

CONSOLIDATED HEARINGS BOARDRECEIVED
CLERK OF THE COURTIN THE MATTER OF Sections 2 and 3 and 6 (3) of the Consolidated Hearings Act, 1981, S.O. 1981, c.20;

— and —

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

— and —

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

— and —

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

— and —

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

— and —

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

— and —

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

— 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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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 Thursday,
February 4, 1988

VOLUME 86

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 and 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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APPEARANCES (Cont'd):

1

C. Stevenson

for Framgard Holdings,

2

P. Hancock

Fosseri Investments

3

Limited, Seriphos

Investments Limited and

Topic Investments

4

J.H. Olah

for the Halton Region

5

Conservation Authority

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Per: P.D. McQueen

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25



1 --- Upon commencing at 9:30 a.m.

2

3 MR. LANCASTER: Good morning, please
4 be seated. I am happy to see we are all here,
5 at least I think we are all here.

6 I think we have some unfinished
7 business this morning. Everyone is here, are they
8 not?

9 The Board has been asked to determine
10 the order in which cross-examination of the present
11 witnesses on behalf of the Town of Milton will be
12 conducted. The Board has also been requested
13 to consider the same question regarding the cross-
14 examination of the witnesses brought forward by the
15 City of Burlington in their presentation. The
16 Board will defer a decision on the second request
17 at this time. However, the thinking of the Board
18 will remain the same subject to intervening
19 circumstances.

20 The Regional Municipality of Halton
21 had the responsibility of selecting a landfill site
22 for the Region. Over an extended period of time
23 it has considered a number of possible sites.
24 Eventually, consideration was reduced to six sites
25 and then to two sites. The one within the City of



1 Burlington, the other within the Town of Milton.
2 The Region did not, however, make a final selection.
3 That responsibility has been transferred to the
4 Consolidated Hearings Board.

5 In the usual course of events, the
6 Region would make the selection and have that
7 selection tested before the Environmental Assessment
8 Board or if warranted, before a Consolidated
9 Hearing Board. In such a circumstance, the
10 Region would undoubtedly remain the proponent.

11 Mr. Hodgson's position that the
12 Region should be permitted to cross-examine last
13 would prevail.

14 That is not the case, however, for
15 this Joint Board. The responsibility of a final
16 selection has been left to the Board. The Joint
17 Board now has the responsibility, indeed the duty,
18 to make that determination to the best of its
19 ability, an onerous responsibility, which, subject
20 to the usual avenues of appeal will result in a
21 final decision.

22 To this end, the Board will insist
23 upon a manner of procedure which will, in the
24 Board's opinion, ensure the best and fairest
25 presentation of all the evidence upon which it must



1 decide.

2 To this point in time, it is clear
3 that the evidence adduced by the Town of Milton
4 would lead the Board to consider that the Burlington
5 site is the more appropriate for the purpose.
6 The evidence of the Region marginally supports the
7 same conclusion.

8 Under the circumstances, the Board
9 will want to ensure the City of Burlington and its
10 citizens have every opportunity to present a
11 contrary case and that the Board will have the best
12 evidence possible from all parties on which to base
13 its decision. That is our responsibility.

14 To that end, the Board directs that
15 Mr. Hodgson will conduct his cross-examination next
16 on behalf of the Region. Mr. McQuaid from
17 Burlington and Ms Vigod for the Citizens of West
18 Burlington will then cross-examine in an order
19 which they may determine. That is the decision
20 of the Board on that motion.

21 Ms Cronk?

22

23

24

25

DR. RONALD KERRY ROWE, resumed
DR. DAVID LEONARD CHARLESWORTH.
resumed



1 CROSS-EXAMINATION BY MS CRONK (continued)

2 Q. Dr. Charlesworth, yesterday,
3 you will recall, I asked you to the fullest extent
4 it was possible, to produce for me a list indica-
5 ting all of those reports which you had reviewed
6 in preparation for your assessment of Site F and as
7 a basis for formulation of the opinions that you
8 have expressed to the Board. Is that the list
9 that you have in your hand?

10 DR. CHARLESWORTH: A. This is the
11 list, yes. I should say that this starts at
12 number 15 and includes the ones that are in the
13 references in the report and then ...

14 Q. This then is a continuation.

15 A. This is a continuation from
16 Section 8 of the report.

17 MS CRONK: Can I ask that that be
18 marked as the next exhibit?

19 MR. LANCASTER: That will be
20 Exhibit N-473.

21
22 --- EXHIBIT NO. N-472: List prepared by Dr.
23 Charlesworth.

24 MS CRONK: Q. Have you prepared a
25 list similar to Dr. Charlesworth and can you provide



1 me with any omissions or additions to the list as
2 it pertains to you?

3 DR. ROWE: A. I have reviewed the
4 items on Dr. Charlesworth's list and I have read
5 all the documents on the list.

6 Q. Are all the reports, the
7 main documents that you reviewed, set out in the
8 list that Dr. Charlesworth has now provided?

9 A. To the best of my recollec-
10 tion, yes.

11 Q. Dr. Charlesworth, may we
12 then continue our discussion of last evening.

13 You will recall we had gone to the
14 borehole description logs for HC-15 and had
15 looked as well at the piezometer depths of the
16 installations at that location and I asked you
17 over the evening, as I recall, to look at GL-26
18 and determine for me the depths of the piezometers
19 and the screened intervals at that location.

20 Did you have an opportunity to do
21 that?

22 DR. CHARLESWORTH: A. Yes, I did.

23 Q. Could you tell me, please
24 what are the depths of the piezometers at that
25 location?



1 A. The gravel packed section
2 for piezometer 26-3 is from 0.9 to 6.2.

3 Piezometer 2 is from 11.2 to 12.4
4 metres in depth and piezometer 1 is 17.3 to 18.5
5 metres in depth.

6 Q. And that, I take it, is from
7 page 58 of the Plume Delineation Study, Exhibit H-83?

8 A. Right.

9 Q. What is the screened
10 interval at those three piezometers? Did you
11 calculate that?

12 A. I am sorry, the screened
13 interval as opposed to ...? Five point
14 three metres, for piezometer number 3. One
15 point two metres for piezometer number 2 and 1.2
16 metres for piezometer number 1.

17 Q. Thank you. Could I ask
18 you now to go to page 50 of the Plume Delineation
19 Study, with the borehole log record for GL-26.

20 A. Yes.

21 Q. I direct your attention to
22 the description of the stratigraphic units that
23 were observed and recorded in the log. I
24 suggested to you that from 0.2 metres down to a
25 depth of 5.5 metres, there is an indication that



1 a few small fractures were observed below one
2 metre plus or minus; is that correct? That is
3 in the till.

4 A. Yes, that is correct.

5 Q. As I look at the depths that
6 you have given us, it would appear that none of the
7 three piezometers at that location, at GL-26 were
8 located there.

9 A. It appears to me that the
10 shallow piezometer is actually in the gravel pack. The
11 piezometer tip is from 5.6 to 6.2, but
12 the gravel pack extends from 0.9 metres.

13 Q. So, piezometer 3 then was
14 through that interval?

15 A. Yes. As we discussed
16 yesterday, the gravel pack around it extends from
17 0.9 metres, but the actual screened part of the
18 piezometer is from five to 6.2 metres.

19 Q. Then, secondly in the des-
20 cription of the weathered shale which begins at
21 5.5 metres below surface, there is an indication
22 again of small fractures at depth and as well,
23 water noted below 12 metres plus or minus. Do
24 you see that?

25 A. Yes.



1 Q. As I look at the depths
2 of the piezometers in the screened intervals you
3 have given us, it appears that piezometer number 1,
4 the deepest piezometer, was at depth in what was
5 described as being a fractured wet area?

6 A. Yes, it appears to be.

7 Q. Where is GL-26 in relation
8 to GL-24?

9 A. GL-26 is southeast
10 approaching the North Service Road, southwest.

11 Q. Southwest of GL-24?

12 A. Yes, approaching the North
13 Service Road.

14 Q. Yesterday, I had asked you
15 to look at the results of the testing for organics
16 that Gartner, Lee had conducted at those wells and
17 I think you had a letter exhibit available to you.

18 I am looking at Exhibit H-246,
19 which sets out the detailed results in October of
20 1987 in all of the GL wells, whichever document
21 you care to go to. Can you confirm to me
22 that the only volatile organic detected of the
23 parameters that we have been looking at, GL-26, was
24 TCEA 1,1,1-trichloroethane?

25 A. Are you looking at Exhibit...



1 Q. I am looking at Exhibit
2 H-246. The data is contained in a number of
3 places and I am asking you to confirm that the
4 only volatiles recorded at GL-26, were in fact
5 TCEA.

6 MR. LANCASTER: What did you say the
7 volatiles were?

8 MS CRONK: The only volatiles
9 detected were TCEA 1,1,1- trichloroethane.

10 MR. LANCASTER: That would mean
11 something to my colleague.

12 MS CRONK: You will recall we had
13 a discussion about paradichlorobenzene, chlorobenzene
14 tetrachloroethylene, of the group, this is the only
15 one, I suggest, recorded at that well.

16 DR. CHARLESWORTH: A. Which was
17 the chemical that you said was the only one
18 reported?

19 Q. TCEA 1,1,1- trichloroethane.

20 A. That was recorded in 26-1 at 5.41 .

21 Q. It is recorded as well at
22 the other two piezometer depths in 26.

23 A. That is correct.

24 Q. There was no chlorobenzene, TCE
25 and no PCE detected?



1 A. That is correct.

2 Q. Can we look very quickly at
3 GL-27 and can you just recall for the Board where
4 that well is in relation to GL-24?

5 A. GL-27 is south of GL-24
6 and east of GL-26.

7 Q. If we go to page 58 of the
8 Plume Delineation Study can you help the Board
9 again as to the piezometer depths and screened
10 intervals for that well?

11 A. Yes. Referring to the
12 gravel pack, the gravel pack is from 1.5 to 6.1.

13 Q. That is for which?

14 A. That is for piezometer
15 number 3.

16 Piezometer number 2 is from 11.2 to
17 12.4 metres depth and piezometer number 27 is
18 from 17.3 to 18.5 metres depth.

19 Q. If you go now to the bore-
20 hole description log at page 51?

21 A. Yes.

22 Q. This is the description for
23 GL-27 as I understand it?

24 A. Correct.

25 Q. Looking at the description of



1 the stratigraphic conditions in the till, there
2 is no suggestion of fracturing recorded in that
3 till?

4 A. There is no reference to
5 fracturing in the till.

6 Q. Looking at the description
7 of weathered shale beginning at 4.3 metres below
8 surface, there is an indication, I suggest of
9 several very small fractures intercepted below eight
10 metres plus or minus?

11 A. That is correct.

12 Q. Further, there is a water-
13 bearing fracture indicated at two locations, 9.3
14 metres to 9.5 metres plus or minus and also at a
15 depth of 14.3 metres to 14.4 metres plus or minus?

16 A. That is correct.

17 Q. Now, given the depths you
18 have indicated for those piezometers, I suggest
19 it does not appear that any of the piezometers in
20 the shale at this location were in the location of
21 the two water-bearing fractures described; would
22 you agree?

23 A. I would agree with that,
24 Mr. Chairman.

25 Q. May they, however, have been



1 in the area below eight metres described as having
2 very small fractures?

3 A. Yes, they are in the area
4 below eight metres and that is described as having
5 a depth below eight metres and that is described
6 as having several very small fractures.

7 Q. Dr. Charlesworth, I suggest
8 it is not conclusive given the description that
9 we know they were screened over the interval where
10 those fractures were reported.

11 A. It is not conclusive, but
12 we know they were screened.

13 Q. In fractures?

14 A. It is not conclusive, that
15 is correct.

16 Q. Looking again at the volatile
17 organic results obtained by Gartner, Lee Associates
18 in October of 1987, can you confirm for me again
19 that of the organics that we have been concerned
20 with TCEA 1,1,1-trichloroethane was the only one
21 recorded in this well location?

22 A. That is correct.

23 Q. It appears then, I suggest,
24 Dr. Charlesworth, given the review of HC-15, GL-24
25 and GL-26 and GL-27 that we have discussed that



1 at a number of piezometer depths at those well
2 locations, there is an indication in the borehole
3 logs that in fact the piezometers were screened in
4 fractured areas; isn't that so?

5 A. Yes. There is an indica-
6 tion that they have been screened in the fractured
7 areas.

8 Q. Yesterday, Dr. Charlesworth,
9 I suggested to you in the afternoon, recognizing
10 the areas of disagreement that you have told us you
11 have with the work done by Trow at Site F, there
12 are also a number of areas of agreement. We
13 talked about a few items in that regard where you
14 appeared to be in substantial agreement, if not in
15 complete agreement with the opinions expressed by
16 Trow.

17 There is another that I would like
18 to explore with you this morning. I understood
19 you to say in your evidence in-chief,
20 Dr. Charlesworth, that you did not regard a liner
21 as being necessary at Site F. Do I have that
22 correctly?

23 A. That is correct.

24 Q. Could you explain for me,
25 please, the basis for that opinion? What is it



1 that leads you to that conclusion?

2 A. The basis of that conclusion
3 is the performance of the existing landfills. I
4 would say primarily the performance of the existing
5 landfills at that site. The work that Dr. Rowe
6 has done, indicated there will be attenuation
7 within the shale and my own conclusions that regardless
8 of the flow path that we may have modelled, I
9 think that any contaminants that escape into the
10 system would only move off-site by moving downward,
11 not discharge off-site.

12 Q. Dr. Rowe, is a liner necessary
13 in your opinion at Site F to control or reduce
14 contaminant migration?

15 DR. ROWE: A. Based on the evidence
16 available to me, I do not believe a liner is
17 necessary.

18 Q. Do you have anything to add
19 or to alter in the reasons advanced by Dr. Charles-
20 worth for his conclusion in that regard.

21 A. The only other reason I would
22 give is particularly if one adopts Trow's idea of
23 the system where they have shale, the weakly fractured
24 shale unit with vertical hydraulic conductivity of
25 10^{-8} , that is about as good as you can expect to do



1 with a clay liner. So, putting an extra one
2 metre of compacted clay liner in addition to
3 the thickness they have got would not make a
4 significant difference if you accept that, their
5 hydrogeologic interpretation.

6 Also, they did a finite element
7 simulation as I recall looking at the effect of a
8 liner and those indicated that the effect would be
9 very small particularly when one looks at the fact,
10 Mr. Chairman, if I recall correctly, the Trow model,
11 the liner in their flow calculations, the thickness
12 of the liner they used was constrained by the
13 thickness of the row of elements they had. So,
14 in fact, they were modelling a very thick liner
15 is my interpretation, much thicker than they would
16 use in practice.

17 Q. Could I ask you -- perhaps
18 Dr. Charlesworth can provide it to you, Dr. Rowe,
19 to Exhibit N-471, the one which was the July 1985
20 review document prepared by Morrison Beaty.

21 A. I have Exhibit N-471 in
22 front of me.

23 Q. Could you give me one moment,
24 doctor, please?

25 Doctor, I direct your attention to



1 page 7 of that document in which there is a
2 discussion of what are termed liner considerations
3 beginning first in paragraph 1 the authors of this
4 document indicate:

5 "Based on our knowledge of the
6 groundwater and surface water
7 conditions at Site F, we remain
8 convinced there is no valid
9 technical reason to install a
10 liner. This is because (i) the Queenston
11 shale contains poor natural ground-
12 water quality; (ii) there are no
13 existing or future groundwater uses
14 between the site and Lake Ontario."

15 Do you see that?

16 A. I see that.

17 Q. The second paragraph:

18 "If a liner is needed to obtain
19 political support, it is our
20 opinion that shale quarried on -
21 site could be used for this
22 purpose. To be ideal for use
23 as a liner, the shale would have
24 to be weathered to reduce the
25 large shale fragments.



1 Laboratory tests by Golder
2 Associates on weathered shale
3 samples taken in the vicinity of
4 the Bayview Park Landfill in
5 (Aug. 1979) suggest that it
6 may be possible to achieve a
7 permeability in the order of
8 5×10^{-8} cm/sec."

9 Stopping there for the moment,
10 Dr. Rowe, you mentioned that conductivity a few
11 moments ago as well. What is the significance
12 in the context of a liner, a permeability or a
13 conductivity in the order of 5×10^{-8} ?

14 A. A hydraulic conductivity
15 of a compacted liner in the order of 5×10^{-8} is a
16 reasonable order for a compacted clay liner.

17 With some soils you may be able to
18 do better than that but the tests conducted by
19 Golders were suggesting 5×10^{-8} for this particular
20 soil.

21 As I mentioned, certainly in the
22 Hydrology Consultants' better-fit model, we picture
23 the hydraulic conductivity of the weakly fractured
24 shale as being less than that.

25 DR. KINGHAM: Do you understand them



1 to be using permeability as interchangeable with
2 hydraulic conductivity in this case?

3 DR. ROWE: That is a terminology
4 problem, Dr. Kingham. In geotechnical engineering
5 the term "permeability" has most commonly
6 been used in hydrology

7
8 they have tended to use hydraulic conductivity but
9 in this context it means the same.

10 MS CRONK: Q. There is also the
11 suggestion by these authors that the shale would
12 have to be weathered to reduce large shale fragments.
13 In your mind, or in your view, Dr. Rowe, is
14 weathering the shale on Site F a laborious process
15 or do you know?

16 DR. ROWE: A. I wouldn't wish to
17 comment on that.

18 Q. Dr. Charlesworth, can you
19 help me with that?

20 DR. CHARLESWORTH: A. I understand
21 this is the process that they use in the using of
22 the clay in their manufacturing process. I would
23 not imagine that it would be a laborious process
24 to stockpile it in piles if necessary.

25 Q. If you dig the shale up,



1 Dr. Charlesworth, and simply leave it sitting on
2 the ground in flat or in large rock chunks and
3 leave it exposed to the elements will that, with
4 the passage of time, in fact weather it?

5 A. Certainly, that would be
6 the kind of process I would envisage. I don't
7 know what time scale they use in the manufacturing
8 process, but it is obviously a process that they
9 are using at the present time and I wouldn't see
10 it as a problem if you wanted to do the same thing
11 and use the material for a liner.

12 Q. Dr. Rowe, could I come back
13 to you, please? I asked Dr. Charlesworth
14 yesterday if he was familiar with the Golder
15 Associates firm and he indicated he was. Are
16 you?

17 DR. ROWE: A. I am familiar with
18 that company, yes.

19 Q. My information is they are
20 a firm of geotechnical engineering consultants.

21 A. They are very highly
22 respected geotechnical consultants.

23 Q. Are you familiar with the
24 permeability tests that were conducted by Golder
25 Associates as in this paragraph?



1 A. I am generally familiar
2 with Golder.

3 Q. I was being more specific
4 than that. Are you familiar with the tests in
5 this paragraph?

6 A. I would have to familiarize
7 myself with the tests. The tests used are usually
8 standard. It is my understanding these tests
9 did not involve leachate soil.

10 Q. Did you, amongst the reports
11 that you read with respect to Site F, read yourself
12 the Morrison, Beatty Phase 2 Report concerning
13 Site F?

14 A. I did.

15 Q. Did you read as well, the
16 appendices to that report?

17 A. I did.

18 Q. I suggest to you, and you
19 might look in your own copy of the report, Dr. Rowe,
20 that included in the appendices to that report are
21 the results from the Golder Associates analysis
22 performed in August, '79, to test the suitability
23 of these materials for use as a liner.

24 DR. KINGHAM: We are now looking
25 in M-440, I believe?



1 MS CRONK: I am suggesting he check
2 in the Morrison, Beatty Phase 2 Report.

3 DR. KINGHAM: That is not an exhibit.

4 DR. ROWE: I have checked that out.
5 I am familiar with the technique used ...

6 MS CRONK: Q. Are those materials
7 contained in the appendices to the Morrison,
8 Beatty Phase 2 Report?

9 A. I am sorry?

10 Q. Appendix C?

11 A. Yes, that is my understanding.

12 Q. I am showing to you, Dr. Rowe,
13 an extract from the Morrison, Beatty Phase 2
14 Report, Appendix C, being a letter dated August
15 15th 1979 and a letter from Golder Associates.
16 Could you check this and confirm for me, if you can,
17 that this is the documentation included in that
18 report from Golder Associates with respect to these
19 tests?

20 A. That is correct.

21 MR. McQUAID: Mr. Chairman, before
22 we have that, can we just be directed to which
23 appendix it is?

24 MS CRONK: Appendix C.

25 To assist the Board, a portion of this



1 report was marked as an exhibit previously, a
2 portion of the Phase 2 Report only. Exhibit
3 N-186 was the portion of the report, the Phase 2
4 Report, marked as an exhibit.

5 I am tendering now, a further
6 extract from the Phase 2 Report.

7 MR. LANCASTER: That will be
8 Exhibit N-473.

9
10 --- EXHIBIT NO. N-473: Extract from Phase 2
11 Report by Morrison,
12 Beatty dated June 1980

13 MS CRONK: I am sorry, what number
14 did you assign?

15 MR. LANCASTER: N-473.

16 MS CRONK: Q. Dr. Rowe, I draw
17 your attention to the first page of the letter
18 from Golder Associates addressed to Morrison,
19 Beatty Limited. It is dated August 15, 1979;
20 is that correct?

21 DR. ROWE: A. That is correct.

22 Q. In the first paragraph, it
23 indicates that the letter reports on the results
24 of geotechnical laboratory tests carried out on
25 soil samples that were delivered to our laboratory



1 tests carried out, samples that were delivered to
2 our laboratory on July 19, 1979, is that so?

3 A. That is correct.

4 Q. Dealing in the second
5 paragraph, there is an indication that the firm
6 of Golder Associates were requested to carry out
7 permeability tests on disturbed bulk samples of
8 what was identified as weathered Queenston shale .
9 The samples to be tested were taken by Morrison,
10 Beatty from random locations within an existing
11 stockpile; is that correct?

12 A. That is correct.

13 Q. And the Morrison, Beatty
14 Report that we looked at a few moments ago
15 indicated that weathered shale samples were taken
16 in the vicinity of the Bayview Park Landfill in
17 August 1979 and were tested by Golder Associates.

18 A. That is my understanding
19 from the letter.

20 Q. Now, Dr. Rowe, unless there
21 is some particular significance to it, I don't
22 intend to take you through the nature of the
23 testing particularly, but I would ask you to direct
24 your attention, if you would please, to the
25 concluding paragraphs on page 2 of the letter.



1 Specifically, the second last paragraph and
2 perhaps you could simply read that paragraph to
3 the Board.

4 A. This is the paragraph
5 commencing "In summary ..."?

6 Q. Yes.

7 A. "In summary, it has been
8 shown that the laboratory permea-
9 bility for the weathered Queenston
10 shale, compacted to the maximum
11 dry density as established in a
12 standard proctor compaction
13 test has a permeability in the order
14 of 10^{-7} centimetres per second.
15 However, it should be noted that
16 due to the variation in grain size
17 distribution and the possible
18 inclusion of shale fragments within
19 a fill area the actual
20 permeability in the field could be
21 greater. Only a large scale field
22 test would determine the actual
23 permeability of this type of
24 material."

25 Q. Then, could I ask you to turn



1 if you would, to Table 1 of the letter. Does
2 that set out the results of the samples tested by
3 Golder Associates with the coefficient of per-
4 meability?

5 A. That is correct.

6 Q. Am I correct that the ranges,
7 that the various permeabilities reported were
8 respectively, 10^{-8} , 1×10^{-7} and 3×10^{-8} ?

9 A. That is correct.

10 Q. Are you familiar with the
11 type of testing that was done by Golder Associates
12 in this instance?

13 A. Yes, the general technique,
14 yes.

15 Q. In your view, can any
16 observations be made on the basis of these tests
17 as to the likely or unlikely suitability of
18 weathered shale on the site at Site F for use as
19 a liner if that were necessary?

20 A. Based on the evidence avail-
21 able to me at this time it would appear to be
22 suitable. I would concur with Golder Associates'
23 conclusion that one would have to test it in the
24 field. Also, I would think it prudent to check
25 for leachate soil compatibility when determining the



1 hydraulic conductivity. That applies to the
2 material proposed as a natural liner at Site D as
3 well.

4 Q. Could I ask you now to go,
5 with reference to something you said a moment ago,
6 to Exhibit H-40, which is the Trow Report on Site
7 F?

8 I am going to direct your attention
9 to page 128 and 129 of that report. Perhaps,
10 Dr. Charlesworth, I am going to require your
11 assistance in this discussion as well.

12 A. Have we finished the
13 Morrison, Beatty?

14 Q. Yes, we have. Page 129
15 of the Trow Report on Site F, Exhibit H-40.

16 A. I have that.

17 Q. Do you have it, Dr. Charles-
18 worth?

19 DR. CHARLESWORTH: A. Yes, I do.

20 Q. Looking at page 129 under
21 the discussion entitled "Availability of Material"
22 this whole section of the report deals with liner
23 considerations at Site F and sets out Trow's
24 observations, opinions and conclusions on that
25 subject; is that so?



1 A. That is correct.

2 Q. In the Availability of
3 Material section is states:

4 "The construction of the clay liner
5 at Site F could involve: (a) the
6 installation, compaction and
7 testing of the 1.0 metre thick glacial
8 till liner."

9 Then it goes on to indicate what
10 else would be necessary. The installation of a
11 0.5 metre thick sand layer; the installation of
12 sophisticated monitoring devices; and the
13 construction of a leachate collection system on
14 top of the liner. It then continues and in that
15 context, could I ask you, Dr. Charlesworth, to go
16 back to page 128 in the introduction to this
17 discussion which begins:

18 "Liners are considered for the
19 protection of the water resources
20 in hydrogeologic environments where
21 significant off-site contamination
22 can occur. For example, high hydraulic
23 conductivity and low attenuation
24 capability, or where there are
25 significant hydrogeological



1 complexities that require special
2 treatment."

3 Stopping there for a moment, and I
4 direct this question to you, Dr. Charlesworth, do
5 you regard Site F as exhibiting low attenuation
6 capability?

7 DR. CHARLESWORTH: A. No.

8 Q. Is it your evidence, Dr. Rowe,
9 that in fact at Site F, significant off-site
10 contamination is not likely to occur?

11 DR. ROWE: A. Based on the evidence
12 available, that is correct.

13 Q. Do you agree generally,
14 Dr. Charlesworth, or disagree, that those are the
15 types of circumstances as set out at the top of
16 page 128, in which a liner would be considered for a
17 landfill?

18 DR. CHARLESWORTH: A. Yes, I would
19 agree with those criteria.

20 Q. By definition, I suggest,
21 at Site F, based on the work that you have done
22 and your evidence, it would not require a liner;
23 would you agree?

24 A. I would agree.

25 Q. I would ask you now to go



1 back to page 130? The second full paragraph,
2 which reads:

3 "There is no sand on-site for
4 the dessication control blanket.
5 These materials would have to be
6 imported. Data indicate that
7 there is sufficient clayey glacial
8 till at the north end of Site F
9 to construct a one-metre thick
10 liner over the entire disposal area.
11 The clay content of the glacial
12 till varies from 18 to 45 per cent."

13 Stopping there for a moment, Dr. Rowe,
14 you indicated I thought that your understanding of
15 the work done by Trow suggested that they had
16 modelled for a very thick liner?

17 DR. ROWE: A. That was my under-
18 standing. It wasn't entirely clear from the
19 report and I in fact spoke to the modeller at
20 Trow and that was my understanding of my discussion
21 with him.

22 Q. And continuing:

23 "At the Metro Toronto Keele
24 Valley Landfill, experience has
25 shown that similar glacial till



1 containing 20 per cent clay can be
2 compacted to achieve a hydraulic
3 conductivity of about 10^{-8}
4 centimetres per second. Therefore,
5 it is reasonable to assume that the
6 on-site till can be used to produce
7 a liner with a hydraulic conducti-
8 vity in the 10^{-7} to 10^{-8} centimetres
9 per second range."

10 Are those conductivities suggested
11 by Trow consistent with the Golder Associates
12 results we looked at a few moments ago? To
13 Dr. Rowe?

14 DR. ROWE: A. Yes, the range that
15 they have suggested is consistent with the range
16 available, but I think they might be talking about
17 two different things. We are talking here about
18 the till, if I understand it.

19 Q. Yes, Trow is talking about
20 the till.

21 A. In this case we are talking
22 about the shale.

23 Q. If one were to use till
24 as opposed to shale, would that not further
25 increase the level that you could achieve?



1 A. We are talking about the
2 same range. You may be able to get higher, but
3 on the evidence available, I would not speak to that
4 with certainty. Maybe you have got lower hydraulic
5 conductivities.

6 Q. If you use the till, it would
7 be even better than if you used the weathered shale?

8 A. I am not sure that I can
9 jump to that conclusion. It may well be true.

10 Q. Dr. Charlesworth, do you
11 have any comment on that?

12 DR. CHARLESWORTH: A. I would agree
13 it may be true but I would think we would need
14 additional information and testing before actually
15 stating that.

16 Q. It appears though, on the
17 basis of the discussion that Trow has set out that
18 although they regard a liner as unnecessary, they
19 are of the view that there is sufficient till to
20 permit it on-site.

21 DR. ROWE: A. That is their view.

22 Q. It appears on the basis of
23 the discussion in the Morrison, Beatty document,
24 and looking at the Golder Associates laboratory
25 results that the weathered shale itself might be



1 suitable at appropriate conductivities for the
2 creation of a liner.

3 A. Based on the evidence
4 available in this report, that is true.

5 Q. Thank you, Dr. Charlesworth.

6 I would like to turn now, if I
7 could, very briefly to some of the evidence that
8 you have given concerning the phenomenon of
9 matrix diffusion at Site F. I would like to be
10 very certain that I have a fair understanding of
11 what you have said with respect to that process.

12 As I understand your evidence, you
13 have indicated that at Site F, the primary
14 attenuation mechanism you believe will be matrix
15 diffusion if a landfill is placed there. Is that
16 correct?

17 A. For a conservative species,
18 it would definitely be a primary attenuation
19 mechanism. For an active species such as
20 organic, you are also going to have sorption and
21 that is an additional attenuation mechanism. It
22 works in conjunction with matrix diffusion.

23 Q. Those two processes then
24 are to be distinguished in terms of level of
25 significance at Site F from other attenuation



1 processes that we have heard are available?

2 A. They are particularly
3 significant at Site F.

4 Q. More so than other
5 attenuation mechanisms that might apply there?

6 A. I indicated in my evidence,
7 I think, that there are other attenuation measures.
8 For example, dilution is an attenuation mechanism.
9 Particularly if you adopt Trow's interpretation
10 to the hydrogeology at Site F and also when you
11 are dealing with organics, I think Trow spoke to
12 this and I also mentioned that you can get bio-
13 degradation as an additional attenuation mechanism.
14 They are a bonus over and above what I have been
15 talking about.

16 Q. I think that translates to
17 a yes. I was suggesting that at Site F, the
18 two most important mechanisms are matrix diffusion
19 and in the case of organics you have added to that,
20 adsorption.

21 A. That is correct.

22 Q. What you are telling us,
23 however, is there are a number of other attenuation
24 mechanisms that are likely to occur and in your
25 words would be a bonus to the processes you have



1 already described.

2 A. That is correct.

3 Q. Matrix diffusion and
4 absorption in that context are to be distinguished
5 from what you have described as a primary transport
6 system for contaminants; is that correct? In
7 other words, we should distinguish obviously between
8 primary attenuation mechanisms and primary transport
9 mechanisms?

10 A. Yes.

11 Q. Do I have it correctly that
12 the transport mechanism at Site F, you have indicated,
13 will be the flow of the groundwater through
14 fractures?

15 A. That is correct.

16 Q. That is advection
17 we have heard?

18 A. That is correct.

19 Q. I would like to spend just
20 a few moments, Dr. Rowe, with you and understand
21 the source of some of the material that you have
22 used and explain to the Board in talking about the
23 attenuation mechanisms at Site F.

24 Matrix diffusion is, according to
25 my information, not a new or recently discovered



1 phenomenon; is that fair?

2 A. I think that is entirely
3 fair and I indicated that in my report and in my
4 presentation of evidence, I think. Certainly,
5 back in the mid-1970's it was recognized as a
6 potentially important phenomenon.

7 Q. Is it associated by geo-
8 technical engineers with particular types of media?

9 A. Yes. When we talk about
10 it in the context of matrix diffusion, what we are
11 usually talking about, Mr. Chairman, is the
12 situation such as at Site F, where one has flow
13 through fractures and diffusion from the fractures
14 into the matrix of the material on either side.
15 It could be a clay material, or it could be rock,
16 in the case of shale on Site F.

17 Q. Is it regarded as being
18 more often a phenomenon in fractured rock environ-
19 ments as opposed to granular environments?

20 A. Definitely. Granular
21 environments, you wouldn't be concerned about it.

22 Q. You have referred in the
23 materials that you provided by way of overheads to
24 the Board, Dr. Rowe, in a number of cases, to
25 materials from Dr. Cherry's book on groundwater.



1 Do you recall that?

2 A. Yes.

3 Q. Do you recognize Dr. Cherry
4 as being a leading authority in the area of ground-
5 water movement?

6 A. Yes, I believe so.

7 Q. I am going to show to you,
8 I actually gave considerable consideration to this.
9 I didn't want to be the counsel in the room who
10 tendered yet another ...

11 DR. KINGHAM: This is the last
12 chapter in the book now, or is there still some
13 to come?

14 MS CRONK: To make it clear, the
15 Board has, in fact, received part of this extract
16 before, but it was not as complete a package as I
17 now require.

18 Q. Dr. Rowe, I am showing you
19 an extract from what I understand to be Dr. Cherry's
20 book on groundwater, beginning at page 388 and
21 continuing to page 413. I would ask, sir, that
22 that be the next exhibit.

23 MR. LANCASTER: Exhibit No. N-474.

24

25



1 --- EXHIBIT NO. N-474: Excerpt from Dr. Cherry's
2 book on groundwater

3 MS CRONK: N-474, sir?

4 MR. LANCASTER: N-474, yes.

5 MS CRONK: Q. I would ask you,
6 Dr. Rowe, to go to the first page of the exhibit,
7 which is an extract from that portion of Dr. Cherry's
8 book that deals with Transport Processes, at
9 Section 9.2. Do you see that?

10 A. I see that.

11 Q. Moving very quickly through
12 this, and Dr. Cherry, we keep referring to
13 Dr. Cherry, but there is a Mr. Freeze involved in
14 this effort as well, but the authors indicate that
15 the common starting point in the development of
16 differential equations to describe the transport
17 of solutes in porous materials is to consider the
18 flux of solute into and out of a fixed elemental
19 volume within the flow domain.

20 They go on to talk about:

21 "A conservation of mass statement..."
22 and set out the statement for determining that
23 value and go on to suggest:
24

25 "The physical processes that



1 control the flux into and out of
2 the elemental volume are advection
3 and hydrodynamic dispersion."

4 Stopping there for a moment, in
5 very simple, layperson's terms, for my benefit if
6 no one else's, is that simply saying what you
7 have already told us that the primary mechanisms
8 are, in fact, the flow of the groundwater,
9 advection and then the phenomenon known as
10 hydrodynamic dispersion?

11 A. That is correct.

12 Q. Hydrodynamic dispersion,
13 as I understand this passage from the book is
14 a result of both mechanical mixing and molecular
15 diffusion?

16 A. That is correct.

17 Q. The chemical process is
18 involved in diffusion, molecular movement, is that
19 fair?

20 A. That is correct.

21 Q. Can I ask you then, if you
22 would, to go to page 408. This is the section
23 I am particularly interested in dealing with
24 transport in fractured media. I direct your
25 attention to the first paragraph under that



1 section which reads:

2 "Although contaminant transport in
3 fractured geologic materials is
4 governed by the same processes as
5 in granular media -- namely, advec-
6 tion, mechanical dispersion,
7 molecular diffusion, and chemical
8 reactions -- the effects in fractured
9 media can be quite different."

10 Stopping there for a moment, do you
11 agree or disagree with that as a general observa-
12 tion?

13 A. True as a general observation.

14 Q. Continuing on:

15 "The effective fracture porosity
16 of fractured rocks and of consoli-
17 dated cohesive materials that are
18 fractured, such as jointed till,
19 silt, or clay, is normally very
20 small."

21 Do you agree with that?

22 A. That is correct, yes.

23 Q. Then, Dr. Cherry indicates
24 that values in the order of 1-0.001 per cent or
25 10^{-2} to 10^{-5} expressed as a fraction are not



1 unusual. I take that to be an indication that
2 those are the types, those are representative of
3 the very small values that he suggests are
4 observable as fractured porosities in fractured
5 rock.

6 A. You are asking me to agree
7 with that?

8 Q. Correct. (a) Have I
9 stated it correctly; and (b) Do you agree?

10 A. In general terms, I would
11 agree but I would qualify in that I am sure that
12 if Dr. Cherry were here he would indicate that
13 determining the porosity of fractured media is not
14 an easy thing to do.

15 Q. Let us leave aside what you
16 think Dr. Cherry might or might not say.

17 A. It is my opinion as well.
18 I am sure he would agree with me.

19 Q. Is it consistent with your
20 experience, Dr. Rowe, and in particular having
21 regard to work you have done with respect to Site
22 F, and the other professional studies that you
23 have conducted that in fact fractured porosities
24 in the fracture area are very small and the values
25 suggested by Dr. Cherry would not be unusual?



1 A. Certainly the fracture
2 porosity is going to be very small and I have no
3 problem with the range that he has expressed.

4 Q. Indeed, could I ask you to
5 go, if you would, please, to page 30 of your Site
6 F report and suggest to you that the ranges you
7 use in your own study of Site F are in fact ranges
8 described by Dr. Cherry. Do you have page 30
9 of your own report?

10 A. Page 30, I have page 30.

11 Q. Under Section 5.3 dealing
12 with fracture spacing and aperture size, you
13 indicated at the end of the paragraph that with
14 respect to the type of spacing of fractures that
15 you are discussing that corresponds to a range
16 of porosities between 0.0001 and 0.01. Is that
17 correct?

18 A. That is correct.

19 Q. Are those values, in fact,
20 not in the order of 10^{-2} to 10^{-4} ?

21 A. That is correct.

22 Q. Can I ask you to go to
23 Figure 20 of your witness statement.

24 A. Figure 20, the summary of
25 parameters.



1 Q. Looking particularly at the
2 fracture porosity figures, you again indicate a
3 range of 0.001 to 0.01. You indicate that the
4 value you actually used was 0.08 for matrix
5 porosity.

6 A. We are talking about matrix
7 porosity now, that is correct.

8 Q. For fracture porosity the
9 values you give are the very ranges suggested by
10 Dr. Cherry, are they not?

11 A. They correspond fairly well.
12 I looked at a case here, one case of 0.000025 in
13 addition. I want to just check Dr. Cherry's range.
14 He was 10^{-2} to 10^{-5} . This is 10^{-2} to 10^{-4}
15 and getting very close to 10^{-5} .

16 Q. Then continuing on with the
17 passage at page 408 of Dr. Cherry's book, he
18 indicates:

19 "Although the porosities are small,
20 the groundwater velocities can be
21 large."

22 Again, he is referring to fractured
23 media?

24 A. That is true. If you have
25 a very small porosity, you can have a large



1 groundwater velocity because, Mr. Chairman, as we
2 have heard in evidence, the groundwater velocity
3 is the Darcy velocity divided by the fracture
4 porosity, so if you divide a reasonably respect-
5 able looking number by a small number, you get a
6 large number.

7 Q. Could I ask you to go to
8 page 409, the next page and I direct your attention
9 to the second full paragraph in which, I suggest,
10 Dr. Cherry is contrasting dispersivity and
11 granular media versus fractured media, and he
12 indicates:

13 "It was indicated above that in the
14 mathematical analysis of mechanical
15 dispersion in granular media, the
16 media are assumed to be isotropic
17 with respect to dispersivity. That
18 is, longitudinal dispersivity at a
19 point in the medium has a single
20 value regardless of the direction
21 of the velocity vector. Each of
22 the transverse dispersivities has
23 a single value relative to the
24 longitudinal dispersivity. The
25 differences between longitudinal



1 and transverse dispersivities are
2 related to the mechanism of disper-
3 sion rather than to directional
4 properties of the medium."

5 Stopping there for a moment, I don't
6 purport to understand all that, but that is what
7 he is describing as the conditions applicable to
8 mechanical dispersion in granular material.

9 To continue on, he now begins to
10 discuss what happens in fractured geologic materials as
11 being something different. He indicates that in
12 those types of materials, that is fractured
13 materials

14 "...are notoriously anisotropic with
15 respect to the orientation and
16 frequency of fractures. It can be
17 expected that the dispersion of
18 solutes during transport through
19 many types of fractured rocks cannot
20 be described by the equations
21 developed for homogeneous granular
22 materials. Little is known about the
23 dispersion in fractured media."

24 With respect to his description of
25 what happens in fractured material, is that in effect



1 what you were trying to point out to the Board in
2 Figure 15, your overhead?

3 A. Figure 15 was illustrating
4 a blocky structure and I also, I think, referred to
5 Figure 17 which showed a section through this
6 blocky structure.

7 In particular it is a section
8 parallel to the direction of flow and what I was
9 trying to illustrate here, Mr. Chairman, was that
10 we don't expect the fractures all to be nice
11 parallel continuous fractures. We expect that
12 there may be some in that situation and there are
13 also going to be some that are dead-end fractures,
14 some that move around in all sorts of different
15 directions.

16 This can be expected to cause a
17 mixing of the contaminant as it moves along and
18 be manifest in the general way of dispersion.
19 Dispersion is a term, is a grab-all term for these
20 kinds of processes.

21 Q. Dr. Rowe, the point I am
22 interested to confirm at this point is simply this.
23 Dr. Cherry is indicating that what happens in
24 granular media, which I take to be relatively well
25 known, certainly the state of the art is more



1 developed with respect to media of that kind, than
2 it is in respect of fractured media.

3 A. That is true.

4 Q. That the conditions that
5 apply in that kind of media are not those that are
6 to be expected in fractured media. In fact, you
7 get a much different fracture system and type
8 of fracturing that one has to look at in terms of
9 advection and other processes in fractured media.

10 A. They are certainly different.
11 I think there are a number of issues in what you
12 are raising. One issue is a question of scale.
13 Obviously, if we have granular material, we have
14 some solid particles. The process of dispersion
15 tends to involve a number of things. Perhaps
16 I should go back a step.

17 I think this may have been explained
18 before, but dispersion in many ways is a term to
19 explain why contaminants spread more than you would
20 expect them to just considering advection alone.
21 If you just thought in terms of moving through a
22 granular material, they don't spread just the way
23 you think they would, if they were just carried by
24 groundwater velocity. Why do they not move in
25 that way? Well, there are a number of different



1 reasons that have been advanced.

2 Q. I am sorry, Dr. Rowe, before
3 we carry on very much further, can I ask you this.
4 Do you see the phenomenon of matrix diffusion in
5 granular media given what you just said in the same
6 way that you see in fractured media?

7 A. No.

8 Q. Isn't that, in fact, because
9 of the kind of distinction that Dr. Cherry is
10 drawing at page 409?

11 A. That is part, yes.

12 Q. Could I ask you now to go to
13 page 411 with me.

14 Now, at page 411, Dr. Rowe, as I
15 see it, the diagram, Figure 9.15 set out there is
16 in fact, the diagram that you provided to the Board
17 as Figure 8 on your overheads?

18 A. That is correct and which I
19 took from Cherry's report, but originally came
20 from here.

21 Q. Dr. Cherry indicates in his
22 description of it beginning at the first paragraph
23 that when contaminants occur in fractures, there
24 is a gradient of contaminant concentration between
25 the fracture fluid and the fluid in the unfractured
material adjacent to the fracture. If the



1 solid matrix is porous, a portion of the contaminant
2 mass will move by molecular diffusion from the
3 fracture into the matrix. This mass is therefore
4 removed, at least temporarily, from the flow regime
5 in the open fracture.

6 That is simply a textual description
7 of what you were trying to show in your Figure 15?

8 A. That is correct.

9 Q. Then, perhaps to abbreviate
10 this, Dr. Rowe, I would ask you to look at the
11 next paragraph over to the top of page 412, in
12 which Dr. Cherry describes what is happening in
13 Figures (b) and (c), Figure 9.15.

14 A. Would you like me to read
15 it aloud?

16 Q. No just read it to yourself.
17 I would ask you to go back and take
18 a look at the (b) part of Figure 9.15. That,
19 as I understand it, is illustrating the principle
20 of matrix diffusion, adsorption does not occur.

21 A. That is correct.

22 Q. Dr. Cherry indicates, with
23 respect to that phenomenon, I suggest, that the
24 effect of it is simply to reduce the concentration
25 in the fracture, the concentrations gradually



1 diminish in front of the contamination zone.

2 A. That is correct.

3 Q. So, when you just have
4 matrix diffusion, what you are going to get is a
5 natural reduction of the contaminants that would
6 otherwise be in the fractures?

7 A. That is correct.

8 Q. (c) however, of Figure 9.15,
9 is an example of something else, and you referred to
10 it at the beginning of our discussion. That is
11 the situation where you have matrix diffusion
12 coupled with adsorption?

13 A. That is correct.

14 Q. That discussion is at the
15 top of page 412 and as I understand the distinction
16 what Dr. Cherry is saying is that in the circum-
17 stances of Figure (c) you will get the reduction
18 in contaminants that occurs because of matrix
19 diffusion but you will get additional or further
20 reduction as a result of adsorption and that is
21 what you have been telling the Board?

22 A. That is correct.

23 Q. Then, finally, with respect
24 to that issue, Dr. Rowe, another exhibit was put
25 to the Board some months ago through another



1 witness. It was an extract from Dr. Cherry's
2 book as well. I am referring to Exhibit N-204,
3 Mr. Chairman.

4 A. I have N-204 in front of me.
5 It is a copy of page 258 of Freeze & Cherry; is
6 that correct?

7 Q. Yes.

8 As I understand the nature of your
9 opinion and the evidence you have given to the
10 Board, Dr. Rowe, it is in essence this, and I
11 would ask you whether this is a fair statement of
12 it.

13 You have said that because of the
14 fracturing environment at Site F, first matrix
15 diffusion will occur; is that correct, you are
16 nodding your head?

17 A. Yes, at Site F, that is
18 true.

19 Q. The effect of that process
20 will be to severely reduce and to retard the
21 concentrations of contaminants in the fractures at
22 that site?

23 A. That is correct

24 Q. As well, we might have
25 adsorption occur as part of the process that would



1 further reduce the concentrations of contaminants
2 in the fractures?

3 A. That is right.

4 Q. Does it follow from that
5 then, that the more fractures there are in the
6 environment at Site F, the better from an attenua-
7 tion perspective?

8 A. Oh boy, that is ...

9 Q. Let me try to make it a
10 little clearer than. There are no boreholes, as
11 I appreciate the evidence, that extend beyond 30
12 metres into the shale at Site F.

13 A. That is correct.

14 Q. That is correct. There is
15 evidence of fracturing in the depth of the ground
16 that has been tested at Site F with frequent
17 intervals.

18 A. Yes.

19 Q. There is, however, no
20 evidence before the Board of which I am aware, to
21 indicate the extent of fracturing below that
22 depth, below 30 to 40 metres.

23 A. That is my understanding.

24 Q. Were the deeper shale to be
25 highly fractured, would that have the necessary



1 result of enhancing attenuation properties that
2 you have been talking about because of the process
3 of matrix diffusion?

4 A. I know you would like a
5 simple answer to that question, but there isn't a
6 simple answer. The extent of attenuation
7 depends not only on the fracture spacing, but also
8 on the Darcy velocity. If there were more
9 frequent fractures spacing at depth for the Darcy
10 velocities I have looked at, that would not cause
11 me any concern. I think that is the intent of
12 your question; am I correct?

13 Q. Well, indeed wouldn't it,
14 in fact, be the reverse. Then it would not cause
15 you concern but it would lend you comfort in
16 terms of matrix diffusion process you have des-
17 cribed because it would mean the movement through
18 fractures and the process of matrix diffusion would
19 continue.

20 A. Within the context you are
21 posing the question, that is yes, but one has to
22 be very careful, Mr. Chairman, because one can
23 extrapolate this to the ridiculous. I would not
24 suggest that to have the material that has a lot
25 of fractures is in general better than having material



1 that has no fractures at all. If you have a very
2 intact tight shale which will therefore have a
3 very low hydraulic conductivity and therefore you
4 expect very low flows through it, that is also ...
5 So, you have also got to look at the fracturing and
6 what the flow is through the system.

7 Q. Perhaps you have anticipated
8 my point.

9 Can we deal then with the first
10 supposition. That is, that in fact at depth at
11 Site F, were information in the very deep shale to
12 be available, and were it to show extensive
13 frequent fracturing, that would not cause you any
14 discomfort having regard to the matrix diffusion
15 process you have described?

16 A. It would not.

17 Q. It would mean, would it not,
18 that contaminants moving through that deep shale
19 would be attenuated in the same way that they
20 would moving through the fractured systems at
21 higher heights?

22 A. That is correct.

23 Q. Let us then look at the
24 situation you have anticipated and that is the
25 situation where, in fact, there is not frequent



1 fracturing at depth at Site F. My suggestion
2 with reference to Exhibit 204 is that Dr. Cherry
3 suggests that in those circumstances, in unfractured
4 shale, groundwater cannot move at rates greater
5 than a few centimetres per century. Do you agree
6 with that?

7 A. That number seems intuitively
8 reasonable.

9 Q. That being the case, given
10 that the flow of groundwater advection is what you
11 have described as the primary transport system for
12 contaminants at Site F, doesn't that mean that if
13 the deep shale at Site F is not fractured, there is
14 no reason to be concerned about contaminants,
15 because it is not going anywhere for centuries.

16 A. That is the point I was
17 trying to make.

18 Q. In respect of the discussions
19 set out at page 158 of Dr. Cherry's book, in
20 essence, is that a fair representation of precisely
21 what he is saying?

22 A. Before I comment, I would
23 like to read it.

24 Yes, I agree with what he says
25 in the upper part of page 158.



1 Q. Dr. Rowe, isn't that
2 precisely what we have been discussing?

3 A. It is indeed.

4 Q. Are we then in the situation
5 that regardless of the fracturing characteristics
6 of the deep shale at Site F, there is on the one
7 hand, attenuation processes that will work to
8 protect against contaminant migration and on the
9 other hand, virtually no movement at all which will
10 protect against contaminant migration.

11 A. Yes, you have those two
12 possibilities and the additional factor of the very
13 poor water quality.

14 Q. Now, Dr. Rowe, all of the
15 evidence that you have given with respect to your
16 modelling efforts and analysis at Site F, as I
17 understand it, concerns what will happen with the
18 contaminants that move with the leachate from the
19 landfill south from the landfill down the site.

20 A. That is correct.

21 Q. That means, does it not,
22 that all of the modelling effort that you have
23 done and the considerations you have given applies
24 only to that percentage of leachate that escapes
25 the leachate collection system at Site F.



1 A. That is correct.

2 Q. Do I understand correctly
3 from what you have said to the Board, that when
4 you examined Trow's "better-fit model" it in
5 fact demonstrated that less than one per cent of
6 the leachate to be generated off Site F, would
7 escape that under-drain collection system?

8 A. Based on their better-fit
9 model, that is correct.

10 Q. And the original model,
11 the capture efficiency of the under-drain system
12 was expressed to be about 95 per cent?

13 A. That is correct.

14 Q. So, what we had originally
15 on Trow's work was an escape factor of five per
16 cent. Is that what we are talking about?

17 A. Yes, that is where that five
18 per cent came from.

19 Q. Then, when they did their
20 better-fit model, the actual mathematics, when you
21 work them out, of what they did in that model
22 indicate that less than one per cent of the leachate
23 will escape that system?

24 A. That is correct.

25 Q. You did your own modelling



1 at Site F, and am I correct the results of your
2 modelling confirm that one per cent number and in
3 fact, it will be less than that?

4 A. Yes, for the range of Darcy
5 velocities, Mr. Chairman, I think applicable to
6 Site F, is less than one per cent.

7 Q. Whichever of the velocities
8 you used, I think you indicated it was 0.3 or
9 0.8.

10 A. That is correct.

11 Q. In all of the modelling
12 work that has been done and presented to the Board,
13 in all the discussion about contamination migration
14 at Site F, what we are talking about in each
15 instance is less than one per cent of the leachate
16 and therefore of contaminants moving out from that site.

17 A. Yes, looking at Trow's
18 better-fit model and the results I presented, yes,
19 that is correct.

20 Q. Having said that, is it the
21 nature of your evidence that with respect to that
22 one per cent under any of the scenarios you looked
23 at you need have and the Board need have no
24 concern regarding negative impact on groundwater
25 sources?



1 A. That is correct.

2 MS CRONK: Mr. Chairman, would
3 it be an appropriate time to take a break?

4 MR. LANCASTER: All right, we will
5 do that.

6
7 --- Recess

8
9 MR. LANCASTER: Thank you, please
10 be seated.

11 DR. KINGHAM: Before we get
12 started, I wonder, Dr. Rowe, were you trying to
13 tell us that your concern about increased fracture
14 spacing might increase the Darcy velocity which
15 would be a counterbalancing effect to the attenua-
16 tion and at the same time, the increased fracture
17 spacing would lead to increased attenuation.
18 Is that the dilemma you are wrestling with?

19 DR. ROWE: The dilemma I was
20 wrestling with is I wouldn't want to look at fracture
21 spacing in isolation, you have to look at fracture
22 spacing and what the flow is. The two things go
23 hand in hand.

24 DR. KINGHAM: I think I understand.

25 MS CRONK: Q. Let me make sure I do.



1 If there are then, a large number of fractures at depth
2 at Site F, and were that to lead, as you suggest it
3 will, to variation in the velocities, do you
4 anticipate that would make any difference to the
5 contaminant migration assessment that you have
6 made.

7 DR. ROWE: A. If the velocity is
8 in the range I considered in my Site F report for
9 the shallow region, it would make no difference.

10 Q. Is there any evidence of
11 which you are aware, or any basis in any of the
12 reports and data you have reviewed to suggest that
13 there are large fractures at depth? Is there
14 any evidence of that at all?

15 A. I don't believe there is
16 evidence there. What has been suggested is
17 that the flow would get smaller. The permeability less
18 at depth. I am not aware of any evidence,
19 measurements at depth.

20 Q. So, the evidence is to the
21 contrary, the data is to the contrary?

22 A. That is correct.

23 Q. Dr. Rowe, are you familiar
24 with the interim guidelines of the Minister of
25 the Environment on engineered facilities at landfill



1 sites?

2 A. Yes, you are referring
3 specifically to this exhibit.

4 Q. No, I don't believe they
5 are yet before the Board. They are called
6 Interim Guideline on Engineered Facilities at
7 Landfills, by the Ministry of the Environment

8 A. I think I know what you are
9 referring to -- dated July 13, 1987, is that the
10 document? I have a document, "Ministry Interim
11 Guideline on Engineered Facilities at Landfills"
12 dated July 13, 1987.

13 Q. Yes, have you considered the
14 content of these guidelines with respect to Sites
15 D and F?

16 A. Yes, I have.

17 MR. LANCASTER: Excuse me,
18 Mr. Tidball?

19 MR. TIDBALL: Mr. Chairman, I don't
20 know what Ms Cronk is proposing to do with these.
21 The document that I see in front of me is something
22 that I have seen. It is entitled "Ministry
23 Interim Guideline" and in fact they are guidelines
24 that are used, I guess to be fair, used somewhat
25 at an internal level. They are presently within



1 the policy development process of the Ministry and
2 at present they are not official by any means.
3 It has always been my understanding that they have
4 not been circulated within the broader community. That
5 is beyond the Ministry of the Environment. I
6 don't know whether to even object at this point.
7 It really does depend on what Ms Cronk wants to
8 do with it.

9 MS CRONK: Let me clarify that.

10 It is my information that these are
11 the interim guidelines that the Ministry of the
12 Environment uses with respect to the engineering
13 component of proposed landfills. That they
14 are in place, that they are available to consult-
15 ants in the field. They are not before you yet,
16 but the other Ministry of the Environment guide-
17 lines with respect to landfills are and other
18 government guideline policies are.

19 In my submission, they are highly
20 relevant to an assessment of the engineering of
21 these two sites and I think they should be before
22 you. Indeed they came to my attention only very
23 recently and had I known they existed prior to that,
24 I would have placed them before you, tendered them at
25 a much earlier date. I think they are appropriate



1 and relevant for you.

2 MR. ESTRIN: I had not seen that
3 document prior to essentially now myself. On
4 the other hand, I have looked at a copy, Ms Cronk
5 informed me she had a copy. They are dated in
6 July and I am informed that they are circulated
7 or have been circulated to consultants.

8 If there is -- one has to assume
9 that the fact they have been published in July
10 and circulated to consultants, the natural infer-
11 ence has to be, the natural conclusion has to be
12 that they are being used by some persons within
13 the Ministry to adjudicate upon the applicability
14 of applications that are pending. I think the
15 Board can get a better idea when they look at these
16 before they decide what the official ruling is.
17 There is, in fact, something in there that would
18 clearly confirm that that is the intention of
19 these guidelines, to assist the Ministry as well
20 as consultants or proponents in terms of what it
21 is that the Ministry, at least at this point in
22 time thinks about and has concerns about with
23 respect to engineered facilities.

24 Unless Mr. Tidball is prepared to
25 say that the document that Ms Cronk is intending to



1 use here has no applicability, has never been used,
2 is not intended to be circulated and that the
3 Ministry has no guidelines whatsoever with regard
4 to engineered facilities, then I think we have to,
5 at least, put the document in and examine witnesses
6 with regard to it.

7 If he is prepared to go that far,
8 fine. If he is prepared to tell the Board, let
9 me put it another way. If he is prepared to
10 tell the Board this is not a Ministry document,
11 this is not a guideline that is being used and that
12 it has been retracted and has no validity and
13 won't be applied in this case by any Ministry
14 officials in this case in respect to their opinion
15 in this matter at all, fine, let him retract it.
16 Otherwise ...

17 MS CRONK: Mr. Chairman, I am not
18 sure, with respect to both my friends, that bold an issue.
19 It is my submission to you that they are internal
20 guidelines that would be of assistance to you and
21 are highly relevant. I understand from my friend
22 Mr. Tidball that one of the witnesses that he
23 intends to call when it is his turn to call
24 evidence, is in fact, the author of these documents
25 and their status and their application can be



1 explored with him at that time. My difficulty,
2 of course, is that these two witnesses will have
3 been long gone by then and I certainly would like
4 to avoid a situation that I have to seek from
5 the Board a recall of the witnesses to obtain
6 Dr. Rowe's views as a geotechnical engineer.

7 I support in general terms many of
8 the things that Mr. Estrin said but I wish no
9 inference to be left that I think there is fault
10 in this. I am saying I didn't know, I now do.
11 I think they are relevant and I think they should
12 be entered.

13 MR. LANCASTER: Mr. Tidball, do you
14 still have an objection?

15 MR. TIDBALL: There are a couple
16 of things I want to add because I really want to
17 speak to a couple of things that Mr. Estrin said,
18 Mr. Chairman.

19 I don't have a great problem
20 with them coming in, but I think they will have to
21 come in with the proper explanation.

22 As Ms Cronk says, I propose to call
23 the author of these. I can tell you right now,
24 the author of these is going to say ...
25

MS CRONK: Excuse me, Mr. Chairman,



1 I am not sure I am in a position I want to hear
2 Mr Tidball's evidence.

3 MR. TIDBALL: I will tell you
4 exactly my understanding of the status of this
5 document.

6 My understanding of the status of
7 this document is that this document has no official
8 status and that is what the author will say.
9 When you read these, or if you read these, you
10 will know that from our point of view it is
11 simply a matter of common sense and Mr. Estrin,
12 I sort of get the impression, throws down the gauntlet
13 and says I am prepared to abandon these.

14 What is in there is simply common
15 sense and in large part has been the Ministry's
16 practice over the years. This document is an
17 attempt to try to codify this practice for the
18 use of Ministry staff. This document has not
19 been published as Mr. Estrin suggests and the
20 fact it was printed does not make it published.
21 It was not circulated to the consultant community.
22 To the extent the consultant got a copy of it,
23 he shouldn't have and he shouldn't have put it
24 before this Board. They are here and that's
25 fine. If it goes in, and I think you have to



1 understand that it is under those terms and
2 understand that Dr. Hughes will be coming along
3 sometime later and can speak to them. All I
4 can tell you is that from the point of view of
5 the Ministry of the Environment, it doesn't have
6 any official status whatsoever.

7 MS CRONK: Mr. Chairman, I can make
8 some points. I detect some current of offence.
9 I know my remarks and Mr. Estrin's remarks were
10 not intended that way.

11 May I make two comments? It is
12 my understanding and indeed the source from which
13 I obtained the document was through the consulting
14 community. They have been made available. I
15 know Mr. Tidball will make further inquiries if he
16 thinks that is appropriate to do. They are
17 certainly in the hands of a number of consultants
18 and that is how I obtained them.

19 If they are being used at all, if
20 they are being used internally, they have relevance
21 to you in the deliberations of this hearing.

22 Having said that, I remind the
23 Board that we received the Ministry of the
24 Environment's Reasonable Use Policy without a
25 representative of the Ministry putting them in



1 context and explaining it or introducing it. We
2 have received the Food Land Guidelines the same
3 way. I understand the distinction Mr. Tidball
4 is making between "official and unofficial" but
5 I understand there has been no Ministry official
6 here to explain and introduce it "properly."

7 My suggestion is I simply wish to
8 deal with it now so that the evidence of these two
9 witnesses may be heard on it before they are gone.
10 I don't want to be in a situation where next June
11 I will be asking the Board to recall the witnesses
12 so as I can obtain the engineering opinion on it
13 as I believe we would then be entitled to. I
14 didn't understand Mr. Tidball to be objecting.
15 He said he was simply explaining the status of the
16 document. I don't understand him now to be
17 objecting except to some of the remarks that some
18 of the legal counsel have made.

19 MR. LANCASTER: It seems that
20 Ministry policy -- the Food Land Guidelines were
21 in limbo for quite a few years.

22 The Board will accept it with the
23 explanation of Mr. Tidball.

24 MS CRONK: Thank you, Mr. Chairman.

25 MR. LANCASTER: Exhibit N-475.



1 --- EXHIBIT NO. N-475: Document entitled "Ministry
2 Interim Guideline on
3 Engineered Facilities at
4 Landfills (July 13, 1987)"

5 DR. KINGHAM: Are you going to call
6 this N-475, or E-475. You would rather have an
7 "N" Mr. Tidball.

8 MS CRONK: So, would I.

9 Q. Dr. Rowe, as I understand
10 it, these Interim Guidelines on their face, are
11 expressed to apply to the assessment of new land-
12 fills or landfills requiring expansion.

13 I would refer you in that regard to
14 page 6, the concluding paragraph.

15 DR. ROWE: A. Yes, page 6 says:

16 "These guidelines apply to the
17 assessment of new landfills or
18 landfills requiring expansion."

19 Q. They are dated, as we
20 indicated earlier, July 13, 1987?

21 A. That is correct and perhaps
22 I should point out to the Board that I received
23 this document only a couple of days ago from
24 Ms. Cronk.

25 Q. Looking at page 6 on the



1 bottom in the left-hand corner, that too bears
2 a date of July 13, 1987 and the initials GH/bt.

3 A. GH/bt is correct.

4 Q. And it is dated July 13,
5 1987?

6 A. That is correct.

7 Q. Could I ask you to look, if
8 you would, please, at the first page, and may we
9 briefly go through the guidelines. I am going to
10 invite your views as to the relevancy of some of
11 the comments contained in the guidelines with
12 respect to Sites F and D.

13 In the first paragraph, the first
14 statement is as follows:

15 "Some level of engineering is
16 necessary for all modern landfills
17 that receive hazardous or domestic
18 wastes, both for the protection of
19 the environment and for aesthetic
20 reasons from the discharge of
21 unacceptable levels of liquid and
22 gaseous contaminants."

23 That, I take it, Dr. Rowe, to use
24 Mr. Tidball's words of a few moments ago, is
25 common sense. In any event, it would be



1 a generally recognized fact, I suggest.

2 A. Yes.

3 Q. Continuing on in that
4 paragraph, it reads:

5 "The specific engineered facilities
6 that are required on a particular
7 landfill depend on the environmental
8 conditions that are present and the
9 type of waste, and thus can only be
10 judged on a case-by-case basis."

11 Stopping there for a moment again.

12 With respect to the approach, judging the
13 appropriate environmental conditions for landfills
14 on a case by case basis, I suggest that too is
15 perhaps a common sense approach?

16 A. I would agree.

17 Q. As distinct from articulating
18 or laying down any general fixed guidelines that
19 are to apply across the board to all landfills?

20 A. I would agree.

21 Q. The latter would be, I sug-
22 gest an inflexible process which might lead to very
23 severe constraints as conditions change from time
24 to time?

25 A. I agree.



1 Q. The term "engineered
2 facilities" is referred to in that section of the
3 document, Dr. Rowe.

4 I would ask you to go to page 5
5 and explore with me, the meaning of that term as
6 it is used in these interim guidelines. I would
7 direct you to the section of the document entitled
8 "Scope of the Term Engineered Facility" and do you
9 see that?

10 A. I see that.

11 Q. Am I correct that that
12 section of the document indicates that the guide-
13 lines apply to all engineered facilities associated
14 with the control of contaminants produced from
15 landfills? It is a general statement, that is
16 the apparent expressed intent of the document?

17 A. That is correct.

18 Q. In addition to that the
19 document goes on to specifically identify types
20 of engineered facilities that are to be governed
21 by these interim guidelines?

22 A. That is correct.

23 Q. They include, do they not,
24 the design, installation and maintenance of such
25 items as leachate collection systems, monitoring



1 facilities and leachate treatment facilities.

2 A. That is correct.

3 Q. There are a number of other
4 items set out there, but is it fair to suggest
5 basically, Dr. Rowe, that any engineering component
6 of a landfill designed to deal with or control
7 contaminants is considered to be within the scope
8 of an engineered facility as that term is used
9 in the guideline?

10 A. That would be my interpreta-
11 tion.

12 Q. Specifically, if we look
13 over at page 6, item (g), that is included in the
14 definition of that term, speaks to the control of
15 contaminated groundwater and engineering facilities
16 for that purpose, purge wells and the like.

17 A. That is right.

18 Q. Can we go back then,
19 please, to page 1? I would direct your attention
20 to the second full paragraph which reads:

21 "It is the Ministry's position that
22 there are limitations to engineered
23 facilities and it prefers sites in
24 environments with characteristics
25 that provide a high degree of



1 natural protection (eg. thick clay
2 deposits)."

3 -Stopping there for a moment, I inter-
4 pret that and read that to mean that the Ministry
5 is of the view that landfill sites that require
6 the least engineering possible are preferable.
7 Do you agree?

8 A. I would agree.

9 Q. And that there is expressly stated
10 a preference by the Ministry for landfill sites
11 that have what I would call naturally high atten-
12 uation capabilities?

13 A. I would agree.

14 Q. So that in that context, a
15 high degree of natural protection means a high
16 degree of natural attenuation. Would you agree?

17 A. That is my interpretation.

18 Q. There might be some other
19 aspect of it, but it would certainly extend to the
20 attenuation capability of the proposed site?

21 A. That is correct.

22 Q. Do either of the sites, D
23 or F, Dr. Rowe, have thick clay deposits as you
24 understand that term?

25 A. Neither site has what I would



1 call a thick clay deposit.

2 Q. In your opinion, however,
3 does Site F have a high natural attenuation
4 capability?

5 A. In my opinion, yes.

6 Q. Is it in your opinion,
7 higher than that at Site D?

8 A. Yes.

9 Q. Dr. Charlesworth, in your
10 opinion does Site F have a high natural attenuation
11 capability?

12 DR. CHARLESWORTH: A. Based on
13 the modelling that we have seen on matrix diffusion,
14 yes, it does have a high degree of attenuation
15 capability.

16 Q. Apart from the modelling and
17 the matrix diffusion modelling that Dr. Rowe did,
18 does your understanding of the natural materials
19 at Site F and the process generally of matrix
20 diffusion, assist you in determining, in your own
21 mind as a hydrogeologist, whether you would
22 classify the site as being one with a high natural
23 attenuation capability?

24 Do you understand the question?

25 A. Maybe you could ...



1 Q. I apologize. What I am saying
2 is set aside the results of any modelling that Dr. Rowe
3 did, does a hydrogeologist simply looking at
4 your understanding of the materials that are there,
5 and recognizing the various attenuation processes
6 that apply at the site, in your professional
7 judgment, is there a high attenuation capability
8 at Site F?

9 A. Apart from the aspects of
10 matrix diffusion that Dr. Rowe referred to, I have
11 based my assessment of Site F, I looked primarily
12 at the poor quality of the groundwater and the
13 significance of that in terms of the effects of
14 leachate on the groundwater, but I have not
15 specifically looked at its high attenuation capability,
16 but I think that Dr. Rowe has raised the idea and
17 illustrated with some confidence that matrix
18 diffusion affords a higher attenuation capacity
19 at Site F, so I would say yes on that basis.

20 Q. Thank you, Dr. Charlesworth.

21 Dr. Rowe, you indicated that Site F
22 had, in your view, a higher natural attenuation
23 capability than Site D; do I have that correctly.

24 A. That is correct.

25 Q. Under that criteria then,



1 that is a stated preference for a high degree
2 of natural protection, in your view, is there a
3 preference for Site F or Site D in recognition
4 of that kind of a position?

5 A. Keeping in mind what I have
6 just said and keeping in mind where there are and
7 are not water users, I believe there is a preference
8 for Site F.

9 Q. I would ask you to look
10 at the next paragraph of the document which relates
11 to the Ministry's reasonable use policy.

12 Perhaps you should take a moment
13 to read it if you wish, but I would suggest it
14 simply confirms that policy sets out discharge
15 criteria that are to apply with respect to the
16 discharge of contaminants, groundwater contaminants
17 from a landfill.

18 A. That is correct.

19 Q. It indicates further that
20 in accordance with the reasonable use policy,
21 some type of engineered facilities will be permitted
22 to meet the criteria set out under that policy
23 document?

24 A. Yes.

25 Q. Moving on to the Position



1 Statement section of the document, that is the
2 remainder of page 1 and for the record, it indicates:

3 "Until a final policy is developed
4 ..."

5 Perhaps I could stop there. The
6 language suggests, as Mr. Tidball indicated, this
7 is an interim policy document and the final policy
8 is in the process of being reviewed and perhaps
9 developed as the language suggests.

10 A. Yes.

11 Q "... the acceptability of
12 an engineered facility for a new
13 landfill or a landfill that is
14 expanding will be judged in accord-
15 ance with the following:"

16 Perhaps we can take this in part.

17 "An engineered facility must
18 function as long as necessary for
19 the protection of the environment."

20 I suggest that is simply a general
21 statement recognizing that the time limit for the
22 functioning of the site will be directly related
23 to its impact potential.

24 A. Yes, I would agree.

25 Q. If there is a continuing



1 need to protect the environment, then the life
2 of the facility must meet that.

3 A. Yes, that is true.

4 Q. Continuing on:

5 "If periodic or continuous mainten-
6 ance or replacement of an engineered
7 facility or its parts is required,
8 evidence must be provided by the
9 applicant that this can and will be
10 accomplished."

11 Stopping there that section in the
12 Position Statement is directed to maintenance or
13 replacement.

14 A. Yes.

15 Q. It attaches, does it not,
16 an onus on the applicant or the proponent of the
17 landfill to demonstrate that the maintenance or
18 replacement that may be required can, in fact, be
19 accomplished.

20 A. Yes.

21 Q. I take it from that it must
22 be practicable then?

23 A. Yes, I would understand it
24 to mean that.

25 Q. Am I also correct that would



1 involve a consideration of whether or not the
2 proposed maintenance program will, in fact, work
3 from an engineering point of view.

4 A. That is an important part,
5 yes.

6 Q. Continuing on in the
7 Position Statement:

8 "It is the applicant's responsi-
9 bility to define the service life
10 of an engineered facility and to
11 indicate the frequency of replace-
12 ment and the number of times it must
13 be replaced."

14 Again, that attaches or imposes an
15 obligation on the applicant.

16 A. It does.

17 Q. It further introduces the
18 concept of the service life of the facility.

19 A. It does.

20 Q. I would read that to mean,
21 Dr. Rowe, and please tell me if you disagree, that
22 the concept of service life is directly related
23 to the engineered facility.

24 A. That is my interpretation
25 of it.



1 Q. For example, we know from
2 the definition of engineered facility that it
3 includes leachate collection systems.

4 A. Yes, that is my interpreta-
5 tion.

6 Q. The service life of the
7 facility in that context is the service life of,
8 for example, the leachate collection system that
9 was proposed.

10 A. That is one component.

11 Q. A monitoring program would
12 be another?

13 A. Yes.

14 Q. Continuing on:

15 "In so doing, the applicant must
16 address the contaminating lifespan
17 (i.e. the time period during which
18 the landfill will produce contamin-
19 ants at levels that could have an
20 unacceptable impact if they were to
21 be discharged into the surrounding
22 environment) of the landfill.
23 Equate this with the service life
24 of the proposed engineered facility,
25 and support any procedures he intends



1 to use to ensure that the service
2 life of the facility exceeds the
3 contaminating lifespan of the
4 landfill."

5 Can we stop and examine that for
6 a moment in some detail? We have seen earlier
7 that the concept of the service life of the
8 engineered components of the landfill was intro-
9 duced and now we have introduced, do we not, the
10 concept introduced of the contaminating landfill.

11 A. We do.

12 Q. That appears to relate to
13 the landfill, not the engineering component of
14 the landfill.

15 A. That is my interpretation,
16 yes.

17 Q. The definition of the
18 concept of contaminating lifespan is directed, I
19 suggest, to the issue of how long contaminants
20 will be produced at levels of concern to the
21 environment.

22 A. That is my understanding.

23 Q. Could I ask you to keep
24 that out for the moment and go to Figure 60 in
25 your witness statement.



1 A. I am, for the record, putting
2 up Exhibit M-44-0H60A.

3 Q. That overhead you have
4 explained previously to the Board, Dr. Rowe, sets
5 out the length of time the leachate collection
6 system must function in your view based on the
7 work that you performed and your judgment.

8 I direct your attention to the last
9 table on the far right of the page entitled
10 "Time".

11 A. Yes.

12 Q. And the three asterisks
13 which you have indicated beside that column we
14 see from the bottom of the overhead indicate that
15 the leachate collection system must function --
16 I am sorry, the time the leachate collection system
17 must function to reduce the boundary impact to
18 the value stated.

19 My question to you is this: putting
20 that overhead in the context of the principles
21 contained under the interim guidelines, were you
22 expressing yourself in the time column to the
23 service life of the engineered facility at
24 Site D or to the contaminating lifespan of the
25 landfill at Site D? Can you relate those numbers



1 now to those concepts.

2 A. The numbers given in the
3 right-hand columns of this exhibit relate to the
4 contaminating lifespan of the facility. In other
5 words, that is how long I believe the engineered
6 facilities have to operate before the impact off-
7 site will be at levels less than indicated on the
8 right-hand side of that overhead.

9 Q. I wish to be very clear.
10 Are you saying that the times indicated on the
11 overhead are the times which you say, during which
12 you say contaminants will be produced at Site D
13 at levels sufficient to be concerned?

14 A. Based on the assumed initial
15 concentrations, yes.

16 Q. Forgive me, but your
17 asterisk at the bottom of the overhead appears to
18 suggest something different. It seems to suggest
19 that the times were directed towards the facility
20 itself, the engineered facility, or is that just
21 a question of language?

22 A. It is perhaps a question of
23 language but these here are indicating how long,
24 based on my calculations, it would be for the impact
25 to be less than those values indicated at the top



1 of the table be it 25 milligrams per litre or 10
2 milligrams per litre. Although, I haven't
3 seen this document at the time my thinking was
4 I think in accordance with what is expressed in
5 this document, if this is the contaminating life-
6 span of the landfill, then your engineering
7 facilities should be such that it can survive that
8 long.

9 Q. In fact, if we look to the last
10 sentence on page 1 of the interim guidelines, it
11 suggests that the service life of the facility
12 must exceed the contaminating lifespan of the land-
13 fill, does it not?

14 A. Yes.

15 Q. That indeed the applicant of the
16 landfill proposal must ensure that the service
17 life will exceed the contaminating lifespan?

18 A. That is what it says.

19 Q. Does it follow from that
20 then that the time during which the hydraulic trap
21 at Site D as the leachate collection system must
22 operate are times in excess of those shown on your
23 overhead 60?

24 A. That would be my interpreta-
25 tion.



1 Q. Looking at the range of times
2 that you set out as being the contaminant
3 generation times, if I can express it that way,
4 the rate I suggest is anywhere from 50 years at
5 the lower end, to 80 years or more at the higher
6 end.

7 A. That is correct.

8 Q. So that if indeed contaminant
9 concentrations are produced at Site D for that
10 length of time, then the hydraulic trap must
11 function for at least that period of time and longer
12 if we take into account the provisions of these
13 interim guidelines.

14 A. That is correct.

15 DR. KINGHAM: Dr. Rowe, I had
16 difficulty understanding this before and now your
17 answer to Ms Cronk, I am not sure if it has
18 clarified it or made it more difficult.

19 I think I understood you to say it
20 had to function for those numbers of years after.

21 DR. ROWE: What I am looking at
22 here is I am asking, my starting point in a sense,
23 Dr. Kingham is what is acceptable at the boundary
24 of the property. Given as a starting point that
25 25 milligrams per litre would be acceptable,



1 the question then is how long would it be before the
2 concentrations in the leachate in the landfill are
3 reduced to a point that if they were to escape into
4 the environment by the time they reached the site
5 boundary, they would have attenuated to the level,
6 in this case, of 25 milligrams per litre. So, I
7 am in essence going in reverse through the calculations
8 saying suppose we can accept 25 milligrams per
9 litre per boundary, how long will it take, and
10 perhaps it might help if I was to place exhibit,
11 overhead 53 up.

12 This is showing, I will take off
13 Exhibit 60 for the moment. This is showing the
14 concentration in the leachate varying with time.
15 The impact at the site boundary is dependant upon
16 what the concentration is in the leachate at the
17 time failure occurs.

18 If we were to have, say 1,500, it
19 would fail instantaneously as soon as the leachate
20 built. We would have impacts based on my cal-
21 culations as high, more than 1,200 milligrams per
22 litre in the worst case.

23 However, if the failure doesn't
24 occur instantaneously, if the system operates for
25 a period of years, during that time the concentration



1 would decrease and let us suppose that it was to
2 fail at sometime, just for the sake of convenience,
3 at 25 years based on Trow's projections, then the
4 initial concentration would be 200 milligrams per
5 litre. That would have an impact greater than
6 25 milligrams per litre at the boundary.

7 So, what I am asking myself is, how
8 far does this have to be reduced to before the
9 impact at the boundary is less than 25 milligrams.
10 Then, what is the time required to reduce that
11 level.

12 DR. KINGHAM: I think I understand
13 it now. So, the numbers that you have in that
14 column on the other chart where you had an initial
15 concentration was at time zero, not at the time
16 of failure. You say initial source concentration
17 Co and you have 1,500 milligrams per litre and so on.
18 That was at the beginning of the landfill regard-
19 less of when it fails.

20 DR. ROWE: That is correct. That
21 is the starting point here. This particular
22 diagram is at 1,500.

23 Let us suppose it started at
24 1,500. How long would it have to operate,
25 decrease along a curve such as this before the



1 impact at the boundary when the failure occurred
2 would be less than 25 milligrams per litre.

3 DR. KINGHAM: Thank you very much.
4 I think that is clearer now.

5 DR. ROWE: I am sorry if I didn't
6 explain it clearly.

7 MS CRONK: Q. Could I ask you,
8 Dr. Rowe, to go back to the definition of
9 contaminating lifespan that appears on page 1 of
10 the interim guidelines. The definition, or
11 explanation, if you will, of the term reads:

12 "The time period during which the
13 landfill will produce contaminants
14 at levels that could have an unaccep-
15 table impact if they were to be
16 discharged into the surrounding
17 environment."

18 That language too suggests that
19 in determining what the contaminating lifespan of
20 the landfill is, one must approach it from the
21 very beginning of the generation of contaminants
22 through until the levels produced are at acceptable
23 values. Isn't that so?

24 A. That is my understanding, yes.

25 Q. That is consistent with the



1 zero out projections you have just explained to
2 Dr. Kingham?

3 A. Yes.

4 Q. Could you put Figure 60
5 back up again, please?

6 Are you able, Dr. Rowe, based on
7 the work that you have done and the data available
8 to you, to assist the Board as to what you regard
9 as the service life of the landfill facility at
10 Site D to be?

11 A. Yes, from what Dr. Charles-
12 worth has said, if one takes it that the increase
13 in concentration of chloride at the boundary of
14 the property cannot exceed 25 milligrams per litre,
15 then if you look at the range of cases I have
16 examined it is in excess of 50 years.

17 Q. That is at the lower end of
18 the range?

19 A. That is at the lower end
20 of the range. It could be 80 years.

21 Q. Indeed, under the language
22 of the guidelines we indicated a few moments ago
23 it would appear it would have to be longer than
24 either 50 years or 80 years because the guidelines
25 require that the service life be longer than the



1 contaminating lifespan.

2 A. That is correct.

3 Q. So my question to you really
4 was, I am sorry, I didn't make it clear, was more
5 fixed than that. Can you give me a number as to
6 how long the engineered facility, that is the
7 leachate collection system must function, bearing
8 in mind that whatever the numbers are they are
9 greater than what is shown in your Figure 6. If
10 you are not in a position to do so, please tell me.
11 If you are, I would like the numbers.

12 A. I am sorry, I am not quite
13 sure I understand the question.

14 Q. We know that the contamin-
15 ating lifespan based on your calculation is from
16 50 to 80 years plus.

17 A. Right.

18 Q. We know that the leachate
19 collection system pursuant to the guidelines must
20 function, i.e. not fail for periods longer than
21 that.

22 A. That is my understanding,
23 yes.

24 Q. Are you in a position, based
25 on the data available to you, to determine what



1 that incremental time period is $50+X$ or $80+X$.

2 Do you know what the X is?

3 A. No, I do not know what the
4 X is.

5 Q. Can that in fact be
6 determined given the data available with respect
7 to Site D as you understand it?

8 A. Well, I am struggling with
9 the question, Ms Cronk. I am not trying to
10 avoid it. As I understand it, they say must
11 last longer than the contaminating lifespan. What
12 I have tried to put in this table amounts to the
13 contaminating lifespan. Frankly, I don't know
14 what that means. Maybe the person who wrote this
15 might be able to advise us.

16 Q. That is a fair comment.
17 In addition, I suggest, Dr. Rowe, that there may
18 be some difficulty in determining the service life
19 at Site D having regard to the probability, as you
20 have described it, of partial failure to clogging
21 of materials and the like.

22 A. Yes, that is in fact my
23 most central concern with respect to Site D,
24 Mr. Chairman, is that its performance is dependant
25 upon this hydraulic trap. Based on the evidence



1 above and the evidence of the Region's own
2 witnesses, there is no way that I can conclude
3 that the leachate collection system as designed
4 will function over a period of time. Therefore,
5 contamination is likely.

6 Q. Just to be clear, before
7 we put away Figure 60, I think we have had this
8 before, but may I have your confirmation.

9 The time periods calculated by you
10 and shown on that overhead are premised on an
11 initial concentration of 1,500 milligrams per litre
12 in the leachate; is that correct?

13 A. Half of them are and the
14 other half are premised on 3,000. That is
15 something we don't know precisely, so I wanted
16 to indicate what the range would be.

17 Q. I am sorry, 1,500 to 3,000.
18 We see that if the concentration is higher than
19 1,500 the time period goes up proportionately.

20 A. I wouldn't say proportion-
21 ately, but it does go up.

22 Q. Then, could I ask you to go
23 to page 2 of the interim guidelines and the
24 introductory language to the portions set out on
25 page 2 reads as follows:



1 "In accordance with the foregoing,
2 the only types of engineered
3 facilities that are acceptable, are
4 those that meet the following
5 requirements."

6 And the first requirement is set
7 out in paragraph 1 and it reads:

8 "It must be possible to monitor the
9 engineered facility to verify that
10 it performs to specification.
11 Monitoring must be able to warn of
12 failure sufficiently in advance to
13 allow contingency measures to be
14 taken."

15 Stopping there for a moment,
16 Dr. Rowe, does that suggest to you, as it does to
17 me, that the monitoring system proposed for a
18 landfill, that is the actual engineering component
19 and monitoring program must be able to function as
20 an early warning system?

21 A. That is my understanding,
22 yes.

23 Q. It is a specific requirement
24 of these interim guidelines that that be proven to
25 be possible in order for the engineered facility



1 to be acceptable.

2 A. That is my interpretation,
3 yes.

4 Q. As I understand the evidence
5 you have given, you have considerable concern about
6 the potential for the monitoring system at Site D
7 to in fact satisfy the requirement of functioning
8 as an advance warning system.

9 A. Based on the information
10 available to me from Trow and also from Dr. Charles-
11 worth, that is true.

12 Q. Continuing on in that
13 paragraph:

14 "Contingency measures are designed
15 to accommodate any failure in the
16 design of a landfill and are not a
17 part of the normal operation during
18 the life of the facility."

19 I take it from that that contingency
20 measures are not to be regarded as part of the
21 land itself, and by separate, I don't mean a
22 separate undertaking in the legal sense, but a
23 separate endeavour to respond to problems that may
24 arise at a landfill facility.

25 A. That is my understanding of



1 this document and my own view as well.

2 Q. Is that perhaps why,
3 Dr. Rowe, we do not see contingencies referred
4 to at page 5 or 6 in the definition of the scope of the
5 term engineered facility as they are not
6 considered to be part of the landfill facility
7 itself, but something distinct and supplemental
8 to it.

9 A. I would interpret it that
10 way and view it that way myself.

11 Q. Then, I would ask you to
12 look at requirement number 2:

13 "The contaminating lifespan of the
14 landfill must be addressed in the
15 context of the service life of the
16 various engineered facilities that
17 are used to control contamination."

18 That, I suggest, is a reiteration
19 of the principle we explored at page 1, the basic
20 position statement of the Ministry.

21 A. Yes, I understand that to be
22 so.

23 Q. Finally, item 5 of the
24 requirements:

25 "If an applicant cannot specify the



1 time period for the decommissioning
2 of an engineered facility the
3 Ministry will consider that the
4 facility will be required indef-
5 initely and provisions for its
6 perpetual care, maintenance and
7 replacement must be provided. This
8 is the responsibility of the appli-
9 cant."

10 Stopping there, Dr. Rowe, do you
11 understand the meaning of the term "decommissioning
12 of an engineered facility"?

13 A. It means getting to the state
14 where you can walk away from it and forget about it.

15 Q. Do I take it from that
16 requirement if it is not possible to predict with
17 certainty the time period when you can walk away
18 from the facility, the guidelines require indefinite
19 maintenance of the system?

20 A. That is my understanding,
21 yes.

22 Q. In the instance of Site D,
23 we are talking, the system is the leachate collec-
24 tion system?

25 A. That is a critical component,



1 yes.

2 Q. That is the largest part
3 of the engineered facility proposed for that site.

4 A. That is the most important
5 part, yes.

6 Q. Does that mean then,
7 Dr. Rowe, in your opinion, if it cannot be said with
8 certainty when you can walk away from the leachate
9 collection system at Site D with safety, these
10 guidelines would require that that collection system
11 be maintained indefinitely with perpetual care,
12 maintenance and replacement?

13 A. That would be my understand-
14 ing, Mr. Chairman.

15 Q. Could you contrast that
16 for me or compare that for me, if you would, to
17 the situation at Site F? What do you understand
18 to be the engineered facility at Site F?

19 A. Well, the engineered
20 facility consists of the leachate collection
21 system and the toe drains primarily in the context
22 we are discussing.

23 Q. Are you able to say, Dr. Rowe,
24 when the decommissioning of those facilities at
25 Site F will be possible?



1 A. I think there are two parts
2 to that. The leachate collection system, I
3 think I indicated in response to the question
4 yesterday, although I think it is highly desirable
5 and it should be maintained, in my opinion, for at
6 least 20 years. It is not essential to the
7 attenuation of contaminants moving off-site south
8 of the 403.

9 Therefore, in the context of this
10 you could take it as zero, though in the practice
11 I am not suggesting one should. The toe drain
12 is another issue and based on the information avail-
13 able, one would be looking at a considerable period
14 of time both at Site D and at Site F.

15 Q. The ideal, then just with the
16 leachate collection component at Site F, as I
17 understood your discussion with Mr. Tidball yester-
18 day, you expressed the opinion that in fact Site F
19 could function safely without an under-drain system
20 but you are not recommending it.

21 A. That is my evidence, yes.

22 Q. That is your opinion and
23 your professional judgment from an engineering
24 perspective?

25 A. Based on all the evidence



1 available to me at this time, that is correct.

2 Q. And you have just told me
3 it would be highly desirable to maintain the
4 leachate collection system, that is the under-drains,
5 for a period of 20 years.

6 A. That is my opinion.

7 Q. Is that then, in relation to the
8 leachate collection system at Site F, the service
9 life, as you apprehend it of that engineered
10 facility?

11 A. Yes, I think it could be
12 put that way.

13 Q. Are you in a position to tell
14 us what the equivalent service life is of the
15 leachate collection system at Site D?

16 A. I would say that it is in
17 excess of 80 years based on our earlier discussion.

18 Q. That would be the outside
19 range, would it not?

20 A. We talked about a range of
21 numbers from 50 to 80 years.

22 Q. That is the higher end of
23 the range?

24 A. That is the high end.

25 Q. It could be 50 years plus on



1 the low end?

2 A. Given the problem of course
3 of how long it is going to last. I looked at a
4 range of cases and I am not suggesting that one
5 of those is specifically what is going to happen.

6 Q. Do you regard 50 years,
7 however, as being the minimum?

8 A. Based on the information
9 available to me at this time, yes.

10 Q. Could I ask you then to go
11 to page 3 and I direct your attention to the
12 section of the document dealing specifically with
13 leachate collection facilities and leachate treatment
14 facilities.

15 The first paragraph reads:
16 "To serve effectively leachate
17 collection and treatment facilities
18 must function for the contaminating
19 lifespan of the landfill. The
20 state-of-the-art does not allow
21 precise determination of rates of
22 attenuation or degradation of
23 leachate within landfills. Therefore
24 in the absence of data or site
25 specific information to the contrary,



1 where the complete attenuation of
2 the contaminants in the leachate is
3 necessary, the Ministry will require
4 that these collection and treatment
5 facilities be maintained in
6 perpetuity."

7 Dr. Rowe, in your professional
8 judgment, is the complete attenuation of contamin-
9 ants to be generated by a landfill at Site D
10 required, or alternatively, must they simply be
11 attenuated to levels that afford no potential for
12 negative impact on users of water and the public?

13 A. In my view, they should be
14 attenuated to the point where there is no impact
15 on off-site users.

16 Q. Is that a complete attenua-
17 tion, a reduction of values to zero?

18 A. I believe that would be
19 going too far.

20 Q. Thank you, Dr. Rowe. There
21 are one or two other matters. I propose to leave
22 the interim guidelines for a moment. I am sorry,
23 there are one or two other matters for you.

24 The first relates to Site D and
25 this is really a point of clarification. In



1 your discussions with both Mr. Estrin and
2 Mr. Tidball with respect to your scenario C at
3 Site D, I get back to that, that scenario, as I
4 recall it, is the one in which you considered what
5 would happen if three tiles on the western side
6 of Cell 4 at Site D were to fail.

7 A. That is correct.

8 Q. For whatever reason, be it
9 clogging, malfunction of any kind.

10 A. That is correct.

11 Q. Under that scenario, as I
12 understood your evidence you have given, you
13 assumed there would be 120 metres -- sorry, let me
14 back up -- it was a two-way flow analysis that
15 you considered.

16 A. That is correct.

17 Q. You gave the number of 120
18 metres and I thought you indicated that that was
19 the amount of leachate, if you will, that -- let
20 me ask you, what does the 120 metres relate to?

21 A. If I could put up here --
22 I am referring to Exhibit H-41-D2 and the 120
23 metres that I am referring to is the distance
24 between a collection tile assumed to be working and
25 the next collection tile -- I will back up. It



1 is the distance between the most westerly collection
2 tile assumed to be working and the next easterly
3 collection tile assumed to be working.

4 Q. All right, that is 120
5 metres in total?

6 A. It is approximately 120
7 metres.

8 Q. Sixty metres each way?

9 A. I am assuming 60 metres each
10 way.

11 Q. Does that mean, Dr. Rowe,
12 and this is the point I wanted to clarify, that
13 what you are saying under that partial failure
14 scenario, there would be an aerial extent of 120
15 metres of waste as a source of leachate down below
16 the leachate collection system as a result of
17 failure.

18 A. That is true.

19 Q. What we are really talking
20 about then, and I certainly stand to be corrected
21 on this, but that is about a football field and
22 a half of waste that is the potential source of
23 leachate?

24 A. Yes, it depends on whose
25 football field. Something like that.



1 Q. The only point I am trying to
2 make is, we are not talking about an insignificant
3 area.

4 A. No.

5 Q. That is the aerial extent
6 from which waste, that is the aerial extent of the
7 available waste to produce leachate which could
8 then escape the system.

9 A. That is correct in that
10 scenario.

11 Q. Then, one other item,
12 Dr. Rowe, for you and this relates to Site F.

13 Again, frankly it is more clarification
14 for me. I had understood you to say in
15 evidence, I am sorry, I don't remember now whether
16 it was to Mr. Estrin or Mr. Tidball, that at Site
17 F, either 90 per cent or 99 per cent of the water
18 was contained in the pores of the matrix as opposed
19 to fractures. Am I right, there was a statement
20 of that kind made and if so, what was the percent-
21 age?

22 A. You are right, there was a
23 statement of that kind made. Responding to your
24 question, I would like to just put up the overhead
25 I was discussing. It was overhead number 7 from



1 Exhibit 444. What I was indicating to the Board
2 was what the situation would be given that the
3 matrix porosity was 0.1 and we have got a pretty
4 good handle on that and the fracture porosity was
5 0.001. That would mean 99 per cent of the total
6 voids in the system were in the pores of the shale.
7 Only about one per cent was in the fracture itself.

8 Q. Does that mean that 99 per
9 cent of the water is in the rock, in the matrix
10 of the rock as opposed to the fractures?

11 A. For the saturated rock
12 layers, yes.

13 Q. My question to you is does
14 the phenomenon of matrix diffusion, which applies
15 at Site F, apply to movement of contaminants both
16 from the fractures into the matrix of the rock and
17 the movement of contaminants from the matrix of
18 the rock into the fractures?

19 A. Yes, the contaminants will
20 always move in the direction of the concentration
21 of gradient, all other things being equal.

22 Q. If I understand that, what
23 you are saying is that if the concentrations are
24 lower in the fractures and higher in the matrix
25 of the rock, the pores of the rock, then the



1 contaminants will move from the rock into the
2 fractures.

3 A. That is correct.

4 Q. And vice-versa.

5 A. Correct.

6 Q. In addition to that, we have
7 spoken this morning of the adsorption attenuation
8 mechanism that can apply with certain types of
9 chemical constituents. Does that process apply
10 as well with respect to contaminants contained in
11 the rock as opposed to the fractures?

12 A. In terms of what I model, I
13 assume that the adsorption processes are reversible.
14 That may not be true. The contaminants may, once they
15 sorb onto the organic matter not move out
16 but certainly not as freely as I assumed in my
17 model.

18 Q. Were that to be the case, it
19 would mean that they were not travelling in
20 accordance with advection off-site.

21 A. That is correct. The
22 impacts would be even less than I calculated.
23 Those impacts would be smaller.

24 Q. So, you assumed for the
25 purposes of your model, that advection was in fact



1 a reversible process.

2 A. Sorption was reversible.

3 Q. Did you make a similar
4 assumption with matrix diffusion?

5 A. Yes, I did. The matrix
6 diffusion of a cell should be reversible.

7 Q. Can you tell me, Dr. Rowe,
8 with respect to the 99 per cent figure, what is
9 your basis for it? Is that a pure mathematical
10 calculation based on the values you set out in
11 Figure 7?

12 A. The 99 per cent itself is,
13 yes. Of course, we are talking about a value
14 of porosity within the matrix which agrees with
15 the value used by Trow and also is consistent with
16 the tests we conducted ourselves. The parameter
17 which is less certain is the fracture porosity.
18 That, as we discussed this morning, is typically
19 a very small number and 0.001 seems a reasonable
20 number to be used.

21 Q. When you say the tests you
22 did yourselves, are you referring to the tests in
23 the laboratory?

24 A. That is correct.

25 Q. Did you actually take



1 pieces of the core provided to you and test to see
2 how much of the water element in the rock
3 moved out of the matrix of the rock into fractures?

4 A. Not the water element.
5 We did two types of tests. We did a standard
6 test for determining water content and from that,
7 the porosity. We did diffusion tests, Mr. Chair-
8 man, where we put the sample of shale which
9 initially has a high concentration of chloride in
10 it, as we have heard, and indeed our samples had
11 high concentrations of chloride.

12 So, we put the sample of core in
13 contact with distilled water. That is essentially
14 equivalent to having a sample of intact rock with
15 a very big fracture adjacent to it, and we just
16 let it sit there for a period of time. During
17 this period of time, the chloride diffused from the
18 shale out into the distilled water and if I could
19 just put up one of those overheads to illustrate
20 the point, we determined background concentration
21 of chloride at the ends of each of the samples
22 tested. So, we know it started somewhere around
23 about under nine grams per litre of chloride at
24 the top, and about seven at the bottom. That
25 is where it started. After 45 days on this



1 particular test, the diffusion profile is as shown
2 by those triangles within the sample and the top
3 triangle is the actual concentration measured in
4 what was originally, distilled water. As the
5 chloride diffused out of the sample, of course, it
6 ceased to be distilled water.

7 Q. Thank you, Dr. Charlesworth,
8 thank you, Dr. Rowe.

9 Dr. Charlesworth, you had some
10 discussion with Mr. Tidball regarding the water
11 quality in the granular units at Site D and you
12 may recall there was a discussion as to whether
13 any of the monitoring well data that is available
14 to the Board, applied to data obtained from the
15 upper granular unit at Site D. Do you recall
16 that?

17 DR. CHARLESWORTH: A. Yes, I recall
18 that.

19 Q. As I understood the direction
20 of the discussion, it was being suggested that the
21 water quality in the upper granular unit had not
22 been clearly established.

23 A. That was the gist of the
24 dialogue.

25 Q. Could I ask you to assume,



1 for the moment, that in fact the water quality in
2 the upper granular unit at Site D is not known
3 based on the data available? That could mean
4 clearly, could it not, that the water quality could
5 be quite good as opposed to quite bad. That is
6 a possibility?

7 A. Yes, certainly.

8 Q. It would follow that if it
9 was quite good, would it not, that landfilling
10 at Site D would put a good quality water resource
11 at risk?

12 A. Yes, the risks that are
13 associated with landfill at Site D if the water
14 quality was of good quality would be putting good
15 quality water at risk.

16 Q. Am I also right, it is not
17 only the upper granular unit at Site D that is
18 a water transfer corridor, but also the lower
19 granular unit?

20 A. Yes. We do not know,
21 in my opinion, the role that the lower granular
22 unit plays. Certainly, there is evidence to
23 suggest there is transportation there. There
24 is evidence to suggest the wells could be getting
25 water from the lower granular unit. We don't



1 know its role, but it certainly has some role to
2 play. How big a role, we do not know.

3 Q. The minimum, I suggest, it
4 is clear that the lower granular unit is a water
5 bearing zone.

6 A. It is a water bearing zone,
7 certainly.

8 Q. In addition to the upper
9 granular unit and the lower granular unit, I
10 suggest that the data available indicates that there
11 may be sand lenses on Site D intermittently in
12 pockets that provide a source of water as well, or
13 are water permeable zones.

14 A. There are scattered sand
15 lenses on the site, yes, and they are saturated
16 with water.

17 Q. Could I ask you to go to
18 Exhibit N-462, which is the chart showing the
19 water quality analysis results for the water wells
20 at Site D?

21 A. This was the update of our
22 table?

23 Q. Yes, it is.

24 Could you keep that out, if you
25 would, and also put before you, your Site D



1 Report, and I would like you to go, if you would,
2 please, to Figure 2 in your Site D Report.

3 Sorry, Figure 2 at the very back.

4 A. Section RB-RB?

5 Q. Yes.

6 Figure 2 shows does it not,
7 Dr. Charlesworth, the domestic wells, reading across
8 the top of Site D, we have number 4074, 16hc,
9 5663, 1g, 14c, et cetera?

10 A. That is correct.

11 Q. Looking first at the first
12 three, 4074, 16hc and 5663 as plotted on this
13 cross-section, two of those are shown to be in the
14 lower granular unit; isn't that so?

15 A. Yes.

16 Sorry, which of the three you read
17 to me? Yes, we have suggested that all three
18 could be in the lower granular unit, in fact.

19 Q. With respect to 4074,
20 that is definitely shown on the cross-section
21 because you have the well extending to the lower
22 granular unit?

23 A. That is right.

24 Q. Similarly, with respect
25 to 5663, that is definitely shown on the cross-



1 section because you have the well shown as being
2 in the lower granular unit?

3 A. That is correct.

4 Q. With respect to 16hc, you
5 have a question mark on the lateral extent of the
6 lower granular unit at the bottom of that well and
7 you are suggesting you don't know the extent
8 laterally of the unit so it may be in the unit.

9 A. We don't know the extent
10 at any of those locations. There is an element
11 of supposition and we have interpreted it somewhat
12 differently. It is one of the minor differences
13 between our section and Trow's. I think they
14 actually extended the upper granular unit through
15 those wells.

16 Q. Well 14hc is very close to
17 the surface?

18 A. 14hc, yes.

19 Q. That is the one, as I recall,
20 that when you tested it in September of '87, it was
21 dry?

22 A. That is correct.

23 Q. But it was not in January
24 of this year?

25 A. That is correct.



1 Q. Then, well 1g is actually
2 in the shale?

3 A. That is correct.

4 Q. With respect to the
5 contaminants measured in the first three wells,
6 4074, 16hc and 5663, at 4074, the chlorides
7 were consistently above Ministry of the Environment
8 standards, drinking water standards?

9 A. That is correct.

10 Q. The same is true with
11 respect to 5663?

12 A. That is correct.

13 Q. At 16hc it was true on one
14 sampling occasion only?

15 A. Yes, it was slightly below
16 on two subsequent samplings.

17 Q. With respect to sulphates,
18 well 4074 had acceptable levels on two occasions
19 tested?

20 A. Yes.

21 Q. At well 5663, the qualities
22 measured, the values measured, exceeded Ministry
23 of the Environment standards on both occasions?

24 A. That is correct.

25 Q. At 16hc the levels were



1 within the Ministry of the Environment guidelines?

2 A. That is correct.

3 Q. What I want to come back to,
4 Dr. Charlesworth, is the confidence level that you
5 have in the way these wells are plotted on your
6 cross-section and whether it is, in fact, possible
7 that they are in the upper granular unit and not
8 the lower granular unit, or possibly both.

9 As I understood your evidence you
10 have said that you do not have accurate elevations
11 on 4074 and 5663; is that correct?

12 A. That is correct.

13 Q. Could you just explain to
14 me what you mean by that? Why don't you?

15 A. The elevations are the
16 elevations from the Ministry well records which
17 are just taken off, read off maps. It is not
18 an actual elevation. It could be certainly a
19 couple of metres out.

20 Q. If it was a couple of
21 metres out, could they not be a couple of metres
22 higher?

23 A. They could quite easily.

24 Q. If they were a couple of
25 metres high, is it not entirely possible that they



1 would be in the upper granular unit?

2 A. It is certainly possible.

3 Q. I would ask you with respect
4 to that answer to take a look at, perhaps if we
5 go to Figure 5, it's a little awkward to keep them
6 all open at the same time, but on Figure 5, we
7 see, do we not, Morrison and Beatty well, OW-4.

8 A. Correct.

9 Q. Morrison and Beatty well
10 OW-4 is just a little bit further south than domestic
11 well number 4074?

12 A. It is slightly east of it,
13 actually.

14 Q. In terms of your cross-
15 section on Figure 2, however, it would show between
16 16hc and 4074, if one were to plot it on?

17 A. Yes, somewhere in that
18 vicinity.

19 Q. It is MB OW-4 is in fact
20 shown as being in the upper granular unit, is it
21 not?

22 A. MB OW-4, we have identified
23 a unit there that appears to be the upper granular
24 unit.

25



1 Q. Did Trow consultants not
2 similarly identify the OW-4 as being in the upper
3 granular unit?

4 A. Yes, they did.

5 Q. My suggestion to you is
6 quite simply in support of the suggestion that
7 those two domestic wells might in fact be in the
8 upper granular unit is that that is the case with
9 MB OW-4 according to both your firm and Trow.
10 At least in the case of 4074, they are in close
11 proximity; isn't that so?

12 A. Yes, quite so.

13 Q. Looking again at your
14 Figure 2, am I correct that you are showing the
15 upper granular unit but that the southerly extent
16 of it is unknown and that is signified by your
17 question mark?

18 A. Yes, that is true.

19 Q. Similarly, throughout this
20 cross-section and others where either the lateral
21 or the vertical extent of the units are unknown,
22 you have indicated that by question marks?

23 A. Yes. There is a certain
24 degree of subjectivity in this where we have tried
25 not to be unreasonable in terms of extending



1 it too far where there is a lack of data.

2 Q. Where there is a lack of data,
3 you so indicate with a question mark?

4 A. Usually, yes.

5 Q. Did the water well records
6 that you examined indicate what type of well number
7 4074 is?

8 A. My recollection is that
9 that is a bored well.

10 Q. Similarly, with respect to
11 well 5663?

12 A. 5663 is a bored well.

13 Q. Do bored wells have any
14 steel casing on the inside to prevent seepage of
15 material into the well?

16 A. It depends on the structure.
17 They can do or they can be concrete lined.

18 Q. I am sorry, concrete lined?

19 A. Yes.

20 Q. Are you drawing a distinction
21 there between steel lined and concrete lined?

22 A. It depends on what context
23 you are referring to it.

24 Q. Do you normally have a
25 steel lined bored well?



1 A. Not usually, no.

2 Q. It is usually concrete isn't
3 it?

4 A. Yes, it is usually.

5 Q. Then, if it is concrete it
6 is subject obviously to deterioration over time?

7 A. Yes, it is.

8 Q. Is it not possible then
9 that with those two wells, given the type of wells
10 that they are, there could be seepage into those
11 wells from the upper granular unit, if it extends
12 that far south?

13 A. Yes, certainly that sounds
14 conceivable.

15 Q. Do you have available to
16 you, or can you help us as to the type of wells
17 the other domestic wells are? Tell me whether
18 they are bored wells or not.

19 A. 14hc is a dug well.
20 I am not sure about 16hc but it may be in the
21 appendix in the Trow Report.

22 Q. Perhaps you can check that
23 over lunch time and let us know.

24 A. I can't remember off-hand.

25 Q. Dr. Charlesworth, quite



1 clearly what I am suggesting to you then is that
2 for a variety of reasons it might be quite possible
3 that those domestic wells we have looked at
4 are in fact in the upper granular unit or are
5 receiving water from the upper granular unit.

6 A. I agree that is possible,
7 yes.

8 Q. We do know, however, based
9 on the cross-sections you have done that they are
10 in fact in the lower granular unit based on those
11 cross-sections?

12 A. Those cross-sections
13 suggest that they are in the lower granular unit.
14 I hesitate to say we know they are in the lower
15 granular unit.

16 Q. That's fair. I under-
17 stand. With respect to the way you have plotted
18 them, they are clearly receiving water from a
19 granular unit of some kind at Site D and if it is
20 not the upper granular unit, it has to be either the
21 lower granular unit or a sand lens?

22 A. Yes, that is correct.

23 Q. My only point being then
24 that even if they are not in the upper granular
25 unit, the water quality data that you have obtained



1 suggests that the other granular units at that site
2 have very poor quality water.

3 A. Yes, it suggests, that they
4 are above drinking water guidelines in a few of the
5 parameters we have looked at.

6 Q. And as we have seen, some of
7 them are under the MOE drinking standards and
8 some are closer than others to the actual standard
9 value.

10 A. That is correct.

11 Q. Dr. Charlesworth, very
12 briefly, still dealing with Site D, I would like to
13 make sure I understand what your overall conclusions
14 are with respect to the site. I recognize that
15 you have spent some considerable time outlining
16 those to the Board, so I don't mean to contract
17 them in an inappropriate way.

18 As I understand your evidence, it
19 comes to this with respect to Site D, that based
20 on your analysis, there are significant problems,
21 in your opinion, with siting a landfill over a
22 groundwater resource in a rural area such as Site
23 D.

24 A. I don't think that really
25 summarizes my primary conclusions. My primary



1 conclusions, Mr. Chairman, are that there are a
2 number of uncertainties left at Site D that have
3 not yet been answered. That is a reasonable
4 assessment of my main conclusion and that Trow
5 were not always conservative in their assumptions.

6 Q. Because of the existence
7 of those uncertainties, based on the data currently
8 available to the Board, in your judgment those
9 uncertainties themselves pose
10 problems with respect to a landfill at Site D, do
11 they not?

12 A. They pose problems, the
13 uncertainties pose problems with the approval of
14 the landfill at Site D at this time. My opinion
15 is that the site has not been proven at this time.

16 Q. You have indicated that,
17 based on your review, it is your professional opinion
18 that the extent of the granular units at Site D
19 and their role in the transport of water and
20 contaminants has not, with certainty, been determined
21 as of today's date.

22 A. That is correct.

23 Q. Having regard to that, as
24 I understood what you said, you do not place any
25 confidence in the ability to detect and control



1 contaminant movements at that site based on what
2 you know today.

3 A. I think at this time it would
4 be difficult to design, based on the information we
5 have at the moment, it is difficult to design any
6 monitoring or contingency system at Site D.

7 Q. Thank you, Dr. Rowe.

8 There is one final point with respect
9 to Site D that I wish to raise with you. We have
10 heard your evidence several times as to your basis
11 for believing that there was a probability that
12 the extent of the mounding at Site D could exceed
13 the 1.5 metres postulated by Trow.

14 DR. ROWE: A. Yes, that is correct.

15 Q. Do I understand Trow's
16 work, do I understand correctly Trow's work to be
17 premised on ensuring that the mound at Site D
18 does not exceed 1.5 metres?

19 A. I would not quite go that
20 far. I would say that their design is premised
21 on not exceeding the head that would cause reversal
22 of the hydraulic trap.

23 Q. How do I relate to that
24 in terms of metres and the height of the mound?

25 A. That depends on where you are



1 beneath the landfill.

2 As Dr. Charlesworth has indicated,
3 we don't really know with all that much certainty
4 where the heads are in the upper granular unit,
5 for example. But, at one location, the head is
6 at 181.6.

7 At that location, once the mound
8 within the landfill fills up -- it would be 181.6
9 datum level, that is 2.6 metres above the base of
10 the landfill, the trap would reverse.

11 At another location, if my memory
12 serves me well, the head on the upper granular
13 unit was 181.2. So, at that location, you
14 could only go to 2.2 metres. It depends on where
15 you are.

16 Also, Dr. Charlesworth indicated,
17 I think, that if somebody off-site pumped, there
18 is the potential of lowering the head in the upper
19 granular unit to less than 181.6 or less than
20 181.2. At that point, the trap reverses for
21 even a small amount.

22 Q. Taking those various
23 possibilities into account, is it your opinion
24 to the Board that if there is mounding at Site D
25 for any of the potential reasons that you have



1 outlined, that that could occur. If there is
2 mounding at Site D, in excess of -- to be fair,
3 let's take the highest -- 2.6 metres that in fact
4 the trap will reverse and there will be a contamin-
5 ant migration problem.

6 A. If the mounding exceeds 2.6
7 metres, the trap will reverse and if that mounding
8 is over a reasonable area, there are potential
9 contamination problems.

10 Q. In your professional judgment,
11 Dr. Rowe, what is the probability at Site D that
12 will occur?

13 A. In the overall timeframe
14 that we have been discussing, I consider it to be
15 more likely than not, given the design they have
16 proposed.

17 MS CRONK: Thank you very much,
18 Dr. Rowe, Dr. Charlesworth, those are my question,
19 Mr. Chairman.

20 DR. KINGHAM: Just before we break,,
21 can you tell me in your Table 1, do you have the
22 right names for the right well numbers so that we
23 can maybe put them on your charts? You have
24 been referring to Figure 2 and you have the arrows
25 marked for the three wells, 4074, 16hc and



1 5663. We had a discussion a few days ago about
2 whether the names were with the right numbers. In
3 your Table 1 which we now have as Exhibit N-462,
4 you have names and well numbers associated. Are
5 they the right ones?
6 DR. CHARLESWORTH: Those are the
7 right ones.
8 DR. KINGHAM: And Halton doesn't
9 agree with that?
10 MR. HODGSON: (indicates no)
11 DR. KINGHAM: Thank you.
12 MS CRONK: Mr. Chairman, it occurs
13 to me that if Dr. Charlesworth has available
14 to him the water well records on the domestic wells
15 where they were available, the domestic wells at
16 Site D. I would like you to produce those,
17 doctor, so we can have those marked.
18 DR. CHARLESWORTH: All right.
19 THE CHAIRMAN: We will adjourn until
20 a quarter-to-two.
21
22 --- Luncheon recess at 12:20 p.m.
23
24
25



1 --- Upon resuming at 1:45 p.m.

2

3

MR. LANCASTER: Please be seated.

4

5

6

MS CRONK: I put on the desk for
each of you, a copy of the exhibit that went in
first thing this morning. I think it is 472.

7

8

MR. HODGSON: Thank you.

9

CROSS-EXAMINATION BY MR. HODGSON:

10

11

12

Q. If I could, Dr. Charlesworth,
I will start with a few questions for you.

13

14

15

16

17

18

19

20

I take it, Dr. Charlesworth, that
you would agree that the purpose of your being
here is not that you are here to represent the
Town of Milton, but you are here to assist this
Board in understanding, purely from a hydrogeologi-
cal point of view, the relative risks -- I
emphasize -- the relative risks of placing a landfill
at either Site F or Site D?

21

22

23

DR. CHARLESWORTH: A. Yes. I
would concur. I feel that I am here to -- yes,
I guess relative.

24

25

Q. Would you also agree that
in assessing the relative risks at these two sites,



1 that the two sites should be judged on an equal
2 basis.

3 A. They should be judged,
4 yes.

5 Q. I would like to, if I could,
6 explore with you what equal basis might mean in
7 the context of this hearing and in the context of
8 your evidence.

9 First, as a hydrogeologist, you
10 are concerned primarily about the potential impact
11 on groundwater?

12 A. Yes, that is correct.

13 Q. In assessing potential
14 impact, you look at sources pathways and receptors;
15 is that right?

16 A. Yes.

17 Q. It is the concern of the
18 hydrogeologist, you would agree with me, that the
19 concern of the hydrogeologist is primarily on
20 the pathways.

21 A. The concern of the hydro-
22 geologist, I guess in assessing a landfill,
23 becomes public health and safety as the category
24 which we are really looking at, so that is the
25 bottom line.



1 Q. Public health and safety
2 are the receptors, but in looking at the impact
3 on the receptors, we want to examine the pathways
4 to the receptors do we not?

5 A. True.

6 Q. So, perhaps we should
7 qualify hydrogeology. What we are really talking
8 about is contaminant hydrogeology and in contaminant
9 hydrogeology you always require a pathway analysis,
10 is that fair?

11 A. Yes, that is a fair state-
12 ment.

13 Q. Not only are you concerned
14 about the pathways on which contaminants travel
15 but on the assumption that contaminants escape
16 from the system and in fact, reach a pathway, you
17 also want to examine mechanisms for retardation
18 and attenuation.

19 A. Yes.

20 Q. In fact, those aspects of
21 retardation and attenuation have been examined in
22 this hearing by hydrogeologists like yourself,
23 Mr. Sobanski, Mr. Beechinor. By a hydrogeochemist,
24 Mr. Feenstra, by the geotechnical engineer Dr. Rowe?
25



1 A. Yes.

2 Q. Dr. Charlesworth, in looking
3 at the question of how we judge these two sites on
4 an equal basis, I would like to take you to your
5 Site D report, Exhibit M-438. I would like if
6 we could examine together, very briefly, some of
7 the statements that you have made about the
8 unweathered upper till at Site D. First of all,
9 I think you will agree with me that you have said,
10 and it is on page 5-9 of your witness statement,
11 I am sorry, of this Exhibit M-438, that first of
12 all you note that Trow have assigned, in fact, measured
13 a hydraulic conductivity in the upper weathered
14 till of 1×10^{-5} and you have agreed, or at least
15 you have set out in this document that that is a
16 reasonable value, isn't that right?

17 A. I am sorry, which page are
18 you referring to?

19 Q. 5-9.

20 A. That is correct.

21 Q. Just for the sake of this
22 discussion, Dr. Charlesworth, if 5-9 is a
23 reasonable value, would you agree -- I am sorry,
24 if 1×10^{-5} is a reasonable value, would you agree
25 then that 4×10^{-5} is a conservative value?



1 You have suggested in your evidence
2 that Trow's measured value of 1×10^{-5} is a reasonable
3 value. What I am asking you to do now is
4 suggest for this Board, a conservative value.
5 In the last sentence it is a reasonable but not
6 conservative value. What, in your view, is a
7 conservative value?

8 A. Anything less than that.

9 Q. Four times 10^{-5} is something
10 less than that. Would you agree that is a
11 conservative value?

12 A. I am sorry, 4×10^{-5} is not
13 less than 1×10^{-5} .

14 Q. A conservative value is
15 going to be a value that has a greater permeability
16 and 4×10^{-5} would have greater permeability, would
17 it not?

18 A. Conservative from what
19 aspect?

20 Q. From the aspect of contamin-
21 ant hydrogeology?

22 A. No, a lower permeability
23 value would be more conservative.

24 Q. If you are concerned about
25 the upper weathered till as a contaminant pathway.



1 A. Yes.

2 Q. You are concerned about
3 the extent, the way in which contaminants would
4 move through that till and the speed with which
5 they would move through that till then would you not
6 prefer to have that upper weathered till to have
7 a lower rather than a higher hydraulic conductivity.

8 A. Yes, I would prefer to have
9 a lower value. Sorry, maybe I am misunderstand-
10 ing you.

11 Q. I am just trying to under-
12 stand your evidence, Dr. Charlesworth.

13 A. I am saying I would prefer
14 it to have a lower value.

15 Q. You would prefer it to
16 have a lower value and the value that they have
17 assigned is 1×10^{-5} . Whatever it is, it is a
18 value.

19 A. It would be more conservative.
20 If you were being conservative you would go lower
21 than the value that you have measured, that is the
22 point I was making there.

23 Q. You would go lower. You
24 are saying to be conservative, Trow should have
25 assigned in their study, a value to the weathered



1 till.

2 A. I am sorry, I am getting
3 confused. I realize what you are saying now.

4 Q. Don't you mean that to be
5 conservative they should assign a more permeable
6 value.

7 A. Yes, what I am saying is
8 that 10^{-5} was a reasonable value, 10^{-5} was not a
9 conservative value, it was a reasonable value.

10 Q. I know you have said that.
11 What I am asking you is, if it is a reasonable
12 value, what is a conservative value?

13 A. To be conservative, you
14 would be going with a higher value.

15 Q. A higher permeability?

16 A. Yes.

17 Q. Four times 10^{-5} would be
18 a higher permeability.

19 A. Yes, that's right.

20 Q. And 1×10^{-4} would be a
21 higher permeability still?

22 A. That is correct.

23 Q. As between those two values
24 or some other value, what is your evidence to
25 this Board as to the appropriate conservative



1 value for the hydraulic conductivity of the upper
2 weathered till? And I am asking you whether you
3 would agree to 4×10^{-5} as one possible conservative
4 value.

5 A. That would certainly be
6 more conservative than 10^{-5} .

7 Q. Would 1×10^{-4} be more
8 conservative still?

9 A. Yes, that would be more
10 conservative.

11 Q. They would both be within
12 an appropriate range? You wouldn't assign
13 1×10^{-1} , would you?

14 A. No, I would not assign
15 1×10^{-1} .

16 Q. Would the two values I have
17 suggested be appropriate values as conservative
18 values?

19 A. They could be, certainly.

20 Q. Now, could I take you then
21 to the question of the gradient in the upper
22 weathered till? Here, in Exhibit H-170A,
23 Mr. Beechinor recalculated the gradient in the
24 upper weathered till and assigned a value of
25 0.0052. In your evidence, I believe it is at



1 page 5-2 of this exhibit, 438, you have said,
2 this is the last paragraph under the section on
3 watertable:

4 "We are of the opinion that a
5 value of 0.008 would be 'more
6 realistic'."

7 For the consideration of this report
8 you have advanced values which you have labelled
9 "conservative". I want to ask you, first of all,
10 if you meant to say here that 0.008 is a conserva-
11 tive value.

12 A. I was not saying it was
13 necessarily conservative. I was having trouble
14 with that whole method of calculating, of what it
15 meant to calculate the watertable in that kind of
16 fashion. I think, as I have said there, I think
17 the value is of limited value because of the
18 problems I had with assigning an average value to
19 the watertable.

20 Q. Well, first perhaps I
21 should ask you is the value that they reached in
22 the end of 0.0052, is it a reasonable value, is
23 it within the range of reasonableness?

24 A. I would say that value
25 could be a reasonable value but I don't think



1 that it means much necessarily.

2 Q. Then 0.008, obviously you
3 think that is a reasonable value since you put
4 it forward for the consideration of this Board.

5 A. I don't think that value
6 means much either in this concept of taking
7 an average watertable.

8 Q. As an experienced contaminant
9 hydrogeologist, you have some sense of an approp-
10 riate range of values. We have two before the
11 Board, 0.0052 and 0.008. You have already told
12 me 0.0052 is within the range of reasonableness.
13 Is 0.008 a conservative value that you are advancing
14 here?

15 A. Yes, that would be conserva-
16 tive.

17 Q. Thank you.

18 Now, finally in talking about the
19 upper weathered till, could we talk about the
20 gradient. You have in a fair presentation in
21 your report, this is at page 5-14, indicated that
22 whereas Trow were advancing for the consideration
23 of the Board, measured values for hydraulic
24 conductivity and gradient that no one has a
25 measured value for porosity. I am sorry, for



1 porosity and in the absence of a measured value,
2 Mr. Sobanski has advanced the value of 0.001.
3 After a lengthy discussion on the subject,
4 you have suggested here that a more appropriate
5 value, and you say it is a conservative value, it
6 would seem that if Trow were to be conservative,
7 they should have assigned a lower value for the
8 weathered upper till at Site D. For example,
9 0.0005. So, in your view, 0.0005 is a conserva-
10 tive value?

11 A. That is what I am suggesting,
12 yes.

13 Q. You will recall also, at
14 least during the cross-examination of Mr. Sobanski,
15 attention was drawn to the Board from Gartner,
16 Lee's Study at Site D that Gartner, Lee had
17 selected a value for porosity of 0.0001 which is
18 an even lower value than the value you have
19 selected.

20 A. That is true.

21 Q. Now, first you suggested
22 that your value which was what, five times lower
23 than Trow's value? Is that how we do the
24 mathematics?

25 A. My value is half of Trow's



1 value.

2 Q. I am sorry, two times lower.

3 DR. KINGHAM: I don't understand
4 that answer. Your value of 0.0005 is two times
5 lower for porosity than Trow's value?

6 DR. CHARLESWORTH: I said it was
7 half Trow's value of 0.001.

8 MR. HODGSON: Q. Would you agree
9 with it if Trow's value, your value which is half
10 of Trow's value, if your value is a conservative
11 value as you have labelled it, would you agree
12 with me that Trow's value is a reasonable value?

13 A. It is a possible reasonable
14 value. The gist, Mr. Chairman, of these comments
15 were I felt Trow had placed quite a lot of
16 emphasis in presenting their evidence on how
17 conservative they have been. In many cases I
18 felt that they may have been reasonable, but they
19 have not been conservative. I thought it was
20 important to draw attention to that fact.

21 Q. Thank you.

22 Now, Dr. Charlesworth, I am going
23 to show you a matrix that one of my professional
24 advisers ...

25 MR. ESTRIN: Could I ask



1 Mr. Hodgson if he is going to hand out exhibits
2 I haven't seen, could he hand them first to me?

3 Perhaps he could give them to me
4 in advance so as I can see them.

5 MR. HODGSON: Q. Now, Dr. Charles-
6 worth, all we have done here is work through the
7 numbers and the relationships between the numbers.

8 You will confirm for me, will you
9 not, Dr. Charlesworth, that the values, hydraulic
10 conductivity K, gradient I and porosity n are three values
11 that are used to develop groundwater flow velocities?

12 A. Yes.

13 Q. And in effect, the equation
14 is KI/n .

15 A. Yes.

16 Q. Similarly, if we want to
17 develop the Darcy velocity which is something we
18 have heard a good deal about from your colleague,
19 Dr. Rowe, we simply take the first two, $K \times I$ and we
20 get the Darcy velocity; is that right?

21 A. Yes.

22 Q. What we see in this document,
23 we have attempted to calculate, using various
24 values appropriate Darcy velocity relationships.
25 Those appear on the extreme right-hand column.



1 For the moment I would like to ignore those and
2 come back to them later. I would ask you, first
3 of all, to look at the relationships developed to
4 the left and just for everyone's sake in the left-
5 hand column, we have listed three hydraulic
6 conductivities. The first one is the number
7 advanced by Trow which you have suggested in your
8 report is reasonable, 1×10^{-5} . We have also used,
9 for the sake of calculation, two alternative
10 numbers which you have agreed are more conservative,
11 4×10^{-5} and 1×10^{-4} . Then across the top we have
12 used four different porosity suggestions. The
13 first one, Gartner, Lee, the second yourself,
14 thirdly, the value that Trow proposed and lastly,
15 you will recall in his evidence that Mr. Feenstra
16 referred to some work that Dr. Cherry had been
17 doing and Mr. Feenstra suggested that the porosity
18 could be as low as 0.02.

19 So, for the sake of completeness,
20 we have added that. Then, in multiplying in order
21 to develop water velocities, we have, at the bottom,
22 used the two gradients, Trow's gradient of
23 0.0052 and Geocon's gradient, 0.008. Now,
24 just for the sake of the Board, if not for the
25 witness, we have then calculated, and I would ask



1 you to accept this subject to check later if you
2 would, Dr. Charlesworth.

3 A. Certainly.

4 Q. You appreciate how simple a
5 calculation this is and I know you can do them all
6 quickly, but I won't ask you to do that. I
7 would appreciate your telling me Monday if we have
8 made a mistake on here.

9 So, looking first of all at the
10 third column, THCL porosity, 0.001, the first value
11 shown is 16. What that means is that the ground-
12 water velocity calculated using Trow's hydraulic
13 conductivity and Trow's porosity number and Trow's
14 gradient number, gives us groundwater flow of 16
15 metres per annum.

16 Now, Dr. Charlesworth, you have
17 agreed that each one of those values used by
18 Trow is a reasonable value. Would you agree then
19 using three reasonable values to calculate ground-
20 water flow velocity gives one a reasonable ground-
21 water flow velocity?

22 A. Yes.

23 Q. Now, if I could ask you
24 then to go to the second column listed Geocon
25 porosity, 0.0005.



1 A. Yes.

2 Q. If we take the first of your
3 conservative hydraulic conductivities, 4×10^{-5}
4 and we also use your conservative gradient
5 of 0.008 and we are in the column in which we are
6 already using your porosity figure of 0.0005, we
7 get a groundwater velocity of 200 metres per annum,
8 which I think you would agree with me, is a lot
9 greater than 16 metres per annum?

10 A. Yes, certainly. You said
11 you used my hydraulic conductivity. That
12 really wasn't my hydraulic conductivity.

13 Q. It is a hydraulic conductiv-
14 ity value that I suggest to you that you agreed
15 was conservative. Do you want to object to
16 it and have us use a different one?

17 A. I am not objecting to it.
18 I am saying the values Trow used were reasonable
19 but not conservative.

20 Q. I have asked you for a
21 conservative value and you have given me conserva-
22 tive values and what I have done is take your
23 conservative values and multiply them together and
24 I get a result, 200 metres per annum.

25 I am asking you, what kind of result



1 is that? Is that a conservative result?

2 A. It sounds a high velocity
3 but these were all parameters which Trow used to
4 input to their model, a process which I had some
5 difficulty exactly seeing how they input them to
6 the model, but just looking at each one on its
7 own, it did not appear to be conservative.

8 As I say, Trow placed a lot of
9 emphasis on the fact that they had been
10 conservative and went to some length to justify
11 their conservativeness.

12 Q. Doctor, perhaps we could
13 advance this discussion just a little bit.
14 Could I ask you to clean off these exhibits and put
15 up a clean flow chart and I will dictate some words
16 to you and suggest a way in which we may be able
17 to use them. I wonder, in the middle of that
18 page, on the left-hand side, I would ask you to
19 write the word "reasonable."

20 A. Left-hand side, middle of
21 the page.

22 Q. In brackets beside
23 "reasonable" first of all, before you write this,
24 would you agree that what we mean by "reasonable"
25 in the context is that a reasonable result is the



1 most likely result?

2 A. The reasonable value for the
3 parameter is a likely parameter, yes. I think
4 that is a reasonable suggestion.

5 Q. So, why don't we put
6 (most likely)?

7 A. In the absence of better
8 information.

9 Q. So that if you were a
10 betting man and the Board were asking you to give
11 your best judgment as to what was most likely to
12 happen in the world you would give them your
13 reasonable value and your reasonable result; is that
14 agreeable?

15 A. In the analogy you use,
16 it depends. If I was a betting man, I might go
17 for longer odds.

18 Q. Let us suppose the Board is
19 not interested in your long odds but the most
20 likely scenario. Can you agree that "most
21 likely" and "reasonable" mean the same thing?

22 A. Yes, for the purposes of
23 this discussion.

24 Q. Now, since we are in the
25 area of contaminant hydrogeology and not in the



1 area of developing groundwater resources for use,
2 can I suggest and this suggestion has come as much
3 from you and your colleague as it has from my
4 notebook.

5 Several times during your evidence,
6 I have noticed you have used the word "conservative"
7 and also expressed some discomfort about it.

8 I would like to suggest, for the
9 purposes of this discussion, that we chuck out the
10 word "conservative" and try to find some other
11 language. I am not sure that this adoption of
12 the political vocabulary is advancing our under-
13 standing of the hydrogeology. I don't know if
14 you would agree or disagree. Can we try this.
15 Can I suggest that below the word "reasonable"
16 you write the word "pessimistic"?

17 A. Well, it is your word.

18 MR. LANCASTER: Are you suggesting
19 that word instead of "conservative"?

20 MR. HODGSON: Q. If a reasonable
21 value is the most likely value, then can I suggest
22 that the pessimistic value is a possible value but
23 less likely?

24 A. Yes, I can go along with
25 that.



1 Q. So, perhaps you can write
2 in brackets "possible but less likely".

3 A. Although I suppose the
4 pessimist would not agree with you.

5 Q. I don't want to drag the
6 pessimist into this discussion.

7 Can I ask you then, below
8 "pessimistic" to write in "highly pessimistic"
9 and can I suggest to you that "highly pessimistic"
10 means "still possible, but much less likely"?

11 Now, we have got "reasonable"
12 which is most likely; "pessimistic" which is
13 possible but less likely; "highly pessimistic"
14 which is still possible but much less likely.
15 Can I suggest that if we are going to work on a
16 continuum here that the next one that goes below
17 "highly pessimistic" would be "ridiculously
18 pessimistic" and that we would mean then, not
19 possible. Would that be acceptable?

20 For the purposes of having a range
21 so that we can describe things on a range, can we
22 have something that defines the end of the range
23 and this, I suggest, does. "Ridiculously
24 pessimistic" meaning "not possible". Can you
25 write in brackets there "not possible"?



1 A. I hate to say that anything
2 is not possible but recognizing that qualification
3 we will put that.

4 Q. Now, we are in the context
5 of contaminant hydrogeology so that may I first
6 suggest to you that when you have been using the
7 word "conservative" you mean something that was
8 pessimistic or highly pessimistic, something that
9 was less likely or much less likely as a reasonable
10 value, but a value that allows you to err on the
11 side of safety?

12 A. I don't mind. I mean,
13 obviously, we can go along with this. I think
14 this is an important distinction. I think this
15 is a matter of semantics here.

16 In contaminant hydrogeology,
17 "pessimistic" is not the same as "conservative".
18 To put it this way, if "pessimistic" is
19 "conservative" I tend to say that "reasonable"
20 is "optimistic" because you are being optimistic
21 about the fact that everything you have assumed is
22 correct and nothing is going to go wrong.

23 Q. Would you be happier if we
24 used the word "skeptical" rather than "pessimistic"?

25 A. I would be happier.



1 I recognize that we have had some problems with
2 when we mean conservative from one aspect or the
3 other, but I still think "conservative" is a good
4 word in this situation, Mr. Chairman. I have
5 difficulty with being pessimistic when you are
6 talking about a matter like contaminant hydro-
7 geology and impact on people's wells.

8 Q. You will recall, Dr. Charles-
9 worth, that you agreed with me that in assessing
10 these two sites that we should judge them on an
11 equal basis and the issue is how we get to an
12 equal basis.

13 A. That is the essence of the
14 problem facing the Board. They are two very
15 different situations.

16 Q. But one possibility would
17 be to have each of the hydrogeologists who comes
18 before this Board give his evidence on the basis
19 that what he is telling the Board is reasonable
20 and by that he means the most likely thing that
21 will happen at the site. Would you agree with
22 that? That would be a possibility?

23 A. Yes, given that my problem
24 with Site D is we don't think we will know what
25 will happen because we haven't got all of the



1 information. You can extract these hypothetical
2 values, you can get me to agree that 4×10^{-5} is
3 more conservative than 1×10^{-5} , but really there
4 is a dearth of information at the site and that is
5 the essence of my concerns about Site D.

6 Q. Let me take you back to,
7 I am sorry, did we mark the exhibit?

8 MR. LANCASTER: H-476.

9 MR. ESTRIN: I just wonder whether
10 Mr. Hodgson intends to elicit anything about this
11 piece of paper before we really mark it other than
12 the fact he has put some calculations to
13 Dr. Charlesworth, which he hasn't asked him about
14 except for one or two numbers.

15 MR. HODGSON: I am going to ask him
16 some more questions later.

17 MR. ESTRIN: I assumed you would,
18 but I wanted to know.

19
20 --- EXHIBIT H-476: Flow chart

21
22 MR. HODGSON: Q. If we could,
23 Dr. Charlesworth, look together at what happens
24 on Exhibit H-476 when we use different combinations
25 of values.



1 In the third column, I suggested to
2 you that using all of Trow's values you get a
3 groundwater velocity of 16 metres per annum and
4 you have accepted that subject to check.

5 A. Yes.

6 Q. If we simply, staying in
7 that column, vary the -- substitute the Geocon
8 gradient for the Trow gradient, groundwater
9 velocity becomes 25 metres per annum; is that right?

10 A. That's right, okay.

11 Q. Using three reasonable values
12 from Trow, you get 16 metres per annum. Using
13 two reasonable values from Trow and one conservative
14 value from you, we get 25 metres per annum.

15 Now the question comes, Dr. Charles-
16 worth, is 25 metres per annum a conservative value
17 or a reasonable value?

18 A. As I say, there are a number
19 of unknowns here. For example, the gradient you
20 have used in that calculation, I don't have a value.

21 Q. That's your gradient,
22 Dr. Charlesworth.

23 A. I qualified it by saying
24 that I had difficulties with interpreting that
25 kind of average gradient. If we accept that, in



1 terms of looking at the numbers, 16, I could say
2 that yes, 16 is reasonable and 25 is conservative.

3 Q. Are you saying 16 is
4 reasonable and 25 is conservative?

5 A. I am saying that there are
6 a number of unknowns here. It is difficult to
7 come up with an accurate number, but if you assume
8 that all those were reasonable values, then 16
9 would be reasonable and yes, 25 would be somewhat
10 more conservative.

11 Q. Now, could I take you to
12 the second column where we find the Geocon porosity?
13 Looking at the first value there, 32, that ground-
14 water velocity is generated by using Trow's
15 reasonable hydraulic conductivity, your conservative
16 porosity value and their reasonable gradient.

17 Now, we have a value that is double
18 the value we get using all of Trow's values. Do
19 you see that, it is 32 instead of 16. I would
20 ask you to accept the 32 subject to check.

21 A. Sure.

22 Q. So, we have substituted a
23 different conservative value for the conservative
24 value we substituted in the second line in the
25 third column. Now, we have gone from 16 metres



1 per annum to 25 metres per annum and now we are
2 up to 32 metres per annum. We have still only
3 substituted one of your three conservative values.

4 Is 32 metres per annum a reasonable
5 value, or a conservative value?

6 A. Based on the 16, it is a
7 conservative value.

8 Q. Then, moving down that
9 column, we substitute now your hydraulic conductivi-
10 ty of 4×10^{-5} , or substitute one that you have
11 agreed with me is a conservative value. We
12 substitute your porosity and we stay with Trow's
13 gradient and we have now got a groundwater velocity
14 of 130 metres per annum.

15 Now, first of all, on the range that
16 we put up on the board there between reasonable
17 and ridiculous, where is 130 metres per annum?

18 A. We are getting into an
19 almost hypothetical situation here. You can
20 carry this through and I will agree with you that
21 2,500 being the extreme would come down at the
22 bottom of your chart here. But, nevertheless,
23 there are variables in here and if you are being
24 reasonable on every one, then you arrive at a
25 reasonable value, Mr. Chairman, and not a



1 conservative value. Of course, you can reduce
2 any argument to absurdity, but somewhere along the
3 scale there, if you are dealing with a situation
4 such as a landfill, then I feel that you have to
5 be conservative. If you are going to err, you
6 should err on the side of being conservative in
7 situations of where wells are potentially at risk.

8 Q. Dr. Charlesworth, accepting
9 that you want to err on the side of being conserva-
10 tive, would you agree with me that it would be
11 helpful for this Board to understand how far on
12 the side of conservative you have erred?

13 A. Well, it would be helpful
14 for this Board to understand. I think it would
15 be helpful for the Board to know, obviously,
16 whether the conclusions are based on conservative
17 assumptions or not, certainly.

18 Q. Can I ask you to look at
19 Exhibit H-476?

20 A. Yes.

21 Q. Tell me whether or not
22 130 metres per annum is within the range of what
23 you, as an experienced contaminant hydrogeologist
24 would regard as possible at Site D?

25 A. I consider myself, by the



1 way, as a hydrogeologist, not specifically as
2 contaminant hydrogeologist.

3 Q. I am sorry, a hydrogeologist.

4 A. I mean, you do get ground-
5 water velocities of that kind of value. It
6 doesn't seem to me that you would get velocities
7 as high as that, I think you would not get velocities
8 as high as that in the unweathered upper till.
9 It sounds to be a high value.

10 Q. So, changing the language
11 from "not possible", it is very, very, very
12 unlikely, is that what you are saying, 130 metres
13 per annum?

14 A. I think it is unlikely it
15 would be that high.

16 Q. Well, Dr. Charlesworth, we
17 got 130 metres per annum using two out of three
18 of your conservative values because we still are
19 using Trow's gradient of 0.0052 and if you think
20 130 metres per annum is off the range of what is
21 possible at Site D, would you agree with me that
22 200 metres per annum, using all three of your
23 conservative values is also off the range of what
24 is possible at Site D?

25 A. Just as a point, we got



1 130 using a value which you put forward, it was not
2 my value. I suggested that 10^{-5} is a reasonable
3 value.

4 Q. You have also told the
5 Board on many occasions that they should use
6 conservative rather than reasonable values and
7 you propose it in your evidence a conservative
8 value for porosity of 0.0005 and a conservative
9 value for gradient of 0.008 have you not?

10 A. Gradient, I don't attach
11 a lot of importance to that, but the manner in
12 which, for example, the hydraulic conductivity was
13 raised was that Trow used a value of 10^{-5} and then
14 went to some length to demonstrate that this was
15 a conservative value and those were their words.
16 It was a conservative value. I said that based
17 on the information which they used, Mr. Chairman,
18 to show that it was a conservative value, their
19 argument was not valid. I did not consider it as
20 a conservative value, but a reasonable value.

21 Q. Let me take you back to
22 page 5-9 of Exhibit M-438. The last sentence
23 of that paragraph which is the last sentence of
24 the section, it is two-and-a-half, three-and-a-half
25 pages, three-and-a-third pages long. It is



1 called "Weathered Upper Till". That whole section
2 is pretty well all on the subject of what is the
3 hydraulic conductivity in that till because the
4 section is even entitled "Hydraulic Conductivities"
5 right?

6 A. Yes.

7 Q. The concluding sentence is:
8 "It is a reasonable but not a con-
9 servative value."

10 In the context of Exhibit M-438,
11 Dr. Charlesworth, I put it to you, first of all,
12 you didn't mean to be complimenting Trow, did you?

13 A. I thought there was an
14 important point to be made here, Mr. Chairman, that
15 Trow used their tritium values, presented this to
16 the Board as a way of calculating to show that
17 they would arrive at a lower hydraulic conductivity.
18 From the data I have before me there was a serious
19 flaw, appeared to be a serious flaw in the way that
20 that calculation was done and I felt it merited
21 drawing that to the Board's attention because the
22 data, as I interpreted it, the calculation there
23 and the data we had didn't support that contention.

24 They said, set up the argument that
25 this supports the contention that it is a



1 conservative value. I felt from what I saw that
2 it did not support that. That was the basis as
3 you referred to it.

4 Q. Do you not mean to be
5 suggesting in that sentence, that this Board should
6 use a conservative value and not Trow's value?

7 A. I mean to suggest that when
8 Trow say they have used a conservative value,
9 the evidence that I am pointing out, the evidence
10 they use to support that value is flawed.

11 Q. Well, let us go back to the
12 beginning, Dr. Charlesworth. How is the Board
13 to assess the potential for contaminant migration
14 through the weathered upper till? Are they
15 to assess that potential using Trow's three values
16 which you have described as reasonable values, or
17 are they to assess it using your three conservative
18 values?

19 A. I think that the Board has
20 to keep in mind when they are assessing the whole
21 thing that the value that Trow used was not
22 conservative and then see, whatever the outcome,
23 it is a qualifier. They qualified and then said
24 it was conservative. It is flagged there to say it
25 is probably not conservative and that is the



1 purpose of that. I think that is important.

2 Q. Would you agree this far
3 with me, Dr. Charlesworth, would you agree that
4 when you use the word "conservative" there are
5 degrees of conservatism?

6 A. Certainly.

7 Q. When we use one of your
8 conservative values, we get 25 metres per annum
9 and when we use two of your conservative values
10 we get either 32 metres per annum or 50 metres
11 per annum and that when we use three of your
12 conservative values we go off the scale of what
13 is likely to happen at Site D?

14 A. When we use three of the
15 values that you have presented on this table, yes.

16 Q. Now, what is your evidence
17 as the most reasonable, the most likely thing
18 that is likely to happen at Site D should contam-
19 inants ever get into this pathway of the upper
20 weathered till? How fast are they most likely
21 to move? What is your best evidence, as a
22 hydrogeologist, as to the most likely scenario
23 for Site D?

24 A. I think it can quite
25 easily be in the area of, for example, 32.



1 In that second column, using the lower porosity.

2 Q. Would you agree it can also
3 be in the order of 16?

4 A. It could be in the order of
5 16, certainly.

6 Q. Could it be as low as 0.8
7 metres per annum?

8 A. I think that the movement
9 will be more rapid than that in the weathered upper
10 till.

11 Q. And 1.3 metres per annum,
12 is that a possibility?

13 A. We are into the range of
14 possibilities. I think it would probably be
15 more rapid than that.

16 Q. So, can you give this Board,
17 your range of the most likely travel times for
18 any contaminant, let us just take water, first of
19 all. That is really what we are calculating here,
20 isn't it? What is the most likely range of
21 travel times in the upper weathered till? What
22 is your range, Dr. Charlesworth?

23 A. I would have to think about
24 that. I haven't attempted to calculate range
25 because I think there is a paucity of data on



1 which to base that. It could be anywhere
2 in that range along the top line depending on your
3 porosities. The porosity is a big unknown
4 in this and as we can see, there is quite a
5 difference between Mr. Feenstra's value and the Trow
6 value and the Gartner, Lee value.

7 Q. Would you agree with me
8 that for the purposes of the Board understanding
9 your evidence and for the purposes of the Board
10 assessing the likely risks of landfilling at
11 Site D, versus Site F, that if you are going to
12 give your evidence and your judgment as "conserva-
13 tive judgments" it would be useful for the Board
14 to understand how conservative you are being on
15 each occasion?

16 A. It is a factor that is
17 difficult to quantify. I think obviously ...
18 I think the Board have serious difficulties,
19 Mr. Chairman, in evaluating the two sites because
20 there are the unknowns at D which pose greater
21 problems than any unknowns that are at F.

22 Q. I want this discussion not
23 to be focussed on the relative merits of D or
24 F, but I want this discussion to be focussed,
25



1 if you will allow me this, Dr. Charlesworth, on the
2 way in which the Board is to interpret your evidence.
3 We have seen from H-476 that if we take three
4 conservative values and we multiply them together,
5 they don't stay within the range of what is likely
6 to be seen at Site D. Would you agree with
7 that?

8 A. If it is extended to
9 an unreasonably high rate, yes.

10 Q. We have also seen that if
11 we take one of your three conservative values and
12 multiply it, we get what you call a conservative
13 result and we have seen that if we take a second
14 of your conservative values and two of Trow's
15 values, we get 32 and you have also described that
16 as a conservative result but within the range
17 of what is possible.

18 A. Yes.

19 Q. Finally, we have seen that
20 if we use three conservative values, we start to
21 come off the scale of what is possible.

22 A. If you use three values,
23 yes. If you use those values that are there,
24 you start to reach -- when you combine them all
25 there is a degree of uncertainty posed by taking



1 three "reasonable values".

2 Q. All I want to establish,
3 Dr. Charlesworth, is that when you use the word
4 "conservative" there is a lot of room for play,
5 is there not?

6 A. Certainly, as we have
7 recognized. I must emphasise that Trow were the
8 ones that introduced the word "conservative".

9 Q. That may well be,
10 Dr. Charlesworth, but you have used it and the
11 question is whether or not it is useful to use or
12 whether or not it would be more appropriate to
13 simply discuss reasonable values and then discuss
14 safety factors that should be built in. Would
15 that be a reasonable thing to do?

16 A. I feel that the important
17 point here was that the proponents have claimed
18 to be conservative. It is fair to point out to
19 the Board that there are areas in which they have
20 not been conservative and areas which gave me
21 concern, because they have not necessarily been
22 conservative. If they are claiming to be
23 conservative. So, as I say, they were the ones
24 that introduced the word "conservative".

25 Q. Dr. Charlesworth, I would



1 like now to take you to a different subject, if I
2 could.

3 Could we focus now on Site F?
4 What I would like to explore with you for a while
5 is your interpretation of the flow system, flow
6 regime at Site F. Now, as I understand it,
7 you are suggesting that it is a homogeneous system.

8 A. No. I was suggesting that
9 for the purposes of doing the exercise that
10 Dr. Rowe was doing which I felt was a logical thing
11 to do in the light of the various other work that
12 had been done, including Trow's work, let us
13 consider it in this way. But, Mr. Chairman, I
14 have never said it is a homogeneous system.

15 Q. Is it a homogeneous system
16 in Dr. Rowe's model?

17 A. Yes.

18 Q. It has a uniform hydraulic
19 conductivity?

20 A. As we are modelling it, but
21 I must repeat, and I hope I have made that clear
22 earlier, Mr. Chairman, we have just presented
23 another scenario. I have some disagreement with
24 Trow's interpretation of the flow system there in
25 terms of the weight, at least in their earlier



1 model that they placed on the discharge zone,
2 because I did not see the evidence. I went out
3 to look to see if the discharge zone was there,
4 because it seemed that that was a real area of
5 concern. Trow's modelling had shown that even
6 if it discharged, they concluded it was not a
7 problem. This was an area of concern to the
8 citizens and the opponents of that site. I felt
9 it was important to look at that and I concluded
10 that there was not a discharge zone to the order
11 they were suggesting, certainly in the first bit
12 of their model.

13 In terms of their detailed breakdown
14 I said I had difficulty going from the step they
15 took from the stratigraphic to the hydrostrati-
16 graphic. I acknowledged that what they were
17 trying to do there, and I also acknowledged the
18 constraints I am sure they were working under in
19 terms of being consultants to that kind of project.
20 It is a complex situation as we have discussed in
21 detail. I don't know if they are wrong or not
22 but let us suppose they are wrong, let us suppose
23 -- let us look at that as a simple system and see
24 if that will explain what is happening.

25 It was an alternative approach, not



1 necessarily precluding theirs except I don't think
2 the discharge zone as such, functions.

3 Q. Accepting that, can we
4 discuss your alternative ... It is homogeneous
5 and has a hydraulic conductivity. You agree with
6 that. It is also assuming to be isotropic, is
7 it?

8 A. Yes.

9 Q. It is also as a flow system,
10 I take it, it is a long thin flow system. Is
11 that fair?

12 A. We looked at it recognizing
13 that all the water does not flow simply through
14 that. It is an idealization that is conservative
15 in the sense that I indicated before it probably
16 goes down and moves out of that zone, but to model
17 it, we will model it through there. It is a sort
18 of worst case from that point of view.

19
20 Q. In your alternative system,
21 there is recharge in the uplands and discharge
22 at the lower end.

23 A. My alternative, my overall
24 understanding of the flow system is not significantly
25 different from Trow's except for the discharge



1 zone. I want to make that quite clear. I
2 have flow from the highlands coming along here.
3 Trow have this component that comes up.

4 Q. I don't want you to get
5 into that for the moment, Dr. Charlesworth. I
6 appreciate that part of your evidence. I am
7 saying there is discharge at the low end and I
8 did not mean to suggest in the discharge zone.
9 The water goes in, it comes out. Every flow
10 system works that way, does it not?

11 A. What goes in, comes out.

12 Q. The recharge is in the uplands
13 and the discharge is in the lowlands and that is
14 part of the system.

15 A. The discharge from the
16 system, whether it goes through the shale or
17 whatever.

18 Q. Finally, there is a sloping
19 ground surface?

20 A. Yes.

21 Q. In your system there is
22 predominant lateral flow?

23 A. Yes. It has, obviously
24 a downward component, but yes, for the purpose of
25 the modelling, yes, certainly.



1 Q. Can I ask you,
2 Dr. Charlesworth, to put up an overhead?
3 Dr. Charlesworth, this is a figure from a segment
4 of, believe it or not, Dr. Cherry and Dr. Freeze's
5 book on groundwater. This is from page 196.

6 I first of all, just want to focus
7 you on this portion at page 196. I will be
8 asking you on other aspects of it later.

9 What I want to know, Dr. Charlesworth,
10 is whether or not this figure assists the Board
11 in understanding your proposal for the flow system
12 at Site F.

13 A. I suspect that it probably
14 doesn't just looking at it.

15 Q. Let us look at it for a
16 minute. What we have is a system that slopes
17 slightly to the left.

18 A. Yes.

19 Q. There is recharge in the
20 upland and discharge in the lowland.

21 A. Yes, that is correct.

22 Q. Could you just tell the
23 Board, first of all, what are the lines with
24 arrows on them?

25 A. Those will be flow lines and



1 these will be equipotential lines.

2 Q. What are equipotential lines?

3 A. These are lines of equal
4 head.

5 Q. Looking at the lines of
6 equal head on this figure, could you explain for
7 the Board what these lines tell us, starting from
8 the right-hand end and moving down towards the
9 middle of the figure?

10 A. They tell us that there is
11 a downward component of flow here.

12 Q. A downward component of
13 flow?

14 A. At the right-hand end.

15 Q. At the right-hand end, yes.

16 A. They then get into ,essentially,
17 horizontal flow because the equipotential lines
18 are vertical. Here again, you have recharge
19 coming, you have a downward component and then
20 an upward component to the discharge zone.

21 Q. Now, does that not reflect
22 what you are proposing as the flow system at
23 Site F? Is that not the flow system that
24 Dr. Rowe has modelled?

25

MS CRONK: I am sorry, Mr. Chairman,



1 I am not objecting, but the witness has said, and
2 I suspect that Mr. Hodgson, in fact, means this,
3 the witness has twice said, excuse me, Mr. Hodgson,
4 could you pick a place to stand?

5 The witness has twice said now
6 the system modelled by Dr. Rowe, is yes, uniform
7 isotropic. It has the other features that
8 Mr. Hodgson has described but that his view of the
9 system was different from that and in terms of
10 modelling, yes, it had those characteristics.

11 Mr. Hodgson, I think, is inferring,
12 that is twice now he has put it to him -- for
13 modelling purposes, the answer of the witness was
14 yes, that is correct. For the purposes of
15 modelling, the answer could be different. I
16 simply ask my friend to make the premise of the
17 question quite clear.

18 MR. HODGSON: I think I just asked
19 is this the flow system of the system that was
20 modelled by Dr. Rowe.

21 DR. CHARLESWORTH: No, not really.
22 This is a sort of regional pattern of what
23 Dr. Rowe has modelled. In detail, that is a
24 simplified ...

25 MR. HODGSON: Q. I don't really want



1 to focus on the left-hand end, I want to focus on
2 the right-hand end. Looking at the recharge in
3 the recharge area, is that the kind of recharge
4 that you are modelling?

5 A. We are not really modelling
6 recharge.

7 Q. But you are modelling a
8 system.

9 MR. ESTRIN: Mr. Hodgson --
10 Mr. Chairman, perhaps Mr. Hodgson would restrain
11 himself until the witness answers the question.

12 DR. CHARLESWORTH: We are modelling,
13 I suppose the best you could say looking at this,
14 is that Dr. Rowe has modelled a little piece some-
15 where in here.

16 MR. HODGSON: Q. Is that little
17 piece a piece of a picture that looks like this?
18 Does it look like a system that is homogeneous
19 in which the equipotential lines suggest, what
20 do they suggest, Dr. Charlesworth? Do not those
21 equipotential lines suggest very light downward
22 gradients?

23 A. The downward gradients,
24 horizontal gradients, a very uniform system, no local
25 variations in topography or anything superimposed



1 on that. A simplified idealized system on a
2 regional scale.

3 Q. I accept that. Are the
4 downward gradients in this figure weak downward
5 gradients or strong downward gradients?

6 A. Over here, they are strong
7 downward gradients, I suppose.

8 Q. Dr. Charlesworth, would
9 the equipotential lines be closer together if they
10 were strong downward gradients?

11 A. All things are relative.

12 Q. All things are relative, but
13 are these relatively strong here?

14 A. I am not sure
15 what the scale is here. I would have to check and
16 see what the scale is. It doesn't refer to that.
17 I think even allowing for exaggeration, even on
18 a real scale, I suspect we would see more of these
19 on the system that we are talking about. I
20 suspect that you would go higher.

21 Q. Is the system ...

22 A. Let us assume, so you can
23 develop your argument, Let us assume this is a
24 simplified representation of the system in which
25 case you would have surficial deposits spread
out across here.



1 Q. Are you comfortable with
2 that assumption?

3 A. Not entirely. I think it
4 is -- it doesn't quite fit the picture.

5 Q. You tell us then please,
6 because I want your evidence before the Board, what
7 fits the picture? If you want to take a pen out
8 and readjust that, please feel free to do so.

9 What I want is your evidence for
10 the Board describing the flow system that has been
11 modelled at Site F.

12 A. I am saying that we have
13 modelled a small part of that. We have not modelled
14 the regional flow system. The two are incompara-
15 ble.

16 Q. Can we just look then at
17 the right-hand end of the figure that is on the
18 overhead? In the small part that you have
19 modelled, have you modelled the situation where
20 there are weak downward gradients or mainly lateral
21 gradients?

22 A. We have assumed lateral
23 gradients, although we recognize there are down-
24 ward gradients.

25 Q. But you have modelled



1 lateral.

2 A. Yes.

3 Q. You have modelled lateral
4 gradients.

5 A. Modelled lateral gradients.

6 Q. Thank you, Dr. Charlesworth.

7 Now, Dr. Charlesworth, one of my
8 friends would like to have this marked,
9 Mr. Chairman, if we could mark the overhead.

10 MR. LANCASTER: H-477, I believe.

11
12 --- EXHIBIT NO. H-477: Overhead - page 196 from
13 "Groundwater" by Freeze
14 and Cherry

15 MR. HODGSON: Q. Dr. Charlesworth,
16 in preparing to give evidence in this proceeding,
17 did you have an opportunity to examine any of the
18 cores that were developed out of boreholes at
19 Site F?

20 A. Yes.

21 Q. Which cores have you
22 examined?

23 A. Four, six, eight, I would
24 have to check, a number of cores.

25 Q. Can you check here?



1 A. I would have to check in
2 Toronto, but certainly a number of them.

3 Q. You have examined the
4 core from Borehole HC-4-85?

5 A. Yes.

6 MR. HODGSON: Thank you. Mr. Chair-
7 man, I would now like to have Dr. Charlesworth show
8 us and talk to us about some of the core from
9 HC-4-85. It is sitting on the floor over there.
10 It may be simpler, and in fact, I would prefer to
11 do the following. Take all the lids off all the
12 boxes as they are over there so that the Board can
13 have us all go over there so that everyone can see
14 all of the core at once, and then I would like
15 Dr. Charlesworth to perform some specific tasks
16 on a certain portion of the core. For that
17 purpose, we will lift them up and put them on chairs
18 so it is easy for him to work and for him to
19 describe what I am going to ask him to describe.

20 Would that be acceptable to the
21 Board? Can we work over there?

22 MR. LANCASTER: As long as you
23 don't forget the Reporter. We had better take a
24 break.
25



1 --- Recess

2
3 MR. HODGSON: Q. Dr. Charlesworth,
4 I don't want this to be an extended exercise,
5 but first, Mr. Chairman, if we could mark this
6 box as the next exhibit. We have already marked
7 in evidence, HC-6, which is the other set of boxes.
8 This is HC-4-85. Can you confirm, Dr. Charles-
9 worth that this is a core taken from approximately
10 the middle of the proposed Site F?

11 A. Yes, that is correct.

12 Q. What I want you to do,
13 Dr. Charlesworth, is first, in looking at this
14 core, can you generalize, are there areas, would
15 you agree with me that there are areas in which
16 you find quite frequent fracturing and areas in
17 which you find much less frequent fracturing?

18 A. As the cores are at the
19 moment, yes, I would agree that is true. I
20 would qualify it in terms of what it really means
21 in terms of when it was in the ground.

22 Q. Why don't you qualify?

23 A. This core has been out of
24 the ground for a long time. It has been kicking
25 around, so there may be fractures that have



1 subsequently developed. I myself saw how it was
2 handled. So, I think the significance of the
3 fractures no longer has much meaning because you
4 can't tell, there may have been a fracture there
5 which was a closed fracture, it was not a flow path
6 necessarily. You can really only tell that when
7 it comes out of the ground. You have to log
8 it on the ground.

9 I also have another concern about
10 the whole thing. I don't believe these were
11 drilled with triple-tube drillers, a triple-tube
12 core barrel and maybe Mr. Sobanski ... I under-
13 stood they were not drilled that way and that is
14 a problem. Normally if you are seriously inter-
15 ested in logging fractures, there is a technique
16 known as triple-tube, where you have an inner core
17 barrel, it is a split tube and it tends to reduce
18 the torque on the core itself so that you don't get
19 -- it reduces the breaking in the ground. So,
20 I think from the time that they were actually taken
21 there are some concerns about what they do mean,
22 but I do agree that there are sections which show
23 no fractures and there are some other more broken
24 sections which may or may not have had hydrogeologic
25 significance when it was in the ground. At



1 least it is hard to assess the extent of that.

2 Q. We can correlate these
3 elevations later if necessary on Exhibit H-220,
4 but I would like you to look at the first three
5 boxes to the left.

6 The core runs, would you agree,
7 from the uppermost core on the left-hand side and
8 the bottom borehole on the right-hand side?

9 A. Probably. I would just
10 like to look. I seem to remember we looked at
11 these before. Some of the markers were in the
12 wrong places but the top 30, top 20, I am assuming
13 that is the top of the 20 feet and then it goes
14 down and then 30 feet.

15 Q. What we have is approximately
16 10 feet of core in each box?

17 A. That appears to be the case,
18 yes.

19 Q. Can you confirm that in
20 continuous coring there is always some core lost
21 so that for any 10-foot run of the core barrel,
22 we wouldn't necessarily have 10 feet of core.

23 A. There is usually core loss,
24 but not always.

25 Q. The point being that we can't



1 conclude anything from the fact that there might
2 not be 10 feet of core in each box.

3 A. No, it can be a function of
4 the quality of the rock, it can be a function of
5 the quality of the driller.

6 Q. You will find, Dr. Charles-
7 worth, in the fourth box from the left-hand side,
8 which is labelled -- I am sorry, I can't read that.

9 A. I am wondering about these
10 pieces lying on the ground, Mr. Hodgson, I am not
11 sure where they came from.

12 Q. The box labelled "Top 51"
13 in the middle, what we find in the core is a
14 label "weakly fractured shale" in the middle of
15 the middle column of the fourth box. Do you
16 see that?

17 A. Yes, I see that.

18 Q. I want you to, assuming
19 that is the point from which Trowhave interpreted
20 the weakly fractured shale, what I would like you
21 to do is starting at that point, I would like you
22 to assist the Board in interpreting the remains
23 that we now have, taking into consideration what
24 you have already told us about the contrast between
25 what would have come out of the ground in 1985 and



1 what is on the floor of this room in 1988.

2 A. Okay. I think there is an
3 interesting point right away, that I am assuming
4 is meant to be the top of the weakly fractured
5 shale. You can see immediately, for example,
6 we have a long run in this box.

7 Q. This is the third box?

8 A. This is the third box.

9 Q. You are referring to the
10 middle run in the third box?

11 A. Yes. I don't know what
12 the exact depth is, except there is a pretty
13 competent five feet of rock or so there with very
14 few fractures.

15 Q. Are there other areas in the
16 first three boxes where you have runs of competent
17 rock and runs of less competent rock?

18 A. There appears to be.
19 There is quite a broken up section here. That
20 being in the middle of the box that starts at
21 30 feet.

22 Q. In the middle run?

23 A. In the middle run, but what
24 that means in terms of what it was like in the
25 ground, is difficult to say. It is probably



1 broken up in the drilling process, more broken up
2 than it was in the ground.

3 Q. Is it likely that it was
4 broken up in the ground?

5 A. I would say that it is
6 likely that it was. In fact it is sort of,
7 there is actually a mud zone in there an unconsoli-
8 dated zone. That is the kind of zone that was
9 probably not very permeable in the ground, but
10 breaks up during drilling and looks rubbly almost,
11 to use Mr. Tidball's expression.

12 Q. Looking at the first
13 three-and-a-half boxes to the top of the weakly
14 fractured shale, can you agree with me that where
15 we find what are obvious now as fractures that would
16 have existed in the ground where we tend to find
17 more than one clustered together.

18 Do you agree that we find clusters
19 of fractures?

20 A. There are zones, yes,
21 there are zones like the one I referred to here.

22 Q. Here being?

23 A. Here being the top of Box
24 20, but it is difficult to know. That is probably
25 induced, but maybe it is original. It may be an



1 original fracture. I suppose you can say there
2 are some clusters, there are zones going towards
3 the far end of Box 20 where there is a cluster of
4 fractures.

5 Q. Did I hear you correctly, are
6 you telling us that, assuming that a hydrogeologist
7 was either on-site while the drilling was taking
8 place or logged these cores immediately after that
9 the hydrogeologist would have a better opportunity
10 to decide whether or not a particular fracture
11 which obviously had existed in the ground, was a
12 fracture that carried water in the ground?

13 A. I personally would not assign
14 a hydrogeologist to log the cores initially as
15 they came out of the ground. I would assign an
16 experienced geologist who is more geological than
17 hydrogeological. That is just a point.

18 Q. Could an experienced geologist
19 tell whether or not some of the fractures carried
20 water and some did not?

21 A. Yes, there could be an
22 indication of that.

23 Q. But not today?

24 A. I think it is difficult to
25 tell today. The cores have been out of the ground



1 so long.

2 Q. Now, Dr. Charlesworth, I
3 hope this won't take too long, but I would like
4 to take the last five boxes, and starting with
5 the section labelled "weakly fractured shale"
6 I would like you to run down the cores that remain
7 and identify for the Board, which fractures in
8 your professional judgment existed in the ground
9 and which fractures are related to drilling,
10 handling, drying out or whatever and if there are
11 some that are in doubt, indicate the doubt and we
12 will all keep track by counting because what I
13 would like to produce from this is some kind of
14 record of how many cracks we have in the weakly
15 fractured shale and how many we have in the highly
16 fractured shale.

17 So, starting at the top of the
18 weakly fractured shale, could you go crack by crack
19 and tell the Board for the record, whether or not
20 the particular fracture existed in the ground.

21 A. Recognizing, and I don't
22 want to be difficult about this, but you are
23 asking me to do something which I think is, as I
24 say, given all the qualifications I have made, it
25 is quite difficult. I would think that the first



1 one and the second one was probably in the ground.
2 It is kind of muddy in there.

3 MR. LANCASTER: What do you mean by
4 "in the ground"?

5 DR. CHARLESWORTH: It existed in the
6 ground, fractured in the ground.

7 MR. HODGSON: Q. So, we are at 2.

8 A. I suspect there was a natural
9 weakness in there of some sort and it broke up.

10 Q. Is that 3 or 4?

11 A. I would say that is a zone
12 there of fractures.

13 Q. Can we call it just number
14 3?

15 A. Call it number 3.

16 I would say that is probably 4.

17 It is difficult to say now. That looks like it
18 is a fairly clean break. Yes, that looks like a
19 break. That one is not so clean. I suspect
20 in general that was a fairly competent piece of
21 rock in the ground so I would be inclined not to
22 count those two. I don't know what has happened
23 here. I guess that is the end. Maybe 5.

24 Q. So, in the first box we
25 have maybe 5?



1 A. Yes. Here we have an
2 unusual feature. It is a CRA fracture, it looks
3 like Conestoga Rovers has taken a piece that had a
4 natural fracture at one end and a break at the other.

5 Q. So, are we at number 6?

6 A. Probably. I thought you
7 were keeping count. Seven, I would say, and this
8 looks like a machine break. That is quite an
9 interesting one. On first examination, that
10 looks clearly like a machine break. On first
11 examination that looks clearly like a machine break
12 but when you look inside, there is actually, it
13 may be the effect of it sitting around for a while.

14 Q. For seven?

15 A. Probably, yes, seven.

16 Q. Was the last one a fracture
17 or a break, Dr. Charlesworth?

18 A. I am not sure.

19 Q. Shall we call it seven and
20 a maybe?

21 A. I think we could call
22 seven maybe and a possibly. That is broken
23 there, isn't it?

24 Q. Is that a vertical fracture,
25 Dr. Charlesworth?



1 original fracture. I suppose you can say there
2 are some clusters, there are zones going towards
3 the far end of Box 20 where there is a cluster of
4 fractures.

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6 you telling us that, assuming that a hydrogeologist
7 was either on-site while the drilling was taking
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20 water and some did not?

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22 indication of that.

23 Q. But not today?

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25 tell today. The cores have been out of the ground



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10 Q. Is that 3 or 4?

11 A. I would say that is a zone
12 there of fractures.

13 Q. Can we call it just number
14 3?

15 A. Call it number 3.

16 I would say that is probably 4.

17 It is difficult to say now. That looks like it
18 is a fairly clean break. Yes, that looks like a
19 break. That one is not so clean. I suspect
20 in general that was a fairly competent piece of
21 rock in the ground so I would be inclined not to
22 count those two. I don't know what has happened
23 here. I guess that is the end. Maybe 5.

24 Q. So, in the first box we
25 have maybe 5?



1 A. Yes. Here we have an
2 unusual feature. It is a CRA fracture, it looks
3 like Conestoga Rovers has taken a piece that had a
4 natural fracture at one end and a break at the other.

5 Q. So, are we at number 6?

6 A. Probably. I thought you
7 were keeping count. Seven, I would say, and this
8 looks like a machine break. That is quite an
9 interesting one. On first examination, that
10 looks clearly like a machine break. On first
11 examination that looks clearly like a machine break
12 but when you look inside, there is actually, it
13 may be the effect of it sitting around for a while.

14 Q. For seven?

15 A. Probably, yes, seven.

16 Q. Was the last one a fracture
17 or a break, Dr. Charlesworth?

18 A. I am not sure.

19 Q. Shall we call it seven and
20 a maybe?

21 A. I think we could call
22 seven maybe and a possibly. That is broken
23 there, isn't it?

24 Q. Is that a vertical fracture,
25 Dr. Charlesworth?



1 A. That is what I am looking to
2 see. It looks like it, yes. Yes, I would say
3 certainly on this piece there was a vertical
4 fracture and this piece has broken off here.

5 So, yes, it looks to me as if there
6 is a vertical fracture in there.

7 Q. Do you find much vertical
8 fracture in these cores?

9 A. I didn't, when I looked at
10 them before with Mr. Beechinor, there was not as
11 much vertical fracturing as I would have expected.
12 But then, if it is truly vertical rather than
13 sub-vertical, you will tend to miss it with a
14 vertical borehole. Well, there is another one
15 in there.

16 Q. That is number 8?

17 A. Probably. I would say 9.

18 This is interesting here. A
19 disc of, I guess, probably gypsum which came out
20 rather nicely in the core.

21 The rock breaks very easily so --
22 I would say we are up to about 11, 12 say. I
23 suggest some of these probably were natural fractures
24 or weaknesses in the rock, but there was no flow
25 taking place through them so they were closed, very



1 impermeable fractures that opened up.

2 Q. Do you want to give us a
3 number?

4 A. No. Quite a different
5 appearance to some of these fractures.

6 Q. Dr. Charlesworth, we are
7 losing count. How many are we at?

8 A. I don't know, around 20
9 maybe.

10 Q. Do you mind giving them to
11 us one at a time so that we can keep track?

12 A. Well, to some extent, yes,
13 because I think what I am doing is not a very
14 accurate exercise.

15 Q. I appreciate it is not
16 accurate, but it is the best that we can do today.

17 A. Say 22.

18 Q. Excuse me, we are at the
19 break with the highly fractured shale and the
20 label here says "77 feet". So, exclude anything
21 that you encountered at the end of the highly
22 fractured shale, how many do you get? Is it
23 around 22?

24 A. I would say around 20, 22.

25 Q. Can you estimate the length



1 of the core run in the weakly fractured shale?
2 It is labelled there "57 to 77". Will you accept
3 subject to checking later, that what we are looking
4 at was 20 feet of core run and that we have got
5 20 fractures?

6 A. Maybe, yes. Some of these
7 could be machine breaks. To be conservative I
8 would say there were 20, but I think some of them
9 are open to conjecture.

10 Q. Is an estimate of one
11 fracture per foot of core run a reasonable
12 estimate?

13 A. I would think so, yes.

14 Q. Could I ask you to go through
15 the highly fractured shale, starting here where it
16 is labelled "highly fractured" and carry out the
17 same exercise.

18 A. One, two, three, then there
19 is a zone in here. Maybe we should count that
20 as 3 or 4, say 5.

21 Q. Just stopping there and
22 if we can ask everyone else to remember we were
23 at 5. Would you agree with me, Dr. Charlesworth,
24 that where we find a zone with a series of
25 fractures that are fairly closely spaced, that it



1 is likely that in the ground, not only would you
2 find those fractures laterally extensive, but also
3 because they are so closely spaced that there would
4 be some interconnection between them.

5 A. You would find breakage,
6 yes, there wouldn't be planes that were separated.
7 You would have a zone there.

8 Q. A lot of vertical fracturing
9 as well.

10 A. I would expect in that
11 kind of situation, yes, you would have horizontal
12 and vertical fracturing.

13 Q. So, if there was a zone in
14 which there is more flow, is that likely to be in
15 the zone?

16 A. Yes, I would expect so.
17 I should say that when I looked at these, I found
18 a reasonable correlation on the holes that I looked
19 at between Trow's logs and their stratigraphic
20 correlation. Certainly, where they have zones
21 marked, a bunch of fractures shown, you could see
22 those in the cores and there were sections like
23 that that I pointed to which were clearly very
24 competent rock. There were other zones that
25 when you got down to the specifics, it was hard to



1 be sure that you had moved from one zone to the
2 other in detail, but in general terms, I think --
3 I thought there was a reasonable -- recognizing
4 that you are not logging it when it comes out of
5 the ground, I thought that there was reasonable
6 correlation.

7 Q. Recognizing that the
8 difficulty of the task is great, I have asked you
9 to perform, could you take a quick run through the
10 highly fractured shale and estimate for the Board,
11 what you believe were the likely numbers of frac-
12 tures that identified set of core runs? I
13 don't want you to go any faster than you feel
14 comfortable with, I recognize it is an imperfect
15 exercise.

16 A. There is obviously a natural
17 fracture that is infilled essentially with a mud.

18 Q. Do you want to give us a
19 number to the end of that box?

20 A. About 21.

21 Q. I read somewhere that if you
22 want to see the world become a geologist and if
23 you want to body-build, be a geologist.

24 A. But don't get involved in
25 landfills, it is no fun.



1 There we have some vertical
2 fracturing.

3 Q. Is that the second vertical
4 fracture you have identified since we started this
5 exercise?

6 A. Yes, it is.

7 Q. Have you any sense of how
8 long that vertical fracture is? Can you give an
9 estimate?

10 A. No, because the core above
11 it appears to be missing. It appears to be a kind
12 of three-way system.

13 Q. Is that about four inches in
14 length?

15 A. Yes.

16 Q. Is it fractured at the top
17 and bottom naturally?

18 A. Yes, it appears to be.
19 I would say that it is. It goes out of the core
20 to the side there.

21 Q. Dr. Charlesworth, can I stop
22 you there? You commented that a piece of the core
23 appears to be missing. Each of these boxes is
24 intended to contain 10 feet of core. Eyeballing
25 it, would you agree that in fact that box contains



1 10 feet of core?

2 A. Is that a five-foot length?

3 If it is a five-foot length, it contains more, or
4 is it four feet, probably about nine feet here.

5 MR. LANCASTER: Does that not tell
6 you there?

7 DR. CHARLESWORTH: Yes, it probably
8 does.

9 MR. HODGSON: Q. Coming into this,
10 we were at what?

11 DR. CHARLESWORTH: Twenty-one
12 until I came into this box.

13 Q. Yes.

14 A. We are still in the highly
15 fractured zone, the zone that was mapped is that?

16 Q. Yes, we are.

17 A. Here we have a fairly
18 competent piece which may be a machine break in
19 the middle, about 35, 36.

20 Q. In total, or in that box?

21 A. In total, I am up to that.

22 Q. Before you leave this box,
23 would you mind taking this yardstick or metrestick
24 actually, and for the record indicate for the
25 Board, how long the core run is in this box?



1 So, there is four feet, nine inches
2 for each length of the core.

3 A. So, you have 10 feet plus
4 in this box. Of course, they are spaced out.

5 Q. Just if you would, stand up
6 and eyeball the other boxes. Would you agree
7 that each box contains roughly 10 feet of core?

8 A. Yes, I would agree.

9 Q. We are not missing very much
10 core, if any?

11 A. There is not much core
12 missing.

13 Q. You are finished with this
14 box?

15 A. Yes.

16 Q. Before we conclude, towards
17 the end of the core in this box, I am pointing to
18 a zone that appears to be two fractures up from
19 the end, can you indicate for the Board what you
20 find there?

21 A. Well, there is a sort of
22 rubbly zone here, quite broken up. There appear
23 to be natural fractures.

24 Q. Is it possibly a more
25 permeable zone?



1 A. I think it is possibly
2 a more permeable zone, although, I think it is
3 reasonable to assume that it is.

4 We start off here with a similar ...

5 Q. We are now in the last box
6 at the very top of the core and you are identifying
7 it as a zone of ...

8 A. A zone of broken up rock
9 followed by a competent piece.

10 Q. We are at 36. How many
11 do you want to assign?

12 A. I will assign 2 or 3 to that.

13 Q. So, 39?

14 A. Say 39. And another zone
15 level with that, I will assign 3 to that, 51, 52,
16 another little zone in here. I should make a
17 note of caution that these kinds of zones may not
18 be as permeable as they appear. I think it is
19 reasonable to assume they are, but it is conceivable
20 that there is deposition in there, they are not
21 clean fractures, it is not a clean zone so ...

22 Q. You mean a clogging?

23 A. A sort of clogging,
24 something like tile drains, yes.

25 Q. Is that another vertical



1 fracture?

2 A. That is a vertical fracture
3 here.

4 Q. That is the third one?

5 A. Yes. I think I am up to
6 about, say I think I was up to 62 or 63, something
7 in that order.

8 Q. Could you just -- looking at
9 where you started which is two boxes in the last
10 row, roughly one foot from the top, could you
11 just estimate for the Board how many feet of core
12 run you have been examining?

13 A. Twenty-five feet.

14 Q. Which do you want it to be
15 for the purposes of your evidence?

16 A. I think this is so vague,
17 it doesn't make a lot of difference. You can
18 have it as 24 feet.

19 Q. Twenty-four feet and you
20 have got 62 fractures?

21 A. I was adding in extra ones
22 for the zones, but yes,

23 Q. Is that approximately
24 2.5 fractures per foot of core run?

25 A. That would be correct, yes.



1 Q. Recognizing that the core
2 has been altered since it came out of the ground,
3 would you agree with me, notwithstanding that that
4 in relative terms, that is the number of fractures
5 in the so-called weakly fractured shale, the number
6 of fractures in the run identified as the highly
7 fractured shale, the portions would be roughly the
8 same in the ground as you find now, recognizing...

9 A. I just want to think about
10 that, if you will just give me a moment.

11 Yes, I suppose that is a reasonable
12 assumption to make given the ballpark kind of
13 figures we are working with, yes.

14 Q. Thank you, Dr. Charlesworth.
15 Those are all the questions I have on these boxes
16 of core.

17 A. It is interesting to look
18 when you stand back, there is a difference but
19 there is not a bigger difference for example between
20 the highly fractured zone and the weakly fractured
21 zone as there is between the highly fractured zone
22 and this zone that was not mapped as the weakly
23 fractured zone. That is quite distinctive.

24 Q. You are referring now to
25 the third box, the middle core run?

A. Yes.



1 Q. You find there a zone of
2 what? How would you describe that zone?

3 A. I would describe that as
4 weakly fractured. I mean, it is almost unfrac-
5 tured along a five-foot length.

6 Q. In terms of permeability
7 what can you tell the Board about that zone?

8 A. That would be less permeable
9 than -- one would assume it would be less permeable
10 than the other zones, it is less fractured.

11 Q. Thank you very much,
12 Dr. Charlesworth.

13 Mr. Chairman, we were looking at
14 eight boxes of cores, and I wonder if that could be
15 the next exhibit.

16 MR. ESTRIN: Just on that point,
17 I am going to have a number of questions. I may
18 have questions. I would like ...

19 Dr. Charlesworth has raised numerous
20 ways in which what we are looking at here may have
21 been affected from the way it was derived in the
22 field. I am wondering if Mr Hodgson will assure
23 me that if I wanted an opportunity to examine those
24 persons who handled the core from the moment it was
25 taken in the field to the time it arrived here, I



1 would have that opportunity as his witness so that
2 I could cross-examine, or at least not have to be
3 restricted to non-leading questions.

4 MR. HODGSON: I don't see, Mr. Chair-
5 man, how I could reasonably object to that if you
6 ruled that you thought that evidence would be useful
7 to you.

8 However, before you made such a
9 ruling, I would like to explore whether or not that
10 evidence would be useful to you and I would like to
11 do it with these witnesses. I would like to
12 do it with Dr. Charlesworth, I think I have already
13 explored it with Dr. Charlesworth. I tried to do
14 that as we started.

15 Q. What I would like to ask you,
16 Dr. Charlesworth, is, can you be reasonably
17 comfortable in looking at a core as it exists
18 today in identifying breaks that were clearly
19 breaks that were made subsequent to the core being
20 taken out of the ground, are these fairly clearly
21 and easily identified?

22 A. There is some room for
23 ambiguity, but I think you can get an overall
24 appreciation. It is also interesting to note,
25 Mr. Chairman, I am just looking at Figure 2 in



1 Exhibit H-40 and just by way of general interest
2 but the zone that I commented on that looked
3 particularly competent in there but was not in
4 the weakly fractured zone was from the 40-foot
5 mark which shows on that figure there as being
6 unfractured. It is in the moderately fractured
7 weathered shale zone.

8 Q. You are looking at which
9 figure from H-40?

10 A. I am looking at Figure 2.
11 Yes, it is interesting, around the
12 125-metre elevation which is about the 40-foot
13 mark in depth in HC-4, and that competent sample
14 that I noted was not in the weakly fractured unit
15 started at 40 feet, so you can see it has been
16 logged there and then they went into a more
17 fractured piece just above the weakly fractured
18 massive shale. I think it is interesting that
19 just the figures I came up with preliminarily
20 there, I think it was what, about 0.3 of a metre
21 spacing or something in the weakly, and about 0.1 in the highly
22 fractured. I notice there are no fractures
23 logged on the core there for the weakly fractured
24 massive shale.

25 Q. Dr. Charlesworth, do you



1 think that we could more closely identify which of
2 the fractures that now exist in the core runs that
3 are exhibited, what is the exhibit number, I am
4 sorry?

5 MR. LANCASTER: I am sorry.

6 MR. HODGSON: Is this 477?

7 MR. LANCASTER: This will be 478.

8

9 --- EXHIBIT NO. H-478: Core runs

10

11 MR. HODGSON: Q. Do you think that
12 the fractures that are now shown in the core run
13 in Exhibit H-478, could be more carefully divided
14 between fractures that existed prior to drilling
15 and fractures that existed as a result of drilling,
16 carrying, drying out, being dropped or carried to this hearing?
17 Do you think as between the two kinds of fractures
18 we could more closely identify which was which if
19 we had evidence from all the people who handled
20 the cores since they were taken out of the ground?

21 In other words, Dr. Charlesworth,
22 are you satisfied that your evidence is reasonably
23 accurate and useful to this Board as to the number
24 of fractures that probably existed in the ground?

25

A. I can't, I don't know if it



1 is useful to the Board or not and I think it is of
2 limited value, but I am not sure that having anyone
3 else look at it now would necessarily facilitate
4 any more detailed interpretation. There was a
5 question about how it was drilled in the first place
6 as well. I think I can accept, I personally can
7 accept some kind of general overall scenario.

8 Q. Thank you.

9 MR. ESTRIN: Mr Hodgson has asked
10 this witness about what conclusions for his purposes
11 he might be prepared to draw based on the cores as
12 they are presented. I have to concern myself
13 about argument that Mr. Hodgson and other parties
14 may wish to make later on. I would simply wish
15 to indicate that I would like to reserve, have the
16 opportunity of asking Mr. Hodgson, after I hear
17 the whole of this cross-examination, have the
18 opportunity of having Mr. Hodgson bring here, if I
19 require it, some of the people at least who have
20 been involved in handling that core. I don't
21 know where all of this is going so I am not
22 pressing at this point, but since Mr. Hodgson
23 feels it important to see the core and have my
24 hydrogeologist comment on it, and not his, at least
25 to this point, I have some lurking concern that



1 perhaps I should preserve my rights.

2 MR. LANCASTER: That sounds reason-
3 able.

4 MR. HODGSON: The proponent will not
5 take the position that evidence this Board will want
6 to hear will be withheld from this Board.
7 I think the easiest way to resolve this, Mr. Chair-
8 man, is if Mr. Estrin has evidence he wants to call,
9 let him call it. If he wants to know who has handled
10 the cores, I will supply him with a list of names
11 and he can call his witnesses himself.

12 MR. ESTRIN: That's not what I am
13 asking for and I don't think we have the facility
14 to determine at this time -- if I can convince
15 the Board at some point, if I come to the position
16 that that evidence is going to be germane to the
17 Board to have in evaluating what all this means,
18 the fair and only possible way for it to be put
19 in is through the Board directing Mr. Hodgson to
20 call the people from his consulting firms that
21 handled the core. He can examine them and if
22 there are any questions, I can put those, but we
23 don't have to determine that now.

24 MR. LANCASTER: No.

25 MR. HODGSON: Q. Dr. Charlesworth,



1 I wonder if you could just review with me a little
2 bit of history so that we can -- you can describe
3 for the Board how it is that the fractures that we
4 have been looking at came to exist in those cores.
5 It might assist us in interpreting the geology and
6 the hydrogeology of this site. Would you agree
7 with me, Dr. Charlesworth, that this shale material
8 was laid down in a sea of some sort of unknown depth
9 about 450 million years ago?

10 A. Yes, I have in the back of my
11 mind, 350 million, but I won't quibble about
12 100 million.

13 Q. Neither, Dr. Charlesworth,
14 will I. And would you agree with me that after
15 this material was laid down in the sea, that other
16 material was laid down on top of it?

17 A. Yes.

18 Q. And there was at least another
19 thousand feet of rock laid down on top of this
20 segment of rock?

21 A. I don't have those kind of
22 figures to mind. It sounds a reasonable number.
23 I won't argue with you, but I won't say, it is
24 probably reasonable.

25 Q. Is it in the ballpark?



1 A. It probably is, yes.

2 Q. If it is in the ballpark,
3 does that mean there was a lot of weight put on this
4 material?

5 A. Yes.

6 Q. Now, geologists have a word
7 to describe a situation where rock that was once
8 buried is now unburied. It is called a major
9 unconformity; is that right?

10 A. No, that doesn't describe
11 the process. Most rock that is exposed, all rock
12 that is exposed was once buried. A major un-
13 conformity is where you had a sequence of rocks
14 laid down, then you had them eroded and for example,
15 there could be more rocks deposited on top, but
16 between where there is a major break in the succes-
17 sion.

18 Q. Perhaps as between the tail
19 and the top of the weathered shale, there is a
20 major unconformity.

21 A. Certainly, that is right.

22 Q. The major unconformity is
23 the aproximate 1,000 feet of rock that was laid
24 down on top of this rock is now gone; is that
25 right?



1 A. Yes.

2 Q. Whether they are simultaneously
3 or subsequent and I don't know whether you can help
4 us with that, Dr. Charlesworth, four major
5 glaciations have passed, have they not through this
6 area?

7 A. Yes.

8 Q. It is likely that glaciers
9 have sat on top of this more or less exposed
10 shale at various times in the past?

11 A. Yes.

12 Q. And those glaciers may have
13 been up to two miles in thickness?

14 A. Yes.

15 Q. That again, would have put
16 a great deal of pressure on these rocks?

17 A. It certainly would.

18 Q. At some time during the
19 time that those glaciers sat on top of this rock,
20 is it possible that this whole area was below
21 sea level?

22 A. Yes.

23 Q. In fact, this part of Ont-
24 ario would have been depressed by the weight of
25 that glacier?



1 A. It could have been depressed,
2 yes.

3 Q. After the glacier, the
4 last glacier withdrew or perhaps as each glacier
5 withdrew, there would be a certain element of
6 rebound?

7 A. Yes.

8 Q. So that the area would then
9 again rise above sea level?

10 A. From whatever level it
11 would have been depressed to, there would have
12 been an uplift as a result of the release of
13 pressure.

14 Q. Can we assume that it is possible
15 at least, or can we assume that the fracturing
16 that we now see in the shale, this fracturing that
17 occurred as a result perhaps of the stripping off
18 of the rock overlaying this shale and/or the
19 movement of the glaciers and the removal of the
20 glaciers from the rock?

21 A. And the release of the
22 pressure, the uplift pressure, yes that is a
23 reasonable assumption.

24 Q. Now, would you agree with
25 me, Dr. Charlesworth, that the fracturing that



1 we see is somewhat unpredictable. There is no
2 uniformity to it, that there are zones of more
3 fracturing and zones of less fracturing.

4 A. Yes. There is certainly
5 a variability there.

6 Q. As the shale exists out at
7 Site F, would you agree with me that it dips
8 slightly towards the direction of Detroit?

9 A. Yes.

10 Q. But for the purposes of
11 our discussion, can we assume it is virtually
12 horizontal?

13 A. Yes, I think I made that
14 statement and other people have.

15 Q. And therefore, the plane
16 of it, as it were, is more or less parallel with
17 the surface of Lake Ontario.

18 A. A slight dip but almost
19 horizontal.

20 Q. And the fracturing that we
21 see, would you agree as fracturing along bedding
22 planes.

23 A. Yes, it appears to be
24 predominantly -- there were predominantly
25 horizontal fractures.



1 Q. Bedding planes are horizontal
2 to Lake Ontario as opposed to horizontal to the
3 surface of Site F?

4 A. That is correct, yes.

5 Q. Now, as it sits on the
6 ground, is this shale isotropic or anisotropic?

7 A. It is anisotropic.

8 Q. When you have selected a
9 value for the hydraulic conductivity of this shale
10 of 4.5×10^{-6} are you assuming it is anisotropic?

11 A. For the purposes of that
12 assumption, well, we have taken the values and we
13 have assigned one value, so I guess inherent in
14 that process is -- no, the value we have assigned
15 is a horizontal permeability.

16 Mr. Chairman, the value we have
17 assigned is a horizontal permeability because the
18 values that we had were the values derived from
19 the various investigators, the tests that were
20 conducted essentially measure horizontal permea-
21 bility because you are injecting or taking out
22 water and it will move along the horizontal
23 plane. The value that we have assigned is
24 -- this mean value we have derived is based on
25 horizontal values.



1 Q. Horizontal values. Have
2 you assumed the rock is isotropic?

3 A. For the purposes of
4 modelling, we assumed it was isotropic. For
5 the purposes of achieving this value, it was
6 simply an exercise to achieve a mean value.

7 Q. Can I take you to your
8 Exhibit M-445?

9 First of all, Dr. Charlesworth, can
10 you put this up on the board there? And would
11 you indicate -- this is cross-section A-A from
12 Exhibit H-40. It doesn't appear to be marked
13 and I don't want to mark this one because I can't
14 identify who wrote on it, but since it is Exhibit
15 H-40 already in evidence, I don't think we have
16 to mark it separately.

17 Can you identify, from Figure 6,
18 Dr. Charlesworth, the maximum elevation of the
19 shale on Site F, on proposed Site F?

20 A. The maximum elevation of
21 the shale would be up here about 170.

22 Q. One hundred and seventy.
23 Would you indicate the height, the maximum height
24 of the shale at Lake Ontario?

25 A. Seventy-five, maybe.



1 Q. Would you agree with me then
2 that a drop of water that enters Site F at the
3 maximum height of the shale, 170, would have to
4 travel vertically, a total of 95 metres in order
5 to exit at Lake Ontario?

6 A. Yes.

7 Q. Now, looking briefly at
8 Exhibit M-445R, is there any magic, Dr. Charles-
9 worth, to the selection of a chloride concentration
10 of 5,000 milligrams per litre?

11 A. No, there was nothing magic
12 to it. It seemed from looking at the profile of
13 the chlorides that that was a zone where it did
14 seem to increase quite dramatically below that.
15 That was why we took that and then of course we
16 extended it down 25 metres below that.

17 Q. And in drawing that dotted
18 line, which I take it is your representation of
19 the division between the more than and less than
20 5,000 milligrams per litre of chloride.

21 A. Not really. That is the
22 line that represents what I have called this
23 upper zone.

24 If you take the 5,000 contour, it
25 comes out much closer as you get in the vicinity of



1 403 here. That was the starting point, but as
2 I discussed the other day, I think other processes
3 come into play and as you start going down gradient
4 the salinity does increase in the water. So,
5 that line, 5,000 comes up quite close in this
6 vicinity here. I have an overhead.

7 Q. Can I show you, Dr. Charles-
8 worth, I am happy to look at your overhead, but
9 could you also consider H-40-D21?

10 A. Yes.

11 Q. Can you read off the legend,
12 what does the blue line represent on H-40-D21?

13 A. The blue line is the 1,000
14 parts per million chloride.

15 Q. Are there lines beneath the
16 blue line that reflect other levels of concentra-
17 tion?

18 A. There is the 5,000 below
19 that.

20 Q. Would it be too much trouble
21 to take a marker and mark it? A red pen, it
22 doesn't matter what colour, anything but blue,
23 and mark it in.

24 DR. ROWE: While he is doing that,
25 Mr. Hodgson, can I just ask, you mentioned, you asked



1 Dr. Charlesworth about the drop in the shale down
2 to Lake Ontario. You didn't say anything about
3 the distance. These scales are very distorted,
4 askew.

5 MR HODGSON: I appreciate that,
6 Dr. Rowe.

7 DR. CHARLESWORTH: That is the
8 5,000 contour I plotted there.

9 MR. HODGSON: Q. Now, would you
10 agree with me that the 5,000 contour, to say the
11 least, is irregular?

12 DR. CHARLESWORTH: A. Yes. We are getting into
13 semantics again. It is a reasonably level along
14 here, but it does fluctuate, yes. It is not a
15 straight line.

16 Q. And it has been drawn
17 between data points, has it not?

18 A. It has been based on data
19 points from the Trow boreholes predominantly.

20 Q. Looking at the most
21 northerly extremity of the 5,000 contour line.

22 A. Right.

23 Q. Would you agree with me that
24 it is unlikely to be that regular in the field?

25 A. Certainly. I mean, it is



1 unlikely, for example to be at any given point
2 where it is drawn. Chances that you have drawn
3 it where it really is when you are interpolating
4 between points, it probably isn't at that point.

5 Q. Can you suggest an alterna-
6 tive route for it?

7 A. It is reasonable to draw
8 it. I am just pointing out that it is not,
9 it is an interpolation and not a real fact.

10 Q. Does it vary significantly,
11 as a distance from the ground surface to the 5000
12 contour?

13 A. Yes.

14 Q. It does?

15 A. Well ...

16 Q. Are there areas where it
17 appears, in fact, to run parallel to the bedding
18 planes of the shale?

19 A. Certainly, along this --
20 here it appears to be predominantly, almost
21 horizontal as you would expect beneath the plane.

22 Q. Why would you expect that,
23 Dr. Charlesworth?

24 A. Well, if you are getting
25 predominantly lateral flow here, although we have



1 seen gradients, I think, in general, the feeling is
2 that the main component of flow is probably lateral
3 here and we have seen that there is a fresh water
4 lens that Mr. Sobanski spoke about. So, you
5 have got a fresh water lens in the surficial deposit
6 sitting on top. There may be some recharge
7 through it, I don't know. It is horizontal,
8 almost horizontal with fluctuations.

9 Q. Now, between Boreholes HC-4
10 and HC-6, could you describe for the Board, what
11 is happening with the chloride contours 1,000 and
12 5,000?

13 A. There is no detail for HC-6
14 but from HC-4 to HC-8, it comes up.

15 Q. In fact, it is drawn parallel
16 to the bedding planes for the chloride?

17 A. I would say it is drawn
18 across the bedding planes if we assume the bedding
19 planes are horizontal.

20 Q. Is it more in line with the
21 bedding planes though, the upgrade distance from
22 HC-4?

23 A. Is it what? Could you
24 repeat the question?

25 Q. From HC-4 to the north of



1 the site, the angle ...

2 A. There is a change in angle
3 there, yes.

4 Q. And the angle north of HC-4,
5 in relation to the bedding planes of the shale is
6 more acute to the north of HC-4 than it is to the
7 south of HC-4, would you agree?

8 A. Yes.

9 Q. In fact, to the south of
10 HC-4, between HC-4 and HC-8, it would appear that
11 the chlorides from the data we have, the chloride
12 lines more or less reflects the bedding planes of
13 the shale; would you agree with that?

14 A. I would say the way that
15 Trow plotted it, it actually -- it slopes contrary
16 to the bedding planes. If I rolled my pointer
17 along the line that Trow has drawn, it is a signi-
18 ficant angle to the bedding plane. Here it is
19 at an angle in this direction and here it is an
20 angle in this direction.

21 Q. What we find at HC-8
22 are chlorides that are very high, very close to
23 the surface.

24 A. Yes. There is a complica-
25 tion here and I am probably helping in the point



1 here trying to develop in pointing this out but
2 I think it is important to do that. This was
3 my overhead and actually, as far as I can ascertain
4 ...

5 Q. I am sorry, could you just
6 identify, for the record, this overhead?

7 A. This is our overhead. I
8 have taken a profile through HC-4, HC-8, the same,
9 this is - does this go to nine?

10 Yes, this is an overhead of this
11 piece of the profile from Figure A-A. I plotted
12 the data that Trow are using. I added the data.
13 I don't think they used the data from MB-17
14 and MB-13, which you can project onto that line.
15 So, I added a couple of other factors, I am not
16 sure how far. I would have to look on the map
17 to see, but they are projected on just as Trow did.
18 Trow projected HC-8 onto that cross-section.
19 At HC-8 about 250 metres to the west of the profile.
20 The thing I noticed here, I stand to be corrected,
21 but as far as I could see, Trow have actually
22 plotted HC-8 at the wrong elevation here. I
23 think it should be somewhat lower because the
24 ground surface at HC-8 is actually lower.

25 So, if I could just finish explaining



1 I have plotted HC-8. The borehole would
2 actually start at about the elevation I am showing
3 here.. So, the piezometers from which they are
4 taking the values would all be dropped down a bit.

5 My interpretation is that the
6 5,000 goes more like that than the pattern that
7 Trow have shown on their figure.

8 Q. I am sorry, the 5,000 goes
9 more like that, you were referring to your overhead
10 and you were drawing a line that was parallel to
11 the bedding planes of the shale.

12 A. I am saying on the diagram
13 you referred to in the Trow diagram they have it
14 something like that.

15 Q. Do you think your diagram
16 is more accurate, Dr. Charlesworth?

17 A. Yes.

18 Q. I am accepting that, but
19 what I am asking you is ...

20 A. We have both projected
21 laterally, so I think mine is more accurate, yes.

22 Q. Thank you.

23 On the more accurate diagram which
24 is an overhead, you would agree with me that you
25 have drawn the 5,000 milligram per litre chloride



1 line parallel to the bedding planes of the shale
2 between HC-4 and HC-8?

3 A. Yes, and then down at an
4 angle to MB-17.

5 Q. From MB-17 to MB-13, again,
6 the angle is more or less parallel to the planes
7 of the shale, would you agree?

8 A. Yes, okay, more or less
9 horizontal.

10 Q. Now, Dr. Charlesworth,
11 first can we mark this as an exhibit. I don't
12 believe it is an exhibit.

13 A. No, it is not an exhibit.

14 MR. LANCASTER: It would be M-479.

15
16 --- EXHIBIT NO. M-479: Overhead by Dr. Charlesworth

17
18 MR HODGSON: Q. Would you agree
19 with me, Dr. Charlesworth, that the 5,000 milligram
20 per litre contour you have drawn on M-479, does not
21 run parallel to the surface of the earth as it does
22 in your M-445?

23 DR CHARLESWORTH: A. That is correct,
24 yes. Well, schematically, I suppose if you took
25 -- I guess I should work, I am looking for a short



1 straight edge. It does not run, you could take
2 it through this point here if you average it, this
3 gradient, this gradient, and this gradient. I am
4 not saying it is, but I don't think, for me it is
5 not an important issue, but to answer your question,
6 I suppose you could take an average that would be
7 something like that through there.

8 Q. Do you want to put 445 up
9 again, please? Can you put them up together?

10 A. They are at a different
11 scale.

12 Q. Does the dotted line not
13 represent the 5,000 milligram per litre contour
14 on that exhibit?

15 A. No, it represented -- it was
16 very much a schematic. I said I had used the
17 5,000 to get first an approximation of what may be
18 the more active zone and then I had dotted this
19 line in because I was assuming that as the water
20 moved down gradient, particularly as you get down
21 to this point here, you will get less, you will
22 get less recharge to the shale. So, this was
23 not -- I had hoped I had made that clear, but
24 this line was not the 5,000 PPM contour. It was
25 a crude definition of what may be the more active



1 zone.

2 Q. Can I take you then back to
3 M-479?

4 A. Yes.

5 Q. We have your evidence that
6 M-479 is more accurate, I take it, than M-445 and
7 it is more accurate, in your view, than HC-40-D21
8 in drawing in the chloride contour; is that correct?

9 A. Certainly, this is what I
10 came up with when I drew it. Trow were making
11 it on a much bigger scale, so that may be a factor
12 to take into account.

13 Q. What I want to know,
14 Dr. Charlesworth, is, first of all is there any
15 magic to your 25 metre more active flow zone?

16 A. My 25-metre flow zone is
17 something like that. That would be 25 metres.

18 Q. That flow zone, you would
19 agree, cuts across areas of much higher chlorides
20 and areas of much lower chlorides?

21 A. That 25-metre zone includes
22 areas of high chloride and I have another over-
23 head that I might superimpose on top of that just
24 for the Board's information. I have tried
25 to sketch on there, the highly fractured zone



1 roughly. The red lines, if it makes any sense,
2 is off their Figure 2, that is the figure I was
3 referring to a little earlier in Exhibit H-40,
4 which is their hydrostratigraphic, but the blue
5 line I am pointing to up here is where they extended
6 on Exhibit 2 and 9 which I have -- I think that
7 must be part of the hydrostratigraphic interpreta-
8 tion.

9 So, what we have here, if we can see
10 anything at all, is that our 25-metre zone
11 incorporates what I had originally said may well
12 be a more active zone and it takes in also the
13 highly fractured unit. It does include below
14 that, but there is an effort to sort of incorporate
15 something recognizing that there may be movement
16 beneath.

17 Q. Do I have your evidence
18 correctly that the dotted red line superimposed on
19 the dotted green line, is the upper boundary of
20 the highly fractured units, superimposed on your
21 5,000 chloride contour?

22 A. Yes, that is the intent.

23 Q. Would you agree with me,
24 Dr. Charlesworth, that in a fractured shale
25 environment where the bedding planes are horizontal



1 and where there are at least an appearance from the
2 geology and only from the geology, reminding you
3 of what you showed us in HC-4-85, more permeable
4 zones and less permeable zones. Isn't what you
5 have shown us on this exhibit, M-479 with your two
6 superimposed dotted lines on top more or less what
7 you would expect to find in that kind of fractured
8 shale environment with horizontal bedding planes
9 That is to say the more active zone isn't going to
10 be parallel to the ground surface. The more
11 active zone is going to reflect the bedding planes
12 of the shale.

13 A. If you take the Trow model
14 of the highly fractured unit, that is certainly not
15 following the bedding plane either.

16 Q. That being the line down
17 between HC-8 and MB-13?

18 A. Yes.

19 Q. But the line between HC-4
20 and HC-8 does reflect the bedding plane, does it
21 not?

22 A. Between HC-4 and HC-8 ...
23 yes. To a fair degree of interpolation. I am
24 not quarrelling with their interpretation.

25 MR. HODGSON: Could we mark the



1 two exhibits that have been superimposed?

2 MR. LANCASTER: 479A is the
3 25-metre zone and 479B.

4 DR. CHARLESWORTH: 479B shows
5 the highly fractured unit.

6 DR. KINGHAM: Could we have
7 copies of these as transparencies, rather than
8 on paper?

9 DR. CHARLESWORTH: Yes, that is
10 possible.

11
12 --- EXHIBIT NO. M-479A: Overhead of 25-metre zone

13
14 --- EXHIBIT NO. M-479B: Overhead of highly fractured
15 unit

16
17 MR. HODGSON: I think this might be
18 another candidate for the colour photocopier.

19 The witness is introducing it and
20 I am asking you to produce it for everyone else.

21 MR. ESTRIN: I am not undertaking
22 to make coloured photocopies of that. It is
23 prohibitively expensive. For the Board, we will
24 be happy to fill it in and everyone else has
25 their own assistants.



1 MR. HODGSON: Q. Dr. Charlesworth,
2 stopping there, I would like to ask you, first of
3 all, considering just the chloride contour that
4 you have drawn on M-479, and considering only the
5 geology evidence that we have, from the
6 examination of the cores that have been continuously
7 cored at Site F, would you agree with me,
8 Dr. Charlesworth, that Trow are the first group of
9 researchers, hydrogeologists in this area to
10 continuously core any of the shale, is that correct?

11 A. Yes, I think you are
12 correct.

13 Q. So, Trow, having for the
14 first time developed cores of the shale down to
15 100 feet in any number of places, on Site F, do
16 you regard it, Dr. Charlesworth, as a worthwhile
17 endeavour to attempt to correlate the more
18 fractured zones and the less fractured zones as
19 between boreholes at Site F?

20 A. I will state it again.
21 I think what Trow tried to do at Site F was
22 commendable. What they did was commendable.
23 This is the type of interpretation that is needed.
24 I agree in general with their classification.
25 When we look at the cores, we can see some



1 anomalies but they were trying to superimpose some
2 sort of order on the system and I think that was
3 worthwhile.

4 I have a problem with Exhibit H-220
5 and the step where they go from their stratigraphic
6 to their hydrostratigraphic and it is just that
7 I have some problem with that, but nevertheless,
8 I think their effort has been directed in the right
9 direction. They have done good work on this.

10 Q. Thank you. Dr. Charles-
11 worth. I have one more question for you today and
12 that is, would you put up Exhibit H-220.

13 MR. ESTRIN: That is the
14 multi-coloured one of which Mr. Hodgson did not
15 supply me with a copy and we have coloured by
16 ourselves.

17 MR. HODGSON: I will remind
18 Mr. Estrin that I supplied every party at this
19 hearing with a coloured copy of that. Mr. Estrin
20 has clearly lost his copy.

21 DR. CHARLESWORTH: It is even
22 worse. I have Mr. Hodgson's copy.

23 MR HODGSON: Q. Dr. Charlesworth,
24 you have the original copy which is an exhibit.

25 Would you mind putting H-220 up,



1 please?

2 Now, Dr. Charlesworth ...

3 A. That is a terrible picture
4 to end the week with, Mr. Hodgson.

5 Q. Dr. Charlesworth, you will
6 agree with me it is a worthwhile exercise, having
7 continuously cored a number of boreholes at Site F
8 to attempt to correlate the information developed
9 from the core?

10 A. I agree, it is a worthwhile
11 exercise.

12 Q. There are a number of ways
13 in which that correlation could have been done,
14 would you agree?

15 For one thing, looking at Site F
16 in planview, unfortunately, we don't have a
17 planview up. One can take any number of different
18 lines down Site F connecting up...

19 A. Yes.

20 Q. ... boreholes and do a series of
21 cross-sections based upon those boreholes. That
22 is one way it could have been done, do you agree?

23 A. That is one way it could
24 have been done.

25

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