concerned



1 about is that one cannot, to the best of my knowledge,
2 adequately clean the filter material outside the pipe.
3 You've got the zone, it could be a filter fabric in
4 combination with soil or it could be a graded granular
5 filter. In either case it is difficult, if not
6 impossible, to get in and clean that filter material
7 without actually going in and excavating it which is
8 obviously highly undesirable if you have 20-plus metres
9 of waste above it.

10 Q. Again, do you have any comment on
11 this topic comparing the two sites and whether one is
12 more critical than another?

13 A. It is essentially the same comment
14 I made before that at Site F it is not as critical to
15 be able to clean the system in the sense that if the
16 hydraulic -- if the collection system fails at Site F
17 the impact is going to be less than the potential
18 impact at Site D.

19 Q. Continuing with your witness
20 statement in paragraph 54, another comment of
21 Mr. Hiraishi's was with respect to a monitoring at Site
22 D, that that would occur "as part of monitoring the
23 manholes". Do you have some opinions with respect to
24 that?

25 A. Well, it is my view and if I



1 interpret Mr. Hiraishi correctly it was also his view
2 that watching the volume of leachate in the manholes
3 would not be evidence, sufficient evidence in itself to
4 tell you you had a failure of the leachate collection
5 system. Mr. Chairman, it is in my view, in my opinion,
6 a difficult matter to calculate precisely what leachate
7 is coming into a landfill. If you don't know how much
8 is coming in or how much should be coming in it is
9 difficult to know whether you are not getting some of
10 that, particularly when you are thinking of some of the
11 percentages I had. Perhaps I might put up overhead 60
12 again. When one looks at the percentages, even
13 locally, ten per cent you should be able to detect but
14 76 per cent and 82 per cent, 89 per cent locally ...

15 Q. Sixty-nine.

16 A. Sixty-nine per cent locally may
17 not be readily detected and certainly when you look at
18 it in the overall picture of how much leachate is being
19 collected, I don't think anyone would suggest that you
20 can detect a two per cent change by looking at leachate
21 in manholes and even the 20 per cent change would be
22 difficult.

23 Q. You say in paragraph 54b you agree
24 with Mr. Hiraishi's comment as set out there?

25 A. Yes, that is correct.



1 Q. Now, turning to the next paragraph
2 of the witness statement, paragraph 55, Mr. Sobanski
3 advanced the view that looking at leachate volumes
4 would give an indication of total failure. What is
5 your opinion with respect to that?

6 A. Well, I disagree with it as a
7 general statement for the reasons I have just given. I
8 don't think -- it is my opinion that you wouldn't be
9 able to detect, for example, this change and as I said,
10 even a 20 per cent change would be difficult to detect
11 unless one knew exactly how much leachate you expected,
12 which of course one doesn't.

13 Q. Right now, Dr. Rowe, I would like
14 to bring you to paragraph 56 of your witness statement
15 where you reach some conclusions with respect to Site
16 D.

17 A. Mr. Chairman, I have on overhead
18 62 essentially summarized the points that are raised in
19 paragraph 56 of my witness statement. Perhaps if I
20 could just go through that, there are a number of
21 situations one can consider. The first situation is of
22 course the situation as proposed by Trow; that is a
23 working hydraulic trap. If it is working as intended
24 and by that, if the hydraulic conductivity of the waste
25 is more than 10^{-4} cm/s and if the collection tiles



1 continue to work for more than 80 years without
2 significant blocking or clogging, then given the data
3 available it is my opinion that the hydraulic trap
4 would work at that site.

5 However, my second point is that if the
6 hydraulic conductivity of the waste is, say, 10^{-5} cm/s
7 then significant off-site contamination of groundwater
8 is to be expected at levels of 530 to 760 mg/L based on
9 the calculation that I have performed. Mr. Chairman,
10 this corresponds to my scenario A. It was a scenario
11 that one could readily design around. One could design
12 a system so that this does not occur. However, that
13 doesn't appear to have been addressed in Trow's design.

14 The third point is that if the leachate
15 collection tiles which cannot be cleared, cleaned
16 between manholes, block or clog, for example in cells 4
17 or 5, then one would expect significant contamination
18 of off-site drinking water at the 390 to 590-milligram
19 level for chloride assuming an initial concentration of
20 1,500 mg/L. So, this here is referring to a partial
21 failure of collection tiles. I have discussed failure
22 of the three tiles to the west end of cell No. 4.
23 Obviously there is no reason why other tiles couldn't
24 fail. For example, the tiles between manholes 22 and
25 23 shown on Exhibit H-41-D2 or of those tiles in there,



1 there is one, two, three, four, five, six of them,
2 can't be readily accessed to be cleaned. There is no
3 reason why those six couldn't block up but I have
4 simply restricted my comments to those three. In that
5 scenario then you have off-site impact.

6 The fourth paragraph deals with my worst
7 case scenario which is if all the collection tiles fail
8 in cells 4 and 5 but the subheaders to the north of
9 cell 4 and south of cell 5 continue to function then
10 for the cases I considered the off-site impact had a
11 maximum value between 8, 10 and 12, 60 mg/L. So, that
12 essentially summarizes the results that I have
13 presented to you, Mr. Chairman.

14 Q. Dr. Rowe, just stopping you there,
15 would you clarify the values for chloride that you have
16 stated in paragraphs 2, 3 and 4? What assumption does
17 that make, if any, with respect to background? How can
18 we relate that?

19 A. These are increases over and above
20 background value, Mr. Chairman. These are increases
21 due to the landfill.

22 The fifth point is that if the upper
23 granular unit is not continuous then contaminant could
24 move off-site without being detected. By that I am
25 visualizing a situation where there could be portions



1 of the unit that move off-site but not over the entire
2 area. Unless you have a monitoring point in the
3 portion of the upper granular unit which does extend
4 off-site you would not be able to detect that
5 contaminant moving.

6 As a result, I should point out,
7 Mr. Chairman, that if all of these points that have an
8 asterisk next to them, that asterisk indicates that
9 these impacts would occur, assuming that the
10 contaminant has not been detected in the upper granular
11 unit. Of course that effective contingency measures
12 have not been implemented. My concern is that there is
13 a reasonable likelihood they would not detect it and
14 therefore not be able to bring it back. In that
15 situation, my final conclusion is that there is a
16 reasonable likelihood that groundwater contamination
17 will occur off-site due to the proposed landfill at
18 Site D. That is the conclusion based on the
19 information available to me at this time and the design
20 as Trow have currently proposed it.

21 Q. Thank you, Dr. Rowe, very much for
22 going through your Site D report in some detail. We
23 haven't finished quite yet, however.

24 At this point, Mr. Chairman, we are
25 going to turn to some -- those parts of the witness



1 statement and some overheads that deal with an overall
2 comparison between the two proposed sites based on some
3 specific numbers that Dr. Rowe in particular has
4 arrived at and also Dr. Charlesworth will comment on
5 some of these as well.

6 So, we are coming to paragraph 57 in
7 effect of the witness statement under the heading
8 "Comparisons of Site D and Site F."

9 A. Mr. Chairman, I would like to
10 refer to overhead 63 of the witness statement which is
11 titled "Comparison of Two Sites based on THCL's Data
12 and Design." What I have tried to do here,
13 Mr. Chairman, is to draw together data from Trow's
14 report and to compare the two sites based on that data
15 giving some of my own interpretation in a number of
16 cases.

17 Now, the table has two columns to it;
18 one relating to Site F and the other relating to Site
19 D. The first item in the table is the thickness of
20 the primary barrier. What I am talking about here,
21 Mr. Chairman, we have a concern in all cases of
22 landfills of contaminant moving down into the general
23 soil or groundwater system beneath the site. At both
24 of these sites Trow have, in their interpretation,
25 identified a thickness of material that is going to be



1 the primary means of limiting the downward movement.
2 At Site F they have a weakly-fractured massive shale
3 unit which, if you look through their modelling, they
4 typically use 15 metres and if you look at some of
5 their other graphs it may be 20 metres. The thickness
6 of what they call their weakly-fractured massive shale
7 unit is of the order of 15 metres. Beneath that they
8 visualize having this highly-fractured shale. Once it
9 gets down into that it moves off-site. At Site D they
10 have approximately in their calculations four metres of
11 the upper till underlain by three metres of lower till
12 and then you get the upper granular unit. So you have,
13 when you add the upper and lower till, seven metres
14 based on their calculations. That is the number they
15 used in their calculations of clay till, clay silt till
16 which is intended to reduce the amount of contaminant
17 or control the amount of contaminant getting to the
18 lower granular unit -- the upper granular unit -- I'm
19 sorry.

20 Now, you can see just comparing these
21 two numbers at Site D they have a greater thickness.
22 Let us look at the hydraulic conductivity of these
23 barrier materials. In their better-fit model here they
24 quote a hydraulic conductivity in the vertical
25 direction of 10^{-8} cm/s. If one refers to their



1 calculations in the Site D report, that is Exhibit H-
2 39, in appendix 16 they have -- they quote a hydraulic
3 conductivity for the entire seven metres of 1.4×10^{-7} .
4 So here we have twice the thickness of barrier and at
5 Site F, based on their own model, an order of magnitude
6 difference approximately in hydraulic conductivity;
7 Site F being approximately an order of magnitude less
8 which is better, all other things being equal.

9 The lateral Darcy velocity within the
10 unit where they visualize with contaminant moving off-
11 site, they have a flow based on Exhibit H-221 of two
12 cubic metres per metre per annum. If you assume that
13 is going through a ten-metre-thick zone which is
14 generally consistent with their picture of the site,
15 then you would have a Darcy velocity at Site F of 0.2
16 metres per annum. Based on Trow's own information in
17 table 10 of the Site D report, if they do not have the
18 hydraulic trap then the off-site Darcy velocity is
19 approximately 2.5 metres per annum. So one can see
20 that these two situations, comparing the two so far,
21 Site F appears to be better based on Trow's own
22 information.

23 We have discussed, Mr. Chairman, the
24 issue of collection tiles. At Site F and I will put up
25 Exhibit H-42-B5R which shows the proposed base contours



1 and leachate collection system at F. The perforated
2 leachate collection pipes have been highlighted here in
3 mauve, I'm not quite sure what the correct definition
4 of this colour is but they have been highlighted. If
5 one looks at this diagram it indicates a slope of two
6 per cent. I might mention in passing that they show
7 manholes at every second collection tile. If one
8 wanted to be sure that you could clean those collection
9 tiles, it would be prudent, in my view, to put a
10 manhole at each of those collection tiles so they would
11 be sure to clean them.

12 Coming back to the issue of the slope,
13 this is really shown as two per cent.

14 Q. That was Exhibit H-42-B5R?

15 A. That is correct, yes.

16 I will now refer to H-41-D2 which is
17 Site D, the equivalent part of Site D, the equivalent
18 figure of Site D. The slope is shown at 0.25 per cent
19 on this diagram. So, in terms of the slope of the
20 tiles, you have heard reference for example to the EPA
21 document that they recommend a two per cent slope. The
22 length of the leachate collection system, Mr. Hiraishi
23 in his testimony indicated that the length of the pipe
24 at Site F was of the order of 12,000 metres and at Site
25 D it is in the order of 20,000 metres. So clearly they



1 have a lot more pipe at Site D to clean than at Site F
2 and they can clean most of the pipe at Site D. At
3 least one could clean them if they wanted to based on
4 that design. In terms of their capacity to clean the
5 pipes, this is my conclusion based on the data, is that
6 they have a good capacity to clean the pipes themselves
7 at Site D -- sorry -- Site F. They have a good
8 capacity to clean the pipes themselves, particularly if
9 they put their manholes in as I suggested a minute ago.
10 At Site D they can clean some of the pipes but there
11 are quite a lot of pipes, in particular and even with
12 all the best will, according to Mr. Hiraishi, he can't
13 get this area marked in yellow.

14 The number of collection systems, there
15 is clearly one collection system at Site D. If I now
16 again refer to Exhibit H-42-B5R, this shows that they
17 have what one could refer to as two collection systems.
18 There is the set of tiles which are in place for
19 collecting leachate as it generally runs down the
20 surface or the basin, the contours of the landfill but
21 there is also an extra collection system that they are
22 installing in the gullies which has been highlighted
23 here in purple. So, there are at least portions of the
24 site that have two collection systems underneath them.
25 So, in my overhead 63 when I refer to the number of



1 collection systems at Site F, I am referring to the
2 purple system which is the deeper system and to the
3 general leachate collection tiles which I referred to
4 as mauve.

5 Dilution due to contaminant, I
6 indicated my evidence with respect to Trow's better-fit
7 model, H-221, that their Flonet model indicated that
8 there was approximately one cubic metre per annum
9 coming in beneath Site F and another cubic metre coming
10 in from north of the site. So, based on that number
11 one has approximately a 50 per cent dilution factor at
12 Site F. It is a very simplistic calculation but
13 nevertheless it indicates that there is dilution, apart
14 from anything else, to give you attenuation. At Site D
15 there doesn't appear to be any significant potential
16 for dilution of the contaminant due to flow in the
17 upper granular unit coming from all sides.

18 Potential for attenuation due to matrix
19 diffusion. Now, in both sites, Mr. Chairman, I have
20 focused my attention on what I consider to be the
21 primary mechanism for contaminant transport off-site.
22 At Site F it is movement down into the shale and then
23 laterally off-site beneath Highway 403. I have
24 discussed in some detail the concept, the matrix
25 diffusion as it flows through the fractures, it can



1 diffuse into the matrix of the shale. At Site D I am
2 referring here again to the primary transport path
3 which is down through the upper till, possibly along
4 the thin bed of silt, and as I indicated, the concept
5 of matrix diffusion I think applies to that thin bed of
6 silt and that is why in my calculations I didn't get a
7 big impact. If you go further on down through the
8 upper till to the upper granular unit then there is no
9 significant potential for matrix diffusion as it flows
10 along the upper granular unit. I think at least
11 passing reference was made to that in earlier
12 testimony.

13 The potential attenuation zone, that is
14 how far has contaminant got to travel and attenuate
15 before you need to be too worried about it. Based on
16 Trow's calculations in Exhibit H-86, for example, they
17 did calculations for 650-metres travel distance and a
18 1,400-metre travel distance; whereas, in Site D, we are
19 concerned about the impact 100 metres down, 100 metres
20 from the landfill. That is at the site boundary. This
21 is an attempt to compare the two sites based on Trow's
22 own picture of what the sites are like. My conclusion
23 based on that information alone would be that Site F
24 appears to be a much better site than Site D.

25 Q. Now, I believe that in your



1 witness statement you have also provided a graphical
2 comparison of impacts calculated at both sites. You
3 are doing all the talking here, Dr. Rowe. If you think
4 it's necessary to take a minute break, you tell us.

5 A. I would like to refer now,
6 Mr. Chairman, to overhead 64 in the document in front
7 of you. I moved a lot of writing out of the picture to
8 the bottom of the page, a number I think of
9 observations I would like to make or points I would
10 like to stress.

11 MR. ESTRIN: I think we have copies of
12 them. We have taken the liberty of putting an exhibit
13 number on it.

14 --- EXHIBIT NO. M-444-OH-64A: Overhead showing
15 comparison of impacts
16 calculated at both
17 Sites D and F

18 DR. ROWE: Before I get into the details
19 of discussing that figure, Mr. Chairman, there are a
20 couple of general points I would like to raise. The
21 first is a very general point. Like Mr. Feenstra or
22 anyone else trying to perform a contaminant migration
23 analysis it has been necessary for me to make a number
24 of assumptions. However, I have attempted to indicate
25 to the Board what the assumptions are as well as
indicating the sensitivity of the final results to
reasonable variability in the related parameters.



1 With respect to Site D, I have looked at an envelope of
2 results which I think, which in my opinion, based on
3 the idealization given by Trow, bracket or bound where
4 I think the real situation will be. One part of that
5 bound, of course, is the postulated working of the
6 hydraulic trap and the other part of that bound is the
7 case 8 which I have examined.

8 My analysis and comments on Site D,
9 Mr. Chairman, assume that the hydrostratigraphy is
10 basically as described by Trow. If, as I indicated
11 earlier, the thin bed of silt was either thicker or
12 more granular than I have assumed in my analysis then
13 it might become a critical path for off-site migration.
14 It is also my view, based on my own interpretations as
15 well as hearing Mr. Sobanski part of the time, reading
16 his comments in the transcripts as well as
17 Mr. Hiraishi's comments that it is unlikely that the
18 leachate collection system at Site D will continue for,
19 continue to operate for 60, 70 or 80 years.

20 With regard to Site F, I have
21 acknowledged that there is uncertainty regarding
22 fracture spacing, fracture-opening size. In my report
23 I focus attention on average fracture spacings of five
24 to 30 centimetres and a fracture-opening size typically
25 less than half a millimetre. Mr. Chairman, I am very



1 aware of the fact that at some locations fracture
2 spacings exceed 0.3 of a metre. I also recognize the
3 possibility that the fracture-opening sizes might
4 increase, at least locally, to perhaps one or two
5 millimetres at some locations. However, based on the
6 results of the analyses I have conducted for Site F, as
7 well as the knowledge I have developed from the results
8 of my research into contaminant migration through
9 fractured rock, it is my opinion, Mr. Chairman, that
10 the results in my Site F report are representative of
11 the likely situations to be encountered for a given
12 contaminant species and Darcy velocity.

13 Again with respect to Site F, I have
14 indicated in my evidence, Mr. Chairman, that the
15 results presented were obtained for a flow-through
16 fracture zone 25 metres thick. I pointed out in my
17 evidence that there is nothing special about 25 metres
18 and that for a given Darcy flow laterally off-site the
19 results in my report are not very sensitive to this
20 thickness. Thus, for a given Darcy velocity, these
21 results could be used to estimate the impact
22 irrespective of whether the flow was through a five-
23 metre-thick zone or a 25-metre-thick zone or even a 50-
24 metre-thick zone.

25 With regard to the mass of contaminant I



1 used at Site D was 4,400 tonnes of chloride and at Site
2 F, I used 7,800 tonnes. As I have indicated, based on
3 the available evidence, I think the 4,400 tonnes
4 appears to be a reasonable value. I used 7,800 tonnes
5 at Site F to provide a cushion such that factors, for
6 example uncertainty regarding mass or infiltration
7 could be reasonably varied without impacting on my
8 findings.

9 That summarizes, Mr. Chairman, a number
10 of points that I have raised that I think warrant
11 raising a second time. I would now like to refer
12 directly to overhead 64. What I have done in this
13 overhead, Mr. Chairman, I have taken some of the
14 results from the Site D report and some of my results,
15 the analysis of Site F and put them together on a plot
16 of chloride versus time. Now, in blue I have indicated
17 three cases involving failure of the collection tiles
18 themselves, 4 and 5. Case D is the worst case I
19 considered, case D-8 is the worst case I considered.
20 You can see impacts in excess of 1,200 milligrams per
21 litre at relatively short times, in the order of ten
22 years. Case D-9 is the failure case I considered using
23 Trow's parameters for the waste and the upper till.
24 Even in that case the impact is significant, very
25 significant, in the order of 800 milligrams per litre



1 DR. ROWE: You are referring
2 specifically to case 8? Yes, in all of the cases. I'm
3 not sure if you want me to go back to it but I did have
4 an overhead earlier in my presentation when I explained
5 this range that I am talking about. I indicated at
6 that time that when I was going to talk about K for
7 waste I was going to use a nominal value which is the
8 value given on the right-hand side, the K value. I
9 indicated that there is a range, that the calculation
10 corresponds or can be thought of as corresponding to a
11 range in K. So, I am not saying that the K is
12 precisely 1×10^{-4} for case 8. The range of
13 uncertainty is between 10^{-5} and 10^{-4} in that particular
14 case. So, if I can express it slightly differently,
15 the hydraulic conductivity in the waste which in my
16 opinion would give rise to a mounding with a head of
17 194 is in the range of 10^{-5} to 10^{-4} . Without doing a
18 very sophisticated analysis, one can't be more precise
19 than that.

20 Now, the reason the range is high in
21 that case is you have a lot of flow coming through the
22 system and the growth equation that we have heard about
23 is essentially -- I think perhaps I should go back to
24 the overhead. Bear with me just a moment.

25 This issue was raised with respect to



1 overhead 47 in my testimony. What I was indicating
2 here is that the basic equation that we are using for
3 estimating the height of mounding, strictly speaking,
4 is derived assuming all of the contaminant is going
5 through the tiles. Obviously when you have the flow
6 down into the till then not all of it is going to the
7 tiles, only a portion of it is going to the tiles. So
8 what I did is I calculated a height of mound based on
9 the nominal value. That is the term I have been using
10 when I was talking about the K of the waste. I
11 recognize that to get that mound that would involve
12 some of the flow going through the tiles. To try and
13 take account of that one can think of that in terms of
14 uncertainty regarding the K of the waste. To get the
15 same mound the K of the waste has to lie somewhere
16 between K^* which I can calculate knowing how much is
17 going down and knowing how much is going to the tiles
18 and K which is my nominal value. Those two values have
19 been reported in table 2 so that you can be quite aware
20 of what, if you like, the limitations are of the
21 equations we used to calculate the flow down into the
22 system. In case No. 8 you have large flows, therefore
23 the calculation is not as reliable as when you have low
24 flows. That is reflected by that number and that is
25 precisely why I've put it there.



1 and a time in the order of 30 to 40 years.

2 Shown in the dashed curve is a result,
3 actually case 5 where the leachate collection system is
4 working but the hydraulic conductivity of the waste is
5 10^{-5} instead of 10^{-4} . As we have seen in the detailed
6 results, again we had quite a significant impact in the
7 border of 600 milligrams per litre.

8 In contrast, Mr. Chairman, we have the
9 results for Site F. I have shown here for the results
10 for case 24 in my Site F report which I have tabbed my
11 worst case. Shown in green is the calculated variation
12 in concentration at 300 metres downgradient, 800 metres
13 downgradient based on the concept that Dr. Charlesworth
14 talked about earlier that doesn't have the nice, neat,
15 weakly-fracture massive shale unit underlain by the
16 highly-fractured shale unit but has a more general zone
17 of fractured rock. In these cases the impact, the
18 maximum impact is typically less than 150 milligrams
19 per litre in terms of chloride using that as our frame
20 of reference, 800 metres off-site. Remembering also
21 that this at Site -- at Site D we have people drinking
22 water a hundred metres off-site and at Site F we have
23 heard testimony regarding the poor quality of water.

24 If I was to put on this same figure the
25 results that I obtained from a contaminant migration



1 analysis using Trow's better-fit flows, it is shown by
2 the curve highlighted in red on this overhead. The
3 peak impact downgradient of the edge of the landfill
4 which I calculated for that case was about 85
5 milligrams per litre. This would further attenuate
6 with distance away from the landfill.

7 So, my conclusion, if one was to draw a
8 conclusion from that, is that it would appear that Site
9 F is preferable, not just on the basis of these results
10 but on the basis of the other information available to
11 me, it would appear that Site F is preferable to Site D
12 for siting a landfill.

13 DR. KINGHAM: Dr. Rowe, I asked you this
14 morning and you did clarify that the columns for
15 hydraulic conductivity of waste that you used in these
16 various models represented ranges. It didn't concern
17 me greatly until I see your graph here showing D-8 as
18 the worst case and the hydraulic conductivity from 10^{-5}
19 to 10^{-4} . I am wondering which number you used in
20 plotting that worst case.

21 DR. ROWE: I am sorry, you are referring
22 to table 2?

23 DR. KINGHAM: I just want to understand
24 from where you drew your information to plot this
25 curve.



1 MR. LANCASTER: We will take a break
2 now.

3 --- Recess

4 MR. LANCASTER: Be seated, please.

5 MR. ESTRIN: We have provided for the
6 Board copies of that exhibit with the colours drawn in
7 because it is a bit difficult.

8 Q. Dr. Rowe, I want to turn to
9 paragraph 59 of your witness statement at this point
10 and there was an exhibit produced by Burlington,
11 Exhibit B-259 which was essentially a chart, a graph
12 without a line. That was produced with respect to Site
13 D by Mr. McQuaid testing his hydrogeological opinion,
14 what the impact would be.

15 MR. McQUAID: I think Mr. Feenstra
16 agreed with me ...

17 MR. HODGSON: I don't think
18 hydrogeologically Dr. Rowe and Mr. McQuaid are on the
19 same plane.

20 MR. ESTRIN: Q. In any event, I
21 understand you looked at Mr. Feenstra's figure 332 from
22 his report, H-86. You did some comparison of what he
23 was -- recalculating the chloride concentration at F in
24 relation to this topic. Perhaps you could just refer
25 to paragraph 59.



1 DR. ROWE: A. Mr. Chairman, reference
2 to figure 332 which is chloride concentration from
3 Exhibit H-86, I have got an overhead transparency of
4 that shown here. Essentially this is Mr. Feenstra's
5 calculation of the contaminant concentration in the
6 fractured shale after it has migrated through the
7 weakly-fractured unit based on their original flow
8 model which is what he was given when he was asked to
9 model the impact at Site F. What I wished to do was
10 compare that. You can see that the peak concentration,
11 this is before it has had any attenuation by matrix
12 diffusion or going through the upper till, the peak
13 concentration is somewhere in the order of 500
14 milligrams per litre at something of the order of 50
15 years. If one was to perform a calculation, as I did,
16 and I am referring now to overhead 4 of my witness
17 statement, using the flows based on their better-fit
18 model. What I obtained from this calculation using the
19 much smaller flows that Trow reported in their better-
20 fit model was a peak impact in this highly-fractured
21 shale at the downgradient toe of the landfill of 85
22 milligrams per litre and the peak arrived at around 550
23 years. Now, it is approximately an order of magnitude
24 greater in time and I also point out that up to
25 something of the order of 350 to 400 years there would



1 I am just pointing out that it might be more
2 complicated.

3 Q. That brings us back to some
4 general, overall comments which really commence at
5 paragraph 61 and, Dr. Charlesworth, we are going to be
6 turning to you here as well. So if you could turn to
7 paragraph 61, the statement is made that it is
8 indicated that both of you would comment on the
9 performance of the two existing landfills adjacent to
10 Site F and the results of the various studies relating
11 to both sites and relate that to your opinions which
12 you have reached with respect to the overall
13 superiority of Site F to Site D from the perspective of
14 potential impact on groundwater quality. First of all,
15 Dr. Charlesworth, can you please comment on that, the
16 matters raised in that paragraph?

17 DR. CHARLESWORTH: A. Yes,
18 Mr. Chairman, I am of the opinion that Site F is
19 superior to Site D from the perspective of potential
20 impact based on the evidence that the Board has before
21 them for a number of reasons. I believe that there are
22 significant uncertainties in the understanding of the
23 hydrogeology at this time at Site D. I believe at Site
24 F there is a good understanding of the overall flow
25 system although I recognize there are complexities of



1 details there.

2 At Site D we have two models, the Trow
3 model and Dr. Rowe's model. The Trow model does not
4 indicate a problem. The Trow model at Site D does not
5 indicate a problem if the hydraulic trap keeps working.
6 Dr. Rowe's model which I think, in my opinion, is a
7 more rigorous approach to the problem, does indicate a
8 number of scenarios, reasonable scenarios where a
9 potential problem could occur.

10 At Site F we have two models, the Trow
11 model and Dr. Rowe's model, different approaches, which
12 both indicate that there should not be a problem at
13 Site F. At Site D we have no existing landfill with
14 which to compare the modelling. At Site F we have two
15 existing landfills which we are able to look at in
16 terms of how they have performed. I believe that to be
17 a very important factor in assessing the two sites.

18 Q. The statement is made in paragraph
19 61 of the witness statement that you have reached this
20 conclusion of the comparative superiority of Site F
21 over Site D in terms of potential impact even if in the
22 absence of an underdrain leachate collection system.
23 Can you just clarify or expand on that? Did you
24 assume ...

25 A. There we referred to the fact that



1 at the two existing sites adjoining Site F, at one site
2 there is no underdrain leachate collection system. At
3 the other site under a portion of the site there is no
4 underdrain system but a toe drain. With the toe drains
5 in place the sites are creating negligible groundwater
6 impact.

7 Q. Dr. Rowe, could you comment?

8 DR. ROWE: A. Yes, Mr. Chairman, I
9 would agree with Dr. Charlesworth's general conclusion
10 based on the information I have available to me
11 including Dr. Charlesworth's opinions. It is my view,
12 my opinion that Site F is preferable to Site D.

13 Q. That brings us to paragraph 62 of
14 the witness statement which begins:

15 "In contrast, the proposed design at
16 Site D will only prevent contamination
17 of groundwater if the so-called
18 hydraulic trap can be developed and
19 maintained under the entire site for at
20 least 80 years (and perhaps much
21 longer)."

22 We have heard Dr. Rowe's evidence in that respect and
23 we've also heard him outline details of the failure
24 scenarios. What I really want to bring your attention
25 to and elaborate on is it begins with the first full



1 paragraph on page 35. First of all, the statement:

2 "The contingency measures proposed by
3 THCL for Site D are intended to deal
4 with contamination of the groundwater
5 not if, but when, the collection system
6 and/or hydraulic trap fail."

7 Dr. Rowe, can you comment on that?

8 A. Yes, Mr. Chairman, it is my
9 opinion, as I have indicated to you, that it is likely
10 that the leachate collection system will fail within
11 the period it is needed to be maintained to prevent
12 off-site migration. I have discussed how long it has
13 to be maintained with respect to a number of different
14 scenarios I considered. If it is going to fail, which
15 it is my opinion that based on the evidence available
16 we should design as if it is going to fail, obviously
17 Trow have got their contingency measures with the sole
18 intention of or with the intention of collecting that
19 contaminant after it has gone through the upper till
20 and lower till into the granular units. So, it is my
21 concern that this, these contingency measures are
22 really there as part of the overall design because
23 based on information available to us and including
24 Mr. Hiraishi's testimony and Mr. Sobanski's testimony
25 it appears that both they and I think it unlikely that



1 not be expected to be a conservative contaminant
2 appearing at the location downgradient from the toe of
3 the landfill in the highly-fractured shale unit if it
4 had to migrate through 15 metres of weakly-fractured
5 shale using the flow that Mr. Sobanski quoted in his
6 testimony and diffusion coefficient that we obtained
7 for the shale.

8 Q. Then it is stated in the witness
9 statement, paragraph 59, if you applied matrix
10 diffusion?

11 A. Yes, if you were to apply matrix
12 diffusion as it migrated downgradient of the landfill
13 this concentration would decrease with distance. I did
14 a very conservative calculation which indicated that by
15 the time it had moved 800 it would have reduced from 85
16 to about 60 milligrams per litre. I didn't try to get
17 too sophisticated with that calculation because it was
18 already a very low value.

19 Q. So that you indicate that you
20 reached some conclusion with respect to Exhibit 259?

21 A. Exhibit 259 purported to show the
22 concentrations of chloride, that is a photocopy of
23 Exhibit 259 purported to show the concentrations of
24 chloride at Site D with the hydraulic trap in
25 operation. I have no argument with that if the



1 hydraulic trap is in operation but if one were to
2 simply look at this portion of the plot up to 200 years
3 they are both the same.

4 Q. At which site?

5 A. At Site F.

6 Q. Now, would you turn, please, to
7 paragraph 15 of your witness statement which deals with
8 another aspect of the evidence, Mr. Feenstra's response
9 to a question from Mr. Tidball as to whether the
10 presence of very high concentrations of methylethyl
11 ketones and tetrahydrofurans would be conclusive proof
12 that organic contamination in the wells was due to
13 glues. Mr. Feenstra made some response of a positive
14 nature in that regard to his opinion.

15 A. My comment, Mr. Chairman, I am not
16 arguing with Mr. Feenstra at all. I am just adding a
17 word of caution and that is that dilution of the
18 species along with other organic species may have
19 occurred due to past sampling at these wells and
20 secondly these contaminants are likely to have diffused
21 into the matrix of the rock and I am cautioning that it
22 should not necessarily be anticipated that they would
23 still be at very high concentration levels. The two
24 processes are likely to complicate the interpretation
25 of any test data. I am not arguing with Mr. Feenstra.



1 the leachate collection system will continue to
2 function for the 80 years.

3 Q. All right, then the next sentence
4 in that paragraph reads:

5 "Given the complexity of the
6 hydrogeologic system at Site D and the
7 uncertainty about the likely flowpaths
8 the proposal to develop Site D presents
9 reasonable concerns that contaminants
10 will impact off-site before any
11 detection of failure has occurred."

12 Dr. Charlesworth, could you comment on that, please?

13 DR. CHARLESWORTH: A. Yes,
14 Mr. Chairman, my concern here is that Dr. Rowe has
15 demonstrated that there is a reasonable likelihood of
16 off-site contamination occurring at Site D and you
17 heard my testimony there are still a number of
18 uncertainties about the groundwater regime, the flow
19 directions, the flowpaths at that site and I believe
20 with this uncertainty it is quite conceivable that off-
21 site impacts could occur before the monitoring system
22 had picked it up because the uncertainties in the flow
23 system make it difficult at this time to design an
24 effective monitoring system.

25 Q. The next sentence says:



1 "Unlike at Site F, the undetected off-
2 site migration at Site D will have a
3 direct adverse impact on groundwater
4 downgradient of the landfill."

5 What relevance, Dr. Charlesworth, does that have with
6 respect to your opinion?

7 A. There are two aspects to this,
8 Mr. Chairman. At Site D there are -- the groundwater
9 is usable and people are using it at the present time.
10 The kind of scenarios that Dr. Rowe has demonstrated,
11 the impact on those well owners on the groundwater
12 would be unacceptable. At Site F there are no
13 groundwater users downgradient. We have seen that the
14 groundwater resource is of such poor quality at Site F
15 that the landfill will not have any detectable impact
16 and the second aspect of that is that Dr. Rowe's
17 modelling there has demonstrated that the attenuation
18 processes that would take place in the shale, matrix
19 diffusion in particular, will reduce that impact to an
20 acceptable level anyway.

21 Q. Now, if I can direct your
22 attention to the next full paragraph on page 35 of the
23 witness statement:

24 "At Site F..."

25 Dr. Charlesworth, I want you to go back to something



1 you said and ask you if that is what you meant or not.
2 I think you said in the comment you just made there
3 were no downgradient water users at Site F. Is that
4 what you meant to say?

5 A. There are no downgradient water
6 users at Site F using the groundwater that is of
7 concern at Site F. There may be some users of the
8 shallow fresh water lens, but the groundwater body that
9 we are referring to at Site F is not a resource that is
10 utilized for public or private supply.

11 Q. If I can then direct your
12 attention to the next paragraph:

13 "At Site F in the event the upper
14 leachate collection system fails, there
15 is a secondary leachate collection
16 system capable of underdraining at least
17 a portion of the site. Further, most
18 leachate could be collected by perimeter
19 ditches and toe drains, whereas at Site
20 D a perimeter ditch would only collect
21 leachate tending to go laterally through
22 the weathered upper till. If the
23 leachate collection system at Site D or
24 part of it fails, the leachate plumes
25 must be detected and satisfactory



1 engineering devices installed to prevent
2 off-site impacts."

3 First of all, Dr. Charlesworth, would you agree with
4 the statements written there?

5 A. Yes, I do.

6 Q. Secondly, how do you fit those
7 statements into your overall ranking of the two sites?

8 A. I feel that the -- those
9 statements as set out there make Site F preferable to
10 Site D. We have this backup system or secondary system
11 which is the lower system illustrated on Exhibit H-42-
12 B5r. There will also be toe drains there. At Site D
13 there will be no way of intercepting. The perimeter
14 ditches will intercept water that may move out
15 laterally through the weathered till, the shallow
16 system. There is no mechanism in the design of those
17 ditches. Obviously we are intercepting water that goes
18 down into the upper granular unit and then moves
19 laterally. Thus, at Site D you would have to implement
20 additional measures. You would have to detect the
21 movement and implement additional measures such as
22 purge wells.

23 Q. Now, it is indicated that you
24 would comment next in paragraph 63 with respect to
25 Exhibit H-263. I think that was originally something



1 Mr. Feenstra drew that was reduced to a typewritten
2 form. It is -- I think everyone has the typewritten
3 version of that. It is headed "Evaluation of
4 Groundwater Contamination Migration." You may recall,
5 Mr. Chairman, this was something that Mr. Feenstra came
6 up with during the course of his cross-examination or
7 re-examination. I don't recall which.

8 Now, first of all, I want to direct your
9 attention to the first scenario there. It is
10 postulated by Mr. Feenstra in Exhibit H-263, his
11 typewritten version of this. It is indicated there
12 under scenario 1 "Primary engineered features in
13 operation for Site D." His comment is:

14 "No leachate movement into drains or
15 units, no impact."

16 Would you comment, please?

17 DR. ROWE: A. Mr. Chairman, as I have
18 indicated in my evidence, that if one were to construct
19 a landfill using the proposed design; that is the
20 proposed design for Site D, then if the hydraulic
21 conductivity of the waste were of the order of 10^{-5}
22 cm/s instead of 10^{-4} as assumed by Trow then there is
23 potential for off-site impact even though the primary
24 engineering features are in operation.

25 Q. Now, I guess you have no comment



1 or what is your opinion with respect to his comment
2 under Site F?

3 A. With respect to Site F I would
4 comment that if one looks at the better-fit model, one
5 accepts their better-fit model or if you look at my
6 modelling as reported for Site F, in both cases you are
7 looking at hundreds of years before you get significant
8 impacts south of 403 rather than ten years.

9 Q. Now, let us come down to scenario
10 2 as proposed by Mr. Feenstra in Exhibit H-263. Do you
11 have any reason to reach different conclusions on that
12 scenario?

13 A. No, I agree with Mr. Feenstra on
14 Site D.

15 Q. What about for Site F?

16 A. Well, I would offer the same
17 qualification I made a few moments ago. If you adopt
18 their better-fit-type ideas, in other words the lower
19 hydraulic conductivity of the units they used in the
20 better-fit model or if you look at the worst case I
21 examined, in both cases one is looking at the order of
22 hundreds of years before you get significant -- you are
23 looking at the order of hundreds of years before you
24 get impact south of the 403 and even so it is not a
25 significant impact.



1 Q. Dr. Charlesworth, do you agree or
2 disagree with what Dr. Rowe has said so far on this?

3 DR. CHARLESWORTH: A. I agree on those
4 points, Mr. Chairman.

5 Q. Let us come to scenario 3 as put
6 forward by Mr. Feenstra on Exhibit H-263. Do you have
7 a general comment with respect to that scenario, with
8 respect to Site D?

9 DR. ROWE: A. With respect to Site D
10 providing that they can put effective and timely
11 contingencies into place then I don't have any strong
12 disagreement. I would modify "no impact" to "no
13 further impact."

14 Q. Dr. Charlesworth?

15 DR. CHARLESWORTH: A. I would agree
16 with that and the emphasis has to be on effective and
17 timely contingencies.

18 Q. With respect to Site F, would you
19 make any change in that?

20 DR. ROWE: A. I would make the same
21 comments I made a few moments ago.

22 Q. Now, have you gentlemen prepared
23 in written form how you would modify those comments
24 that you have just discussed in evidence?

25 A. Yes, we have.



1 MR. ESTRIN: You have headed this
2 "Evaluation of Groundwater Contaminant Migration
3 Scenarios" and you have put an asterisk to be compared
4 with Exhibit H-263. Mr. Chairman, could this be given
5 the next ...

6 MR. LANCASTER: It is 460-something.

7 MR. HODGSON: The last one I had was
8 463.

9 MR. LANCASTER: Four sixty-four.

10 --- EXHIBIT NO. M-464: Document entitled "Evaluation
11 of Groundwater Contaminant
12 Migration Scenarios"

13 DR. CHARLESWORTH: There is just one
14 point on there, Mr. Chairman. I think under item
15 scenario 1, Site D, the second point, the first point
16 we said possible leachate movement and the second point
17 should therefore be possible significant impact.

18 MR. ESTRIN: Q. Now, we have had your
19 comments essentially with regard to the first three
20 scenarios and how you would modify what Mr. Feenstra
21 had presented. You have now also in this Exhibit M-464
22 presented a fourth scenario. Can you elaborate on
23 that?

24 DR. ROWE: A. The fourth scenario looks
25 at the situation where the engineering features have
failed and either their contingency measures are not



1 effective or their monitoring is not effective so they
2 don't know that the contaminant is moving off-site. In
3 either of these cases at Site D you would expect or I
4 expect, based on the analyses that I have performed,
5 that there would be significant impact on the
6 groundwater quality at the boundary of the site and
7 beyond. On the other hand, at Site F the situation is
8 essentially the same as it was in the previous cases.
9 You would still get leachate movement into the shale
10 bedrock but still no significant impact south of
11 Highway 403.

12 Q. Dr. Charlesworth?

13 DR. CHARLESWORTH: A. Yes, I would
14 agree with that.

15 Q. Let us go back to scenario 3 as
16 postulated by Mr. Feenstra. You do discuss this in
17 your witness statement I believe beginning towards the
18 bottom of page 36. It begins there by saying you will
19 indicate that scenario 3 is not as likely to occur as
20 Mr. Feenstra indicates, not because contingency
21 measures are impossible but rather, and then you set
22 out a number of reasons. I would like Dr. Charlesworth
23 to address that point.

24 A. The first point, Mr. Chairman, is
25 point A at the bottom of page 36:



1 "The escape of leachate at Site D may
2 not be detected completely or at all
3 before it reaches the upper granular
4 unit."

5 This is simply a matter of logistics. The path for the
6 leachate to the upper granular unit will be downward
7 through the bottom of the landfill and in my opinion it
8 will be extremely difficult to monitor in that zone in
9 order to determine when you have reached the upper
10 granular unit beneath the landfill.

11 Q. Dr. Charlesworth, are you making
12 some distinction between monitoring to determine
13 whether a contaminant exists beneath the base of the
14 landfill as opposed to some other point away from that?

15 A. At that point I am referring
16 specifically to it moving down into the upper granular
17 unit.

18 Q. In that comment, are you making
19 some comment on the relative difficulty or ease of
20 monitoring for that situation beneath the landfill as
21 opposed to some other point?

22 A. Beneath the landfill.

23 Q. You are saying it is which
24 underneath the landfill?

25 A. I am saying it is difficult to



1 monitor beneath the landfill.

2 Q. That is contrasted to ...

3 A. I am not contrasting at that
4 point.

5 Q. Now, we come to paragraph B.

6 A. The point in paragraph B at Site D
7 as we see is that the course of the fluctuations in the
8 natural groundwater chemistry at Site D, it could be
9 quite difficult to detect the onset of contamination
10 because we see for example just on the three analyses
11 that we did that you get variations in the chlorides
12 and sulphates.

13 Q. You say here that you were
14 referring back to Mr. Sobanski's evidence with respect
15 to what you say in paragraph B:

16 "Those responsible for interpreting
17 results may now know or believe that
18 they are witnessing a failure."

19 What volume of evidence are you referring to?

20 A. That was Volume 30, page 6396.

21 Q. Does that really begin around
22 6394?

23 A. Yes, the whole topic begins on
24 6394.

25 Q. Could you tell us, please, what it



1 is in that transcript that you were referring back to
2 specifically? If it is just a short excerpt perhaps
3 you can read it.

4 A. Well, for example, at the top of
5 page 6395 or the mid-point, most of 6395, Mr. Sobanski
6 as I understand says you may get values that you
7 wouldn't respond to, you probably would not respond to
8 one odd value. You would be looking for a trend of
9 values and my point here is that I believe that there
10 are potential problems at Site D because the natural
11 fluctuations may mask what in fact is the onset of
12 contamination. So, one value may rise and as we have
13 already seen a natural decline in the holes that we
14 monitored and that may mask it and you may not
15 recognize a second and third analysis that is still
16 part of the trend of the onset of leachate
17 contamination.

18 Q. Is one of the things Mr. Sobanski
19 says, agrees to -- it was a question:

20 "I think you put it that monitoring was
21 a study of trends?

22 A. Yes, it is."

23 At the bottom of page 6395. Do you agree with that or
24 not?

25 A. I would agree with that.



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Q. "Q. You want something, you need a trigger, I think that is the word you used, you need something to know when to implement contingencies because contingencies may be expensive and you want to make sure the contingency is required?

A. Yes.

Q. Not just a change in background?

A. That is correct."

How does that relate?

A. Mr. Sobanski says contingencies are expensive so there may be a tendency to under-rate, to give less emphasis than one should to a higher value or the start of an increase in values because you want to be sure that it is necessary, that it really is leachate and not natural fluctuations.

Q. Now, the next point is paragraph C on page 37 of the witness statement. It states:

"As Dr. Rowe's work indicates, once leachate arrives at the upper granular unit, there may be relatively very little time in which to take effective remedial action."

DR. ROWE: A. This is essentially a



1 point that arose during the presentation of my
2 evidence; that is that many of the cases I considered
3 you had between six months and three years once
4 contaminant got to the upper granular unit before it
5 had moved a hundred metres off-site. If you looked at
6 the total ranges of cases I examined it was up to 12
7 years and most of the cases were in the six-month to
8 three-year range.

9 MR. ESTRIN: I can indicate to the Board
10 I expect I will be about ten more minutes.

11 MR. LANCASTER: That's fine. Would that
12 complete?

13 MR. ESTRIN: Perhaps in 15 minutes
14 maximum I can complete.

15 Q. The next paragraph, sub-paragraph
16 of your witness statement, we are still looking at page
17 37 of your witness statement, 63D states:

18 "Even if remedial action is taken with
19 respect to some detected contamination,
20 because of the potential complexity of
21 the upper granular unit, i.e.,
22 fingering, there may be contamination
23 occurring at other places which is not
24 detected while the first bout of
25 contamination is being dealt with."



1 Dr. Charlesworth, I believe that at paragraph 22 of
2 your witness statement you have made a comment on
3 monitoring comparing the two sites. Perhaps we could
4 turn to paragraph 22 and relate it back to this
5 statement here.

6 DR. CHARLESWORTH: A. Yes, I think
7 paragraph 22 on page 17, referring to Mr. Feenstra's
8 comments, that included off-site migration through the
9 granular units in a variety of directions, we are not
10 precisely sure in what direction it would go.

11 Q. That is at what site?

12 A. That is at Site D.

13 Q. Do you agree or not with that
14 statement?

15 A. I agree with that statement. An
16 added complexity to that is we do not only know in what
17 direction it may go but until you more accurately
18 define the extent and the flow directions or the extent
19 both vertical and lateral of this upper granular unit
20 that appears likely to be the major flowpath, then if
21 you have a landfill in there that you have not
22 accurately defined that and you may be dealing with
23 leachate moving in one direction and missing the fact
24 it is moving through into fingering in another
25 direction. That just adds to the overall complexity of



1 monitoring and remedial action.

2 Q. There is another comment at
3 paragraph 22 of your witness statement you could deal
4 with right now. First of all, on that point you say,
5 you comment, you refer to the quote of Mr. Feenstra's
6 and then you say:

7 "This is to be contrasted with Site F."

8 A. I think at Site F it is clear that
9 the general flow direction at Site F is clearly
10 defined. Then I go on to say that -- I comment on
11 Mr. Feenstra saying that the same monitoring concerns
12 would be applicable to Site F as are applicable to Site
13 D. This matter refers to the fact that even at Site D,
14 even though the water is used we have elevated values
15 of, for example, chloride which is the standard
16 conservative variety that you monitor for, the kind of
17 fluctuations that we have seen just from our own
18 sampling and from the Trow data means that you would
19 also have to be looking for other parameters, for
20 example organics at Site F in order to be sure that you
21 are not overlooking or ascribing a fluctuation in these
22 matters to natural fluctuations when in fact they were
23 due to leachate.

24 Q. I would like to come back to
25 paragraph 64 of your witness statement and you are



1 commenting -- the comment was made there by Dr. Rowe
2 indicating with regard to Mr. Feenstra's opinion given
3 to Mr. McQuaid that there is reason to prefer Site D
4 over Site F under operating conditions assumed at
5 either site. Dr. Rowe, I wonder if you would ...

6 DR. ROWE: A. Yes, Mr. Chairman, as I
7 have indicated in my evidence, given the design that
8 Trow had presented for Sites D and F it is my opinion
9 that Site F is preferable to Site D under operating
10 conditions.

11 Q. What about the statement of
12 Mr. Feenstra's that there would be no potential
13 contaminant migration into the underlying granular unit
14 during the operation of the site?

15 A. As I have indicated again in my
16 testimony, Mr. Chairman, I have looked at one scenario
17 where you could get contaminant migration down into the
18 upper granular unit even though, if the collection
19 tiles were functioning under operating conditions.

20 Q. It is also indicated you would
21 contrast that to Site F at the bottom of that page.

22 A. At Site F, the calculations, as
23 well as the observed performance of the two landfills
24 would indicate that there is not going to be -- that
25 there will be minimal impact south of the 403.



1 Q. That brings us to paragraph 65
2 and, Dr. Rowe, I wanted to ask you to comment on the
3 first sentence there:

4 "From the standpoint of modelling
5 contaminant migration, Drs. Rowe and
6 Charlesworth will indicate that the
7 proposed Site D is at least as complex
8 as Site F ..."

9 A. Yes, Mr. Chairman, it is my
10 opinion from the perspective of modelling that Site D
11 is at least as complex as Site F. Dr. Charlesworth has
12 talked about these various units such as fingering,
13 we've heard about uncertainty regarding the thickness
14 of the units. We have heard about the uncertainty
15 regarding the significance of the lower granular unit.
16 When you put all of this in perspective and compare it
17 with Site F it is my opinion that Site D is at least
18 as complex as Site F from the standpoint of modelling.

19 Q. The next part of that paragraph
20 states:

21 "In both cases modelling using
22 reasonable combinations of parameters
23 will provide an indication of the
24 potential for contamination of the
25 groundwater. At Site F, there is the



1 unique advantage of having the
2 documented performance of two existing
3 landfills which can be used to calibrate
4 the choice of parameters."

5 Dr. Charlesworth, can you comment? Do you agree with
6 that?

7 DR. CHARLESWORTH: A. A model is only a
8 model. It is an approximation of the real conditions
9 at the site but it is only an approximation. However,
10 if you are able to simulate something that is actually
11 taking place and calibrate your model against that then
12 it makes your model so much -- gives you so much more
13 confidence in the model that you are working with.

14 Q. Dr. Rowe, would you comment?

15 DR. ROWE: A. Yes, I would agree with
16 that, Mr. Chairman. I am far more comfortable with
17 predicting minimal impact at Site F knowing that there
18 are two existing landfills than I would be if those
19 landfills did not exist, and had not been operating for
20 15 or 30 years.

21 Q. In that regard I would refer both
22 of you to paragraph 66 of the witness statement where
23 there is a quote from Mr. Feenstra's evidence:

24 "The comparison of a field example or
25 field observations with any type of



1 calculation or model results I think
2 would have to be considered as a
3 reasonably significant confirmation of
4 the estimates or calculations."

5 Your comments, gentlemen?

6 DR. CHARLESWORTH: A. Yes, I would
7 agree with that statement. It is similar to the point
8 we were making earlier in the previous paragraph. It
9 does give you confidence in the model if observed
10 conditions fit your predictions.

11 Q. And one more reference here,
12 paragraph 67, Mr. Feenstra's response to a question by
13 Mr. Garrod that the existence of data about the plume
14 delineation work at the Burlington site and also data
15 at the Bayview site provides a higher level of
16 confidence with regard to Site F than Site D in terms
17 of its suitability for a landfill.

18 A. I would agree with that statement.

19 Q. Dr. Rowe?

20 DR. ROWE: A. I would agree with that
21 statement.

22 MR. ESTRIN: Well, gentlemen, you will
23 be pleased to know those are all my questions but I'm
24 afraid that won't be the end of your attendance here.
25 Can we take it that cross-examination doesn't begin



1 until tomorrow morning so I can still have a couple of
2 chats with these gentlemen before tomorrow morning?

3 MR. LANCASTER: Yes. We will begin at
4 9:30 tomorrow morning.

5 MR. HODGSON: I thought the chats came
6 to an end with the end of examination in chief.

7 MR. ESTRIN: Mr. Hodgson I am sure is
8 well aware of the rule. The whole object is to prevent
9 me discussing evidence they might be giving in cross-
10 examination.

11 MR. LANCASTER: I think you are at
12 liberty to discuss until cross-examination starts.
13 That is my interpretation.

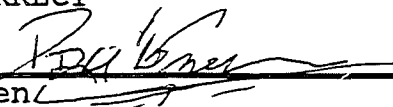
14 I think, Ms Cronk, you will be the first
15 to start?

16 MS CRONK: With your permission,
17 Mr. Chairman, Mr. Tidball has indicated that he will go
18 first and I will follow him.

19 MR. LANCASTER: That is fine. Nine-
20 thirty in the morning.

21 --- Adjournment at 4:42 p.m.

22 CERTIFIED CORRECT

23 
24 P. D. McQueen

25 (page 19900 follows)

