

CONSOLIDATED HEARINGS BOARD

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

— and —

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

— and —

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

— and —

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

— and —

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

— and —

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

— and —

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

— 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;
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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;

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.

VOLUME: 112

HELD AT: Oakville, Ontario

DATE: March 24, 1988

OFFICIAL REPORTERS

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I N D E X

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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,
March 24, 1988.

VOLUME 112

APPEARANCES:

T.R. Lederer and H.D. Hodgson	for the Regional Municipality of Halton (Proponent)
J.R. Tidball	for the Ministry of the Environment
T. Vigod J.F. Castrilli	for the West Burlington Citizens Group
D. Estrin, F.E. Leitch and H. Dahme	for the Corporation of the Town of Milton
S.R. Garrod and A. Nurvo	for the Milton Area Citizens Coalition and several affected Milton area landowners
R.B. Tuer, Q.C. E.A. Cronk and F. Perrier	for National Sewer Pipe Limited
L.F. Longo	for Azova Investments Limited
M.J. McQuaid, Q.C. and C.J. Tzekas	for the City of Burlington
C. Mansfield	for the Ministry of Natural Resources
P. Renaud	for Cumis



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APPEARANCES (Cont'd):

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

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Per: P.D. McQueen



Oakville, Ontario
March 24, 1988

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

MR. LANCASTER: Good morning. Please
be seated.

MR. TIDBALL: I believe Ms Vigod has
to be at a meeting in Toronto this morning.

MR. LANCASTER: She has completed her
cross-examination.

ANTHONY J. CRUTCHER, Resumed

JOHN M. PETRIE, Resumed

CROSS-EXAMINATION BY MR. TIDBALL, Continued:

Q. Mr. Petrie, I understand you
had something you wanted to deal with, left over from
your examination-in-chief?

MR. PETRIE: A. Yes. Dr. Kingham
asked with respect to some tables for which we had
presented calibrated vertical hydraulic gradients and
if we could provide a table which enumerated the
difference between these calibrated gradients and the
field data. I have these tables before me, which I
would like to distribute, if I may.

MR. LANCASTER: These are all
replacement pages for Site F.

MR. PETRIE: Yes, this is correct.
There are three tables I have just distributed, the



1 "Difference." Each relating to the numerical
2 difference between the vertical hydraulic gradient as
3 reported from the field data and the vertical
4 hydraulic gradients as we calculate from the computer
5 output.

6 DR. KINGHAM: Can you make the same
7 comment now about the total differences using these
8 mid-screen separations you have done on this table?

9 MR. PETRIE: The mid-screen
10 separations on this table only relate to the first
11 column being the field measurements. The gradients
12 for the model as noted in subscript 2 at the bottom
13 of the page were calculated using the nodal
14 separations.

15 In other words, using the vertical
16 separation between that point on the computer grid
17 for which the water level data was generated.

18 Yes, noting the differences we do note
19 that Model 2 has a better fit if one was to look
20 solely at the summed vertical hydraulic gradient
21 difference.

22 MS CRONK: Excuse me, Mr. Chairman,
23 just on this replacement page, I had understood in
24 the evidence-in-chief that the same changes to the
25 field measurements were to be made. At a quick look



1
2 I don't think this table has been fully corrected.

3 MR. PETRIE: That is quite correct, Ms
4 Cronk.

5 MS CRONK: I wonder if this would be
6 replaced again with one that has to be corrected
7 again?

8 I think all of them under "Field
9 Measurements," the copies I have.

10 DR. KINGHAM: So, Table C.4.4b, that
11 is page 128R, requires those changes to column 2,
12 "Field Measurements."

13 MR. PETRIE: It does.

14 DR. KINGHAM: We will just wait until
15 we get another version.

16 MR. HODGSON: Revenue Canada has
17 information to their IT115R, then IT115R2 and R3. I
18 think that notation would be successful here.

19 MR. LANCASTER: It is easy to
20 understand too.

21 DR. KINGHAM: And finally, Mr. Petrie,
22 your Table C.4.6b which is labelled page 135R, on
23 this one you would appear to have made the
24 corrections to the "Field Measurements" column.

25 MR. PETRIE: Yes, it appears that way
and as I recall, I have not recalled at the time when



1 first one being Table B.4.1b, the page number is
2 indicated as 59R. The "R" being "revised." The
3 revision relates to the columns marked "Differences."

4 We have a Table C.4.4b, the page
5 number being 128R, and the third one is Table C.4.6b,
6 the page number being 135R. These tables were
7 prepared in response to a request from Dr. Kingham.

8 The Site F Report, Mr. Estrin.

9 MS CRONK: Could I ask Mr. Petrie very
10 briefly to reconfirm what the changes were?

11 MR. PETRIE: You may. There are three
12 tables, they are all indicated with the page number
13 "R".

14 Starting at the 59R, the table B.4.1b,
15 which was page 59, we had previously read into the
16 record some corrections respecting the column marked
17 "Field Measurements." Those corrected field
18 measurements are provided on 59R. The purpose of
19 Table 59R, this table was prepared in response to a
20 request by Dr. Kingham that the difference between
21 hydraulic gradient as reported from the field data
22 and hydraulic gradient as reported by the model be
23 provided. So, the Table B.4.1b, 59R is entitled
24 "Summary of Vertical Hydraulic Gradients and
25 Differences." So the two columns marked "Difference"



1 which are summed at the bottom are provided.

2 DR. KINGHAM: While you are at that
3 point, Mr. Petrie, you might just tell us what it
4 means to you that the difference total assigned to
5 Model 1, being smaller than the difference total
6 assigned to Model 2, what that means in terms of the
7 fit to the vertical hydraulic gradients of the two
8 models.

9 MR. PETRIE: Looking specifically at
10 those values, one might conclude that Model 1 is a
11 better fit, but I caution with respect to this table.
12 I noted that the hydraulic gradients were calculated
13 using what we called the screen separation, the
14 position of the screens. I would not like to read
15 too much into that gradient data.

16 At the point of our review, this being
17 Part B of our Site F Report, we did not initially
18 have the Trow discs, computer discs indicating to us
19 the exact position of the screen relative to the
20 grid. So, at this point we could only assume the
21 grid lay directly on the well screen and made
22 calculations directly therefrom.

23 The second table is entitled, or Table
24 No. C.4.4b, page number 128R, again we have two
25 additional columns on this table, each being marked



1
2 we were discussing this table but in reviewing the
3 table over the weekend we noticed some typographical
4 errors under the heading marked "Model 2
5 Anisotropic." Such that the vertical gradients
6 reported in the initial table being Table C.4.6 were
7 in error.

8 I refer to the HC-4-85, Piezometer 3-4
9 under Model 2 for the next piezometer, HC-5-85,
10 Piezometer 1-2, HC-5-85, for Piezometer 3-4. Again,
11 I am still referring to the column under Model 2.

12 HC-8-85, Piezometer 1-2, HC-8-85,
13 Piezometer 2-3, and Piezometer 3-4. HC-14-86,
14 Piezometer 1-2, 2-3, 3-4. HC-11-85, Piezometer 1-2,
15 such that Table C.4.6b being page number 135R
16 provides the correct values.

17 On those differences, the revised
18 gradient numbers don't make any difference to the
19 conclusions provided from this gradient data.

20 DR. KINGHAM: I guess we are ready for
21 you now, Mr. Tidball, with apologies.

22 MR. TIDBALL: Q. Mr. Petrie, I think
23 my first few questions this morning are for Mr.
24 Crutcher.

25 MR. CRUTCHER: A. Excuse me, Mr.
Tidball, Mr. Petrie and I reviewed that 1.5 per cent



1
2 and we have a couple of comments.

3 Q. Perhaps, Mr. Petrie, you could
4 deal with that first.

5 MR. PETRIE: A. Could you direct me
6 to that portion of M-444 on which you focussed your
7 question?

8 Q. Yes, I think it was around
9 page 20 of the text as I recall. Yes, it starts at
10 the bottom of page 19, it is paragraph 29 of Exhibit
11 H-444, starting at the bottom of page 19.

12 A. M-444? And your comment was
13 specifically focussed onto the 1.5 per cent of flow
14 that would go to the shale.

15 Q. Yes, in fact, to be very
16 specific, Dr. Rowe's evidence, I am sure that his
17 evidence was consistent in-chief and in cross for
18 that matter, was that having remodelled, having
19 remodelled the shale, having remodelled the system
20 using some definite layer for the shale which I think
21 was five metres thick, he ended up with a recharge of
22 something less than 1.5 per cent and you can see in
23 brackets there typically, 0.7 per cent or less going
24 to the shale and I asked you yesterday for your
25 comment and I take now you want to comment further.

A. I asked Dr. Rowe about that



1
2 last evening because it escaped my memory he had done
3 that. He did not provide that, I recall in my
4 discussion with him last evening an exhibit
5 addressing these modelling results. He read them
6 into the record. I might note here that Dr. Rowe
7 undertook essentially two modelling exercises for
8 Site D.

9 The first, as he described it, where
10 he left the bedrock as a sink in the system. He
11 provided no hydraulic control on the bedrock. He let
12 the system respond such that if the water wanted to
13 go to the bedrock, he let it go.

14 That was the result he provided as
15 Exhibit M-442. At some point subsequent to Exhibit
16 M-442, he undertook a second set of models, which are
17 reported as paragraph 29 of Exhibit M-444 in which he
18 introduced the hydraulic characterization of the
19 shale as part of this modelling exercise.

20 Specifically, as he related to me last
21 night, he input the shale as being five metres thick
22 and having a hydraulic conductivity of 1×10^{-5}
23 centimetres per second. Those dimensions being the
24 five metres thick, and the hydraulic conductivity of
25 1×10^{-5} , he obtained from Trow's report. We have
reproduced the appropriate figure in our Exhibit



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B-618 as page 34.

Page 34 just provides a copy of Trow's schematic hydrostratigraphic sequence. One would note there a thickness of weathered shale or bedrock as it is called of 1×10^{-5} centimetres per second. So, Dr. Rowe, as I understand it, entered those components into his model.

By that modelling exercise, he generated the number 1.5 per cent.

Q. If I could just stop you there for one second, Mr. Petrie. I don't want to interrupt your flow, but if you go back to that Figure B.3.1, what we are looking at here is essentially what Dr. Rowe modelled, is it not? If you look, by some coincidence I suppose, the shale there looks about five metres thick, so that is about what he is monitoring.

A. That is where he took the five metres from, correct. So, what that would entail, as I understand his model, that nothing can flow out the bottom of this column of strata, i.e. 29 metres represents the base of the flow system such that any water percolating vertically through the overburden when it enters the bedrock would have to do essentially a right-angle bend and flow laterally. I



1
2 have some questions regarding that modelling
3 exercise.

4 One, the data were not provided by
5 which one could re-examine the vertical gradients
6 within the flow system that would have been generated
7 by that model and I believe Trow did not mean to
8 indicate that the bedrock was five metres thick at
9 that point, nor did it have a hydraulic conductivity
10 specifically of 1×10^{-5} .

11 My recollection is they assumed values
12 and were just looking at the weathered shale at that
13 point. I also understand from the Trow Report they
14 did not focus their investigations onto the bedrock
15 such that a value of hydraulic conductivity of the
16 bedrock was pertinent to their investigation.

17 To that end, I would consider Dr.
18 Rowe's first modelling exercise being Exhibit M-442
19 in which he let the bedrock take all the water that
20 could flow to it as being more representative of the
21 field conditions.

22 I say that for another reason because
23 Trow have generated a lot more data respecting the
24 hydraulic properties of the overburden materials. I
25 feel it more appropriate to use that data in a
modelling exercise rather than using that in addition



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25 when it enters the bedrock would have to do
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1
2 to an assumed value for the bedrock.

3 Given that, and looking at the numbers
4 generated by Dr. Rowe, we note ...

5 Q. Are you in Table 2 there?

6 A. I am on Exhibit M-442, page
7 27, Table 2, correct.

8 We note under the column marked Column
9 7, "Calculated Proportion of Flow to the Shale" and we
10 note that in the Trow case, i.e. Case No. 1, is
11 calculated a proportion of flow to the shale as being
12 30 per cent. Of the modelling numbers provided by
13 Dr. Rowe, that, in my mind, is the more appropriate
14 of the numbers he has provided.

15 I note that this case was examined
16 with a failed landfill where the numbers generated by
17 Trow, those ones can be seen on Exhibit B-207A, for
18 the condition without the landfill.

19 So, we are dealing with an imposed
20 gradient from the failed landfill relevant to ambient
21 gradient. I suggest that Dr. Rowe's modelling is a
22 more rigorous investigation of the flow field within
23 the system. However, I have difficulty with both
24 cases, is that they have assumed continuity of the
25 upper granular unit.

With respect to an impact assessment,



1
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3 exercise.

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11 My recollection is they assumed values
12 and were just looking at the weathered shale at that
13 point. I also understand from the Trow Report they
14 did not focus their investigations onto the bedrock
15 such that a value of hydraulic conductivity of the
16 bedrock was pertinent to their investigation.

17 To that end, I would consider Dr.
18 Rowe's first modelling exercise being Exhibit M-442
19 in which he let the bedrock take all the water that
20 could flow to it as being more representative of the
21 field conditions.

22 I say that for another reason because
23 Trow have generated a lot more data respecting the
24 hydraulic properties of the overburden materials. I
25 feel it more appropriate to use that data in a
modelling exercise rather than using that in addition



1
2 I think it is valid to assume continuity of the upper
3 granular unit in that it represents, to my mind, a
4 worst case.

5 In investigating the water balance of
6 the system, I think it more appropriate to put the
7 geology as one understands it and to recognize that
8 it is my interpretation that the upper granular unit
9 is discontinuous. On those grounds, I felt there
10 would be more flow going to the bedrock than that
11 generated by Trow.

12 I believe, if Dr. Rowe had put lenzoid
13 configuration for the upper granular unit into his
14 model, I would expect that more flow would go to the
15 bedrock. I do not know his model inside out, such
16 that I could attempt to provide a number on it.

17 Q. Thank you, Mr. Petrie, that is
18 helpful. Mr. Crutcher?

19 Mr. Crutcher, while you are setting
20 that up, perhaps Mr. Petrie could put up one of the
21 big panels of Site D, perhaps the aerial photograph.

22 Mr. Crutcher, I have asked Mr. Petrie
23 to put up Exhibit M-102, that's the aerial photo of
24 Site D.

25 MR. CRUTCHER: A. He did.

Q. Just to tell you where we are,



1
2 we are on Site D.

3 A. I hear that.

4 Q. I am up to the part in your
5 report which you entitle "Landfill Design
6 Considerations." I am wondering if you could turn to
7 page 58 of that report, it is B-618. I want to deal
8 here with the design, both the design considerations
9 and your critique of the Trow Report and your own
10 conceptual design, which I assume you are going to go
11 on to talk about next month or whenever we come up to
12 that.

13 A. I don't know exactly when it
14 is going to be.

15 Q. I am almost sure it will be
16 warm out. I want to draw your attention, on page 58,
17 Mr. Crutcher, to the second paragraph where you state
18 the opinion that the whole of the original site is
19 considered as hydrogeologically suitable for
20 landfilling. I took that to mean simply the entire
21 L-shape, that is what you are talking about?

22 A. That is correct.

23 Q. I take that to mean then that
24 you are satisfied, based on the information that is
25 available to you, that the portion of the site, I
guess contiguous to Highway 25 is hydrogeologically



1
2 suitable, there is enough information from that
3 property.

4 A. Yes, there is enough
5 information to indicate it is hydrogeologically
6 suitable. We would like additional borehole
7 information for specific design purposes. More in
8 the -- closer to Highway 25. It depends on where you
9 are looking at the "L" but assuming the "L" is in a
10 north-south direction, the leg of the "L".

11 Q. I am not sure to what extent
12 you are aware of this Mr. Crutcher, but some time
13 ago, I don't even recall during what evidence it was
14 indicated to the Board that in fact the Region of
15 Halton is seeking to expropriate the property that
16 would complete, I guess complete the square there.
17 The property in the lee of the "L", would that be
18 correct, something like that?

19 A. I assume you are talking about
20 in the northeast.

21 Q. Were you aware of that, Mr.
22 Crutcher?

23 A. Yes, I was.

24 MR. GARROD: Mr. Chairman, I am not
25 sure if it is accurate, but they are seeking to
appropriate that part and if it should be the



1
2 landowners' desire, they may acquire the rest of the
3 property they are not seeking to expropriate.

4 MR. TIDBALL: I don't want to mislead
5 the Board, Mr. Chairman. It was my understanding the
6 Region was seeking authority to expropriate the whole
7 parcel.

8 MR. LANCASTER: I thought I had that
9 understanding.

10 MR. GARROD: It is certainly not my
11 understanding, Mr. Chairman.

12 MR. HODGSON: Mr. Chairman, I wasn't
13 here for that evidence. I would have to ask Mr.
14 Lederer. I don't recall that we have received
15 instructions in that regard. Let us leave it open.

16 MR. LANCASTER: For the purpose now.

17 MR. TIDBALL: I can ask him to assume,
18 just so that my recollection is clear, I understood
19 it came out during the evidence of, I think it was
20 Mr. Watson, the second time he was here. There was
21 some evidence as to the relative cost of
22 expropriating and as I recall, much to my surprise, I
23 guess because I don't do any expropriation work, it
24 turned out that the value of the land, the value of
25 the remnant pieces was almost the value of the whole
property and that is why they were seeking approval.



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Q. If you could assume for the moment, Mr. Crutcher, subject to proof, that in fact the Region is either seeking to expropriate or could acquire that property, I wonder if you had any opinion about the hydrogeologic suitability of that property.

MR. CRUTCHER: A. We really had not addressed ourselves to that, but I can give you my comments just off the top of my head on that basis.

MR. ESTRIN: I am sorry, the witness must indicate which property he is now addressing.

MR. CRUTCHER: I am referring to the northeast quadrant of the lots established as a site boundary.

MR. TIDBALL: Q. Just to be clear for the record, it is four separate parcels, one of which is owned by Mr. and Mrs. Tomosky and I think that is the only house on the property.

MR. CRUTCHER: A. I don't know that. There is a creek system that passes through this property which would pose some constraints to the development. That does not say the creek could not be moved, but obviously that would have to be taken a look into in some detail.

I also recall in our cross-section, I



1
2 believe it is cross-section B-B, we also note that
3 the upper till thins passing up in this area so that
4 would also have to be reviewed in some detail to
5 determine the suitability.

6 Q. At this point, would it be
7 fair to say you don't really have an opinion on it?

8 A. No, we have not really
9 assessed that particular item. We were referring to
10 the whole of the site as was originally proposed.

11 Q. In both your critique of the
12 Trow Reports and in your conceptual design, which you
13 laid out, I can't recall the exhibit, but it was the
14 3D picture, you went to some length to try to come up
15 with some different design to maintain the hydraulic
16 trap. I took it from your evidence, that you agree
17 with Trow that the key to the site is maintaining the
18 hydraulic trap.

19 A. That's right. In part, also
20 maintaining the unweathered upper till.

21 Q. In fact, your design document,
22 does it not, tries to come to some balance between
23 those two?

24 A. That is correct.

25 Q. Now, I wonder, Mr. Crutcher,
if you have an opinion, we have on the record now, an



1
2 opinion from Mr. Sobanski and Dr. Rowe concerning the
3 length of time that the hydraulic trap will have to
4 operate in order to -- the length of time it will
5 have to operate to create an acceptable impact, if
6 you will. I wonder if you have an opinion on that?

7 A. You cannot be definitive in
8 years but I can indicate that we would expect the
9 mass of contaminants within the landfill site to
10 decrease with time.

11 Mr. Sobanski, within his report,
12 provided a graph indicating that and that graph was
13 used subsequently by Dr. Rowe. When the mass of
14 contaminants reach the point of being of little
15 concern, I believe that to maintain a hydraulic trap
16 would not be necessary. It is not for ad infinitum
17 but would be something in the order of 20 to 30 years
18 after closure if I was putting a date, but you really
19 would do it off the concentration of the leachate and
20 that would be determined at the time -- as you were
21 monitoring the leachate if the leachate concentration
22 has gotten quite low. In fact of little concern, in
23 fact maintaining of the hydraulic trap, the necessity
24 of maintaining that would not be there.

25 Q. So in that, as I recall, Mr.
Crutcher, you would be agreeing with Mr. Sobanski,



1
2 who, I believe, gave that same range or something in
3 that order, do you recall?

4 A. I don't recall. If he did, I
5 guess I would be agreeing.

6 Q. I take it you would also then,
7 by that you are specifically disagreeing with Dr.
8 Rowe who put numbers ranging from 50 years up to 80
9 years depending on the case.

10 A. Is that 50 to 80 years after
11 closure?

12 Q. That's a very good question.
13 Have you got Exhibit M-444 there, that is the witness
14 statement of Drs. Rowe and Charlesworth? It is
15 M-444, the big blue one.

16 A. Yes, I have that.

17 Q. Could you turn to overhead 60
18 which you will find after Tab 2? If you look at
19 overhead 60, Dr. Rowe has evaluated the length of
20 time that the leachate collection system must
21 function. He has done it in terms of five cases,
22 three of them being complete failure and the others
23 are his two partial failure cases. I understand from
24 your evidence of the last few days you would suggest
25 that a complete failure is entirely unlikely, so we
ought to disregard the top half.



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A. That is correct.

3

Q. Can we look then at the

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partial failure and it was either Case 11 or 12 that

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Mr. Petrie testified was a case he thought to be

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plausible. I don't recall, it may not matter.

7

A. I believe it was Case 11 was

8

the one that had plausibility.

9

Q. So, if we look at Case 11, we

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have got two sets of numbers. One is based on an

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initial source concentration of, I believe this is

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all chloride, of 1,500 milligrams per litre and the

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second one is 3,000.

14

Dr. Rowe has two estimates, 50 to 55

15

years and 60 to 65 years to reach a concentration of

16

25 milligrams. He has higher numbers to reach a

17

lower concentration.

18

First of all on that, Mr. Crutcher,

19

you have designed, I gather, a fair number of

20

landfill sites in your career. Which number would

21

you think is more appropriate, 1,500 or 3,000?

22

A. The 1,500.

23

Q. I take it from your evidence

24

with regard to 20 to 30 years for the trap to be

25

maintained you are then disagreeing with Dr. Rowe's

50 to 55-year estimate?



1
2 A. I refer to after site closure.
3 And we are dealing with something like, or a proposal
4 for something like a 20-year site, so if you add
5 those two together, I am not sure if he is dealing
6 with after closure or not.

7 Q. I guess the record will have
8 to speak for itself, because we are not exactly sure,
9 but -- all right, so you think in fact the two may be
10 compatible if you add the life of the site.

11 A. Yes.

12 Q. Thank you.

13 Dealing specifically with the leachate
14 collection system, Mr. Crutcher, is it your
15 professional opinion that the leachate collection
16 system itself can be made to operate for some 20 to
17 30 years after site closure?

18 A. I do not see any reason why it
19 cannot.

20 Q. If it doesn't, I take it that
21 is when you go on to talk about the contingency
22 leachate wells

23 A. That is correct.

24 Q. Is it your opinion, Mr.
25 Crutcher, that these leachate purge wells, I think
that is what you called them, can be used to maintain



1
2 the mound in the landfill below the critical level?

3 A. When we are referring to
4 leachate purge wells, we are referring to them on the
5 basis that we believe the possibility of a local or
6 partial failure of the system and yes, I believe the
7 purge wells can be used on that basis.

8 For using a purge well for the
9 complete site, it may be somewhat impractical.

10 Q. Thank you, Mr. Crutcher, I may
11 have some more questions for you some weeks from now
12 when you come back on the stand about design, but for
13 now, I think that is sufficient. Mr. Petrie?

14 Mr. Petrie, could you put up Exhibit
15 B-635, that is the small exhibit out of the Trow
16 document. I think it was Drawing 16 wherein you
17 marked your monitoring wells.

18 It is difficult to see from back here,
19 but I think I recall where you put them.

20 Mr. Petrie, you suggested in-chief
21 that in terms of water quality monitoring at Site D
22 you thought Trow had been excessive in their
23 proposals and you proposed a series of, I believe,
24 seven installations around the site.

25 MR. PETRIE: A. Correct.

Q. Could you get out -- Mr.



1
2 Chairman, I have attempted to find Exhibit H-213, I
3 am not sure if it is "H" or "B", but it is number
4 213, which I believe is the Trow Monitoring Proposal
5 out of Exhibit H-40. We can't seem to locate it.
6 So, Mr. Petrie, could you pull out Drawing 24 of
7 Exhibit H-40.

8 Mr. Chairman, that is the last drawing
9 in Exhibit H-40. It is a small map of Site D showing
10 Trow's proposed monitoring program. I am sorry, H-
11 39, I apologize.

12 A. Could you repeat the number,
13 please?

14 Q. It is Drawing 24 out of H-39,
15 I think it is the last one, Mr. Petrie. Missing?
16 You probably used yours for 213.

17 A. Mr. Crutcher has provided me
18 with one.

19 Q. We come back to Dr. Kingham's
20 suggestion about the corkboard, it makes more sense.

21 A. It does, indeed.

22 DR. KINGHAM: If necessary, the Board
23 has a copy of Drawing 24 with those monitoring wells
24 marked on it, which the witness could use.

25 MR. HODGSON: If I may, just at the
end of the evidence of Drs. Rowe and Charlesworth, I



1
2 had located the original of Exhibit 213 and we had a
3 discussion with the Board at the end of one day. I
4 know that exhibit is around here. If you want to
5 give me two minutes, I can go and see if I can lay my
6 hands on it.

7 MR. TIDBALL: Perhaps you could do
8 that. I had a little bit more on monitoring. I
9 could perhaps do that, it would perhaps take us to
10 the break a little bit early and we could perhaps
11 locate it over the break.

12 MR. LANCASTER: Fine.

13 MR. TIDBALL: Q. You can just leave
14 that up, Mr. Petrie. I would like to look at
15 hydraulic monitoring and I am not sure whether I
16 should direct these questions to you or to Mr.
17 Crutcher and perhaps I will just direct them and if
18 Mr. Crutcher feels he should answer them, he can
19 stand up and answer them.

20 I was interested in your proposals
21 regarding hydraulic monitoring. I am having a little
22 bit of difficulty understanding what you are
23 proposing with regard to piezometers set in the base
24 of the landfill and ...

25 MR. PETRIE: A. Are you addressing
that section of B-618, page 100?



1
2 Q. At the bottom of page 100, you
3 are recommending that in each landfill cell four
4 piezometers be installed at the base of the
5 excavation midway between a pair of collection pipes
6 and then you are suggesting flexible tubing be
7 running out. Could you get a blank piece of paper up
8 there and sketch exactly what it is you mean. I have
9 a vision of a piezometer being placed in a well
10 extending from the surface down and I have trouble
11 understanding what you are proposing.

12 A. I have drawn in some fashion,
13 the blue cross-hatched area, being the base of
14 excavation. The right hand side of this figure would
15 be ground surface and I have drawn, what to my mind,
16 represents a piezometer screen, or a well point lying
17 on the floor of the excavation and I have extended a
18 line across the floor up the side to ground surface
19 beyond the site.

20 Q. How is the piezometer set at
21 the base itself? It looks to be set horizontally.

22 A. One can set it horizontally
23 for what they had in mind. It is not a constraint.

24 Q. I am just trying to understand
25 it. Is it some length of slotted pipe?

A. Our regular piezometer is a



1
2 length of slotted pipe whether it be vertical or
3 horizontal. It is just a device for measuring fluid
4 pressure at the point where it is lying.

5 Q. Is this essentially what Mr.
6 Feenstra was talking about, Mr. Feenstra was talking
7 about the use of pressure transducers?

8 A. No, this is a water level
9 monitoring instrument. This is a hollow tube
10 extending across the floor up to the surface so that
11 one can, in some fashion, introduce a measuring
12 device to record the fluid level in this piezometer.

13 It is my recollection they had the
14 same sort of device at Keele Valley. It is also my
15 recollection they had pressure transducers. That is
16 a different device. It is a solid implement that
17 measures the fluid pressure and is transferred to an
18 electrical signal which one reads at ground surface.
19 The strength of that signal is related to the
20 pressure at the point at which the signal is
21 generated. That is a pressure transducer.

22 Q. Can I take it from your
23 recommendations, your recommendation found at pages
24 100 and 101, you are recommending these piezometers
25 over pressure transducers?

A. I did note when I was



1
2 discussing this section that the exact number and the
3 preferred location should be evaluated by a design
4 engineer. I would also add, the design engineer may
5 have a preference for one or the other.

6 I have had more experience with
7 piezometers than transducers. I do not have a bias
8 to one over the other. I note that piezometers are
9 somewhat cheaper.

10 Q. Perhaps, Mr. Crutcher, could
11 you -- I wonder if you could address this. Mr.
12 Petrie has just suggested that he believes these
13 kinds of devices are used at Keele Valley. Could you
14 confirm that?

15 MR. CRUTCHER: A. I am aware of the
16 pressure transducers being used at Keele Valley. I
17 am not aware of the piezometers.

18 Q. Either one of you, perhaps
19 this is undoubtedly a matter for detail design, but
20 on a general level, Mr. Crutcher, are you satisfied
21 as a design engineer that these kinds of devices
22 could be designed so that they would be effective?

23 I am wondering particularly about
24 being able to place them and then move waste over the
25 top of them?

MR. CRUTCHER: Yes, I believe they can



1
2 be placed and adequately protected. It is a matter
3 of the schedule of the pipe and whether you actually
4 protect the pipe with an outer pipe if that is what
5 is required, which is quite easily dealt with at a
6 design phase. The actual choice of which instrument,
7 I think we would have to review the experience of
8 success and I would lean somewhat towards the Keele
9 Valley experience because they are experimenting with
10 various modes of monitoring to see which is the most
11 effective.

12 I certainly do not want to have
13 instruments that give you questionable readings. We
14 note, I believe within the text, or within our --
15 within chief that we can at a later time, install a
16 traditional piezometer if the need arose in
17 questionable areas or areas where we did not have
18 monitoring that we were satisfied with.

19 Essentially, what I am saying is that
20 there are several options available. We have not
21 really selected one or the other. That is more of a
22 matter at the design stage.

23 Q. All right. Do you have any
24 experience with setting piezometers in the base of a
25 landfill, Mr. Crutcher?

A. Not of this particular nature



1
2 that Mr. Petrie is referring to, but of the
3 traditional piezometers, yes.

4 Q. Are you aware of any -- are
5 you aware of any such installations?

6 A. Not of the one type that Mr.
7 Petrie is referring to.

8 Q. For that type -- if you can't
9 answer this, Mr. Crutcher, I would appreciate it, but
10 I understand it. That kind of installation or a
11 pressure transducer, how long would you expect, as a
12 design engineer, how long would you expect those
13 types of devices to last?

14 A. It depends a lot on their
15 design, the type of material that they are
16 constructed of. Assuming that all that is
17 considered, it is a matter of looking at the
18 integrity, assume we are using PVC pipe, the matter
19 of the compatibility of the PVC pipe with the
20 chemicals that would be found in the landfill site
21 and on that we can do an estimate of the site life.

22 The pipe would have to be constructed
23 for structural purposes, but I note that you are on
24 the base of the landfill where you have the best
25 integrity. It is a matter of equipment working in
the area to make sure you have that allowed for.



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Q. Would you expect them to last
for 20 to 30 years after site closure?

A. Assuming they are properly
designed, I do not see why not.

Q. If they fail, is there some
other method that can be used to monitor the level of
the mounding within the fill?

A. Certainly you can install a
traditional piezometer at that time.

Q. Mr. Petrie, back to you for a
moment. I noticed at the bottom of page 102 of your
Site D Report, that is Exhibit B-618, if you could
refer to the first sentence under the heading
"Groundwater Quality Monitoring."

That sentence states:

"It is recognized that for the
hydraulic trap in operation,
the need for comprehensive groundwater
quality monitoring is reduced."

I gather from that, Mr. Petrie, that
you see some relationship between hydraulic
monitoring and water quality monitoring. Am I right?

MR. PETRIE: A. I am not sure I am
understanding your question.

Q. What I am trying to get at is



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your suggesting there that where the trap is

3

operating you need less water quality monitoring.

4

A. The need for it is reduced.

5

Q. Are you suggesting that is

6

what should be done?

7

A. That would be my

8

recommendation that a monitoring program be phased to

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the performance of the landfill. i.e. when the trap

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is operating, one might sample either less wells or

11

less frequently having initially established the

12

background water quality condition.

13

When the concern for the performance

14

of a hydraulic trap is raised, if that eventuality

15

arises, that concern would be raised as a function of

16

reviewing the hydraulic monitoring data.

17

At that time, one might institute a

18

more rigorous or a more extensive or more frequent

19

sampling of the groundwater quality monitoring

20

points.

21

Q. Are you suggesting in any way

22

that you could perhaps do zero groundwater quality

23

monitoring if you are satisfied from all your

24

monitoring that your trap is working?

25

A. I am not suggesting that.

Q. You are suggesting some



1
2 reduced frequency and perhaps some reduced spatial
3 locations?

4 A. Perhaps, yes.

5 Q. If we could come back to water
6 quality monitoring and I think the last question I
7 have before we come to the actual locations, I am
8 wondering what type of construction you are proposing
9 for these monitoring wells, Mr. Petrie, vis-a-vis the
10 type of construction that has been talked about at
11 Site F and I am talking about Mr. Feenstra's
12 proposals with stainless steel and steam cleaning.
13 It is all set out in your Site F Report.

14 A. Stainless steel does have some
15 advantages over PVC. It is my understanding that the
16 advantages are very small and the jury is still out
17 on specifically what those advantages are.

18 I believe that three or four years
19 ago, there was a strong move in the industry,
20 especially in the United States, to go to stainless
21 steel wells. We have indeed installed a lot of
22 stainless steel wells in our programs in the U.S.

23 It is my opinion that PVC does
24 represent a useful material for construction of
25 piezometer devices. It is my opinion that PVC wells
can be used usefully.



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Q. I take it from that, you don't have a concern about interference with detection of trace quantities of organic chemicals?

A. The PVC wells we used would be flush-jointed with no solvent material, no solvent glues used in their construction or installation. The materials would be thoroughly cleaned prior to being installed in the ground. They would be cleaned in the field.

Q. Are you proposing that where new monitoring wells are drilled that they be developed in the manner that is again suggested by Mr. Feenstra at Site F. I think there is a series of suggestions starting with packer tests and moving into pump tests if necessary.

A. I recall Mr. Feenstra's suggestions. No, I am not making that suggestion for this site.

MR. TIDBALL: Mr. Chairman, the last thing I had on Site D then is the monitoring proposed, the actual locations proposed by Mr. Petrie and Mr. Hodgson thinks he can find that. It is quite early but if this would be an appropriate place, perhaps we could break.

DR. KINGHAM: Before we break, since



1
2 you have put that diagram up, perhaps you could make
3 it more useful to the Board.

4 Turning back to your page 101, the
5 first line on that page says:

6 "Mid-way between a pair of collection
7 pipes."

8 If you have a black pen, you might
9 schematically illustrate, would there be a collection
10 pipe on either side of that piezometer?

11 MR. PETRIE: I just drew a horizontal
12 floor of the excavation but yes, there would be.

13 DR. KINGHAM: If you could do that.
14 Just represent somewhere where there would be a pipe
15 and then, since you have used blue for the colour of
16 the bedrock...

17 MR. PETRIE: Excuse me, that would be
18 the clay.

19 DR. KINGHAM: The till and the
20 piezometer -- we will have to use red for water.
21 There would be a mound if the system was operating
22 normally, or as you would prefer to see it operate,
23 of about 0.4 metres at the highest point, is that
24 what we are to understand from your evidence?

25 MR. PETRIE: The design elevation is
1.5 metres above the floor level. The 0.4 metres



1
2 you mention is the allowance for seasonal fluctuation
3 in the system.

4 DR. KINGHAM: Could you draw the mound
5 to the height you would expect it to be, a
6 representative mound between leachate collection
7 pipes and then there would be water, that would be
8 saturated, in essence, within that mound and the water
9 level extending across the pipe to the side. That is
10 the level that you would measure in this piezometer.

11 MR. PETRIE: Correct, yes.

12 DR. KINGHAM: That is the question Mr.
13 Tidball had as to how it would be measured. You
14 would introduce some device into the pipe on the
15 shore side, as it were.

16 MR. PETRIE: The pipe would ideally
17 stop at the surface one would cover in the wall a
18 little bit such that one would have a vertical pipe
19 in the same manner that one measures water level in a
20 conventional piezometer. One would lower a measuring
21 device down to this pipe and record the water level
22 elevation.

23 DR. KINGHAM: And the question that
24 Mr. Tidball put to Mr. Crutcher about the longevity
25 of that system had to do with how long one would be
able to reliably measure water levels in a pipe in



1
2 that configuration. Is that the context in which you
3 gave your answer, Mr. Crutcher

4 MR. CRUTCHER: Yes.

5 MR. PETRIE: I would like to point out
6 in addition, that these devices can be tested as to
7 their performance. One can do a slough test or
8 something like that. Introduce a change or a
9 transient pulse in the system and see how quickly the
10 system would return back to its original level. One
11 might do that with frequency of every year or two and
12 to be sure that one satisfies oneself that these
13 devices are indeed working. That is commonly done
14 with piezometers in the field.

15 DR. KINGHAM: With regard to your last
16 information to Mr. Tidball, where you are observing
17 that the frequency and spatial orientation of
18 groundwater quality monitoring would be dependent on
19 your satisfaction of the functioning of the hydraulic
20 trap, if that water level shown had moved up above
21 what was expected, that is when you would propose
22 increasing the frequency of monitoring.

23 MR. PETRIE: Most definitely.

24 DR. KINGHAM: Before we break, if you
25 are looking for this monitoring thing, you might just
like to have this as a reference.



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MR. TIDBALL: Perhaps we should mark
that as an exhibit.

MR. LANCASTER: B-640, flip chart.

---EXHIBIT B-640: Flip Chart

MR. TIDBALL: I have mine.

DR. KINGHAM: We should find the
actual.

MR. HODGSON: We need the one that Mr.
Sobanski wrote on.

MR. TIDBALL: I thought there might be
some sense in having the original one and have Mr.
Petrie write on it and have one document at the end
of the date.

MR. LANCASTER: I have a note that
mine is missing from my copy and I gave it to Mr.
Lederer, so if you find another one ...

MR. HODGSON: We gave it to Mr.
Lederer last fall. I now can promise you that you
will never get it back!

--- Recess

MR. LANCASTER: Please be seated.

MR. TIDBALL: I believe Mr. Hodgson is
still on the hunt for the elusive 213. Depending on
what he comes in with, we couldn't locate it



1
2 upstairs, Mr. Chairman, but what we have done is, we
3 have obtained a clean copy of Drawing 24 and I have
4 used Mr. Hodgson's copy and my copy which accord on
5 everything except one monitoring point which was the
6 last one. I have got it numbered 20 and Mr. Hodgson
7 didn't have it. With that in mind, I think it is a
8 fair representation and we were simply going to
9 suggest that we renumber this H-213B.

10 DR. KINGHAM: Did you have monitoring
11 point 20 adjacent to and slightly to the east of
12 GL-84-1?

13 MR. TIDBALL: Yes.

14 DR. KINGHAM: That is where we had it.

15 MR. TIDBALL: I think we are in
16 accord.

17 MR. LANCASTER: That would, in effect,
18 be H-213?

19 MR. TIDBALL: We thought perhaps we
20 could number it "B" and if the original shows up, we
21 wouldn't have two exhibits with something different
22 on them.

23 Q. Perhaps before I get to that,
24 Mr. Petrie, I have a couple of more questions that
25 have arisen, occurred to us over the break, about the
hydraulic monitors there.



1
2 What you have got is Exhibit B-640.
3 In the text, you talk about the use of flexible
4 tubing across the floor of the excavation. We are
5 not clear exactly what it is you are talking about
6 there.

7 MR. PETRIE: A. It could be small
8 diameter tubing, or perhaps ideally, it should be
9 larger diameter pipe, an inch or so. I would point
10 out that the specific design of these has to be
11 developed with the design engineer. One has to
12 recognize there is going to be garbage going on top
13 of this and compactors running around on top.

14 I am not so well versed on the
15 practice of landfill design and the practices that I
16 would like to be specific on this point.

17 Such installation could be developed
18 in conjunction with the design engineer.

19 Q. One other matter that in fact
20 was mentioned by Mr. Hodgson. If that flexible
21 tubing had to run up the side of the landfill site,
22 would there be any difficulty in monitoring the level
23 within that, given that it is on a slope?

24 A. I did suggest that it should
25 be vertical. I was just doing a schematic here.

 Q. You are suggesting it would



1
2 come up vertically through the waste then?

3 A. Across the floor of the cell
4 and up vertically on the side. They may have to put
5 an additional cut in the system to install it.
6 Again, I suggest the specifics of design of such
7 devices would have to be done by the landfill design
8 engineer. The intent is to monitor the leachate head
9 within the system.

10 Q. If we could then move on to
11 the monitoring proposal. If you could put that up.

12 So, could we mark that then as, I
13 don't know whether that should be a "B" an "H" or
14 what it should be, but 213B.

15 MR. LANCASTER: We have marked the one
16 we have found H-213 in brackets. We will leave it in
17 the book. I have noted in my book what it is.

18 MR. TIDBALL: Would it be easier to
19 mark it as a new exhibit, and then we don't have to,
20 we are not going to get confused.

21 DR. KINGHAM: Yes.

22 MR. LANCASTER: It is going to be an
23 E-641.

24 MR. TIDBALL: You might as well mark
25 it as a "B" because I am going to ask him to mark
on ...



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MR. PETRIE: I am marking as Exhibit B-641, Drawing No. 24 of Trow's Report, being H-39, Monitoring Well Nests as numbered by A. Sobanski.

There are red circles on the figure up to number 20.

--- EXHIBIT NO. B-641: Drawing No. 24 of Trow's Report, H-39

MR. TIDBALL: Q. What I wanted to do, if we can, Mr. Petrie, is go through what Mr. Sobanski proposed and have you specifically tell us if you will, which ones you think should stay out of his program and which should go.

In that sense, what we are trying to do is meld Exhibits B-635 and B-641. I am wondering, it occurs to me that what might make some sense is if you took a different coloured pen.

A. I have a blue.

Q. And simply circle around. I thought it might make some sense to simply put a circle around the red circle for the ones you think should stay and then we can mark that in the legend. We could mark that in the legend and then for the purpose of the record, we would have it exactly on one page.

If you could deal first of all with the wells up and down the First Line and rather than



1
2 trying to deal with them numerically, Mr. Sobanski
3 jumped around a little bit.

4 I notice that on Exhibit B-635, your
5 suggestions, you have got three nests. Mr. Sobanski,
6 by my count, gets six. Numbering from the bottom he
7 has 1, being a new monitoring nest immediately south
8 of HC-3-85, is that number 1?

9 A. I see that number, yes. Could
10 I just indicate I have an orange pen for additional
11 markings?

12 Q. So, just going south to north,
13 I think I misled you. I said six nests, but I think
14 with the three nests, the next one up there are, in
15 fact, eight nests.

16 A. I count eight nests, if you
17 are counting number 1 as First Line.

18 Q. Actually, it is more like
19 southeast to northwest, but going up the First Line,
20 Mr. Sobanski has one which is adjacent to HC-3-85?

21 A. Correct.

22 Q. He has three new monitoring
23 nests that he has numbered 2, 3, and 4, which are, I
24 don't know how to describe it, but they are
25 immediately along First Line but immediately west of
HC-2-86 in a line across the site.



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A. Correct.

3

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Q. Going further north, he has a well, a new well that is, in fact, doesn't have a symbol on there but was added during evidence by Mr. Sobanski, number 19?

7

A. I see that.

8

9

Q. Which is approximately the centre of the site?

10

A. Approximately.

11

12

Q. Then, further to the north, he has GL-84-1 numbered as 20?

13

A. Correct.

14

15

16

Q. Then he has a new monitor between GL-84-1 and the corner of the site which is numbered as 5?

17

A. He does.

18

19

Q. And he has HC-1-85 numbered as 6?

20

A. He does.

21

22

23

24

Q. Therefore, he has eight nests up that site. You suggest three. Could you circle with that orange pen, which ones you are suggesting should stay?

25

A. I have drawn an orange circle around Mr. Sobanski, well nest number 2, which is



1
2 right on the property boundary.

3 MR. HODGSON: Can I just have that
4 clarified?

5 Two, three and four, I think for Mr.
6 Sobanski were together at that location.

7 MR. PETRIE: Mr. Sobanski has marked
8 three wells, two, three and four at that location. I
9 have circled Well 2 as a well nest. We are
10 referring to nests at each of these locations; am I
11 right, Mr. Tidball?

12 MR. TIDBALL: Q. I think the
13 transcript will show Mr. Sobanski was actually
14 talking about three well nests stepped out from the
15 site from the landfill itself out to First Line.

16 MR. PETRIE: A. That is my
17 understanding also. I have circled number 2 and
18 therefore, I am omitting 3 and 4, Mr. Sobanski's 3
19 and 4.

20 Q. Are you also omitting 1, Mr.
21 Petrie?

22 A. I have an installation marked
23 2-2 on Exhibit B-635, which is in the general area.

24 Q. Perhaps we can come back to
25 that then. All right, proceeding to the north then?

A. The next two installations,



1
2 Mr. Sobanski's numbering being 19 and 20, I note that
3 20 is adjacent to an existing installation. My 1-2
4 as located on Exhibit B-635, I am suggesting should
5 be generally mid-way between those two.

6 Q. Between what is numbered 19
7 and 20?

8 A. Mr. Sobanski's 19 and Mr.
9 Sobanski's 20.

10 Q. Have you drawn an orange
11 circle there?

12 A. I have but it is not even
13 clear to me standing this close to it. I am
14 indicating visually.

15 Q. All right then, could you
16 continue?

17 A. Mr. Sobanski's installation
18 number 5 I would keep and I might be tempted to move
19 it a little closer to the property alignment. I am
20 not exactly sure where the area of landfilling will
21 come to there. The precise position of that
22 location would be a function of the position of the
23 edge of the cell and the property alignment. I am
24 circling number 5.

25 Q. All right. Now, does that --
Mr. Crutcher, I am not sure that I actually take much



1
2 objection to this, but I believe some of my friends
3 might. The rules aren't exactly clear about how
4 panels are supposed to act. I have some problem with
5 things being said between the two of you and without
6 being said on the record.

7 I think to be fair to everyone, if Mr.
8 Crutcher has something to say, he should perhaps say
9 it on the record.

10 MR. CRUTCHER: A. I most certainly
11 can. I indicated to Mr. Petrie that I felt we should
12 be locating the wells, we should also take into
13 account the geology. We should optimize the well
14 locations according to the geology and that would
15 have to be looked at at a later time, because that is
16 a fairly involved process.

17 Q. Thank you, Mr. Crutcher. I
18 meant no offence by that.

19 MR. LANCASTER: I think it is a good
20 point, though. I have noticed it.

21 MR. TIDBALL: Q. Those are the three
22 wells then you think -- the well nests that are
23 required along the First Line, Mr. Petrie?

24 MR. PETRIE: A. Correct.

25 Q. You also have one well nest on
the north -- let us call it, just to be simple, let



1
2 us call it the north boundary and the south boundary.

3 Dealing with the north first, I
4 noticed Mr. Sobanski has a monitoring Well 7, fairly
5 close to the Martin property.

6 A. He has two installations on
7 his north boundary marked on Exhibit B-641. He has
8 number 7 and number 8. I note that 7 is adjacent to
9 a building and 8 is adjacent to HC-3-84.

10 Q. Where are you proposing, I
11 think you numbered it 2-1.

12 A. I have drawn an orange circle
13 to the right or east adjacent to the circle of number
14 7. I notice that is not exactly the same well
15 location identified as number 7 on Exhibit B-641.
16 It is essentially mid-way along the northern
17 boundary.

18 Q. What about the southern
19 boundary? I notice Mr. Sobanski has installations
20 down there. He has number 1, we have already talked
21 about. He has 15 and 16 that appear to be stepped
22 out in a line and he has 14 that is further to the
23 right on that drawing.

24 A. He does -- he has these four
25 installations.

Q. Do you have -- is one of those



1
2 acceptable to you?

3 A. Number 16 is in the
4 approximate location of the installation I have
5 located as 2-2 on Exhibit B-635. I am circling in
6 orange, installation number 16.

7 Q. Now, on the eastern boundary,
8 the northeastern boundary I suppose, you have
9 installation 3-1. I wasn't sure from back here where
10 it was. Can you tell us where you would put it?

11 I notice that Mr. Sobanski has
12 approximately five wells stretched out along that
13 portion of the boundary.

14 A. He does. I am circling
15 approximately Well No. 10.

16 Q. All right. Proceeding further
17 to the south end again, I wasn't clear where your 3-2
18 was. Could you locate it on this plan?

19 A. Mr. Sobanski has a Well No.
20 17. He has no small "x" indicating the exact
21 location of number 17. I am locating my circle
22 approximately south of HC-4-85. It approximates
23 number 17.

24 Q. The transcript will tell, Mr.
25 Petrie, and I think in that case and perhaps several
other cases where there is no specific "x"



1
2 Mr. Sobanski was talking about the use of that
3 particular well, it is already there. So, in that
4 case, HC-4-85 ...

5 A. No, I am circling a little
6 further to the south and I am assuming for the record
7 that the adjacent landfill does not abut that
8 installation.

9 Q. That is the one you suggest
10 would be taken out of service if, in fact, the
11 enlarged design Mr. Crutcher is proposing was
12 approved?

13 A. That is correct. It would be
14 relocated to accommodate the different design.

15 Q. The only other one that I have
16 that you have is -- I numbered it 4. I am not sure
17 what you numbered it, but it was to accommodate that
18 enlarged design and it was along the southern
19 boundary.

20 A. That is correct. I did not
21 indicate it on Exhibit B-635. It's location would
22 be, in part, dependent on the cell geometry.

23 Q. Perhaps we won't mark it on
24 this either.

25 Then, with respect to -- are there any
other monitoring locations proposed by Mr. Sobanski



1
2 that you agree should be monitoring locations at this
3 site?

4 A. I am noting his installation
5 number 13 would provide some measure of control in
6 the general area, being to the southeast of the
7 property. I would like to add that one installation.

8 Q. So, No. 13?

9 A. No. 13. He has a new "x"
10 there, it is a new installation.

11 DR. KINGHAM: What are you suggesting
12 exactly about that No. 13?

13 MR. PETRIE: I am agreeing to Mr.
14 Sobanski's No. 13, by which I should circle it with
15 an orange circle.

16 Mr. Tidball asked me would I like to
17 add any other installations as referred to by Mr.
18 Sobanski. I am indicating that Mr. Sobanski's No. 13
19 on Exhibit B-641 would be an appropriate
20 installation.

21 Q. Ms Cronk has asked whether you
22 could also mark that on Exhibit B-635, so it is clear
23 for the record.

24 MR. HODGSON: If that is going to be
25 done on B-635, could he also put the date beside the
addition.



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MR. TIDBALL: Certainly.

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MR. PETRIE: I am marking with an orange circle in the southeast property corner of Exhibit B-635, being an additional observation installation and the date, March 24th.

7

I am indicating beside that, 24/03/88.

8

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MR. TIDBALL: Could you mark in the legend of Exhibit B-641 with the orange perhaps, Mr. Petrie, what it is that denotes so that it is clear when we are looking at it months from now what it is?

12

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16

MR. PETRIE: I have marked in the legend beneath where it has in red "monitoring well nests as numbered by Mr. Sobanski," that being Exhibit B-641, I have marked an open orange circle indicating "monitoring well nests CRA 24/03/88."

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MR. TIDBALL: Q. Now, Mr. Petrie, the monitors then you propose, and we are now up to, I guess, eight numbers, are these monitors what you are proposing for what may be called the initial stage, this is the monitors, these are the monitors that are put in before there is any -- well, maybe you can tell me.

24

25

Would these be the monitors put in initially?

MR. PETRIE: A. Assuming the final



1
2 design is available, yes.

3 Q. I assume that you are not
4 suggesting that that -- that they need to be the
5 final number if, in fact, there was some detection of
6 contaminant movement there would have to be a re-
7 evaluation.

8 A. Any monitoring program should
9 incorporate that. I am suggesting for this site that
10 these are the initial installations I would
11 recommend.

12 Q. Thank you very much, Mr.
13 Petrie.

14 Mr. Chairman, that concludes the
15 questions I have on the Site D Report. I am now
16 going to move to Site F.

17 First of all, Mr. Petrie, I think the
18 majority of the questions at the first will be for
19 you again. If we could deal with the geology of the
20 site and I would like to do this in the same manner
21 we did Site D, deal with Parts B and C of your report
22 together so that we have an overall picture of what
23 you are saying.

24 Starting with geology, I gather, Mr.
25 Petrie, from everything you said and I don't want to
take too much time because I think this is just



1
2 confirming your evidence-in-chief. Do you agree with
3 the general description of the geology given in
4 evidence by Mr. Sobanski and Dr. Charlesworth, in a
5 general sense?

6 A. In a general sense, yes.

7 Q. Just so we can be specific,
8 could you refer to Exhibit H-40 and specifically
9 starting at page 30?

10 A. Could you give me that page
11 number again?

12 Q. Yes, page 30. It is the
13 beginning of Trow's discussion of the geology. It is
14 numbered Section 4.

15 A. I have it, yes.

16 Q. That section, in fact, goes
17 through, omitting the discussion of the shale
18 resources starting at page 40, it is fact, pages 30
19 to 39 where the discussion of the geology is found.

20 I took it from everything you have
21 said that we want to figure out where everybody sits
22 on this. You would agree with Trow on pages 30
23 through 33, which is their general discussion, but
24 you specifically disagree with most of the material
25 found from pages 34 to 39.

A. That is correct.



1
2 Q. Similarly, if you could go to
3 Dr. Charlesworth's Report, Exhibit M-437, page 2-1
4 and 2-2, this is Dr. Charlesworth's discussion of the
5 physiographic and geologic setting.

6 I also reasoned off here that you
7 would specifically agree with everything that Dr.
8 Charlesworth has on those two pages.

9 A. In general, yes.

10 Q. Including the last statement
11 on page 2-2?

12 A. Page 2-2 you referred me to?

13 Q. The next page is concluding --
14 the concluding sentence to the section.

15 A. Correct.

16 Q. You would agree with Dr.
17 Charlesworth that Trow represented a
18 hydrostratigraphic classification which is too
19 rigorous to be supported by the available data.

20 A. Correct, I do.

21 Q. Would you -- I take it that
22 you also agree, Mr. Petrie with, again, Trow and Dr.
23 Charlesworth, that there is a trend in the Queenston
24 shale at this site to decreasing fracture frequency
25 with depth?

A. There is a trend.



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Q. There is a trend. I find that in your report at page 93, but I don't think there is much of a discussion. I am looking at your Exhibit 617. The first paragraph on page 93 where you note that:

"The fracture pattern is complex although there is a general trend to decreasing fracture frequency with depth."

A. Yes.

Q. I am wondering on what you rely to give the opinion, Mr. Petrie.

A. It is generated from the fracture frequency profiles provided by Trow which we have provided in Part B of our critique, being Figure B.2.2 on page 23.

Q. That is the figure that shows the fracture frequency profiles for four boreholes along the cross-section that you have used for Site F?

A. Correct. I do recall in-chief when we discussed this figure, I noted that the trend is general, but there were some reversals. It is most noticeably apparent at HC-4.

Q. I take it it would be your



1
2 opinion that below these cross-sections were you to
3 drill a well even deeper, you would find a continuing
4 trend towards less fracturing?

5 A. I cannot make an opinion as to
6 what I would expect below. In a general sense, one
7 might expect that.

8 Q. Do you get the same sense out
9 of the visual analysis of the cores that you
10 undertook?

11 A. I looked at Cores HC-4 and
12 HC-6. My recollection was that the fracture pattern
13 on these cores matched the record that was provided
14 by Trow. I also recall in-chief I indicated that the
15 cores when I looked at them were not fresh such that
16 some of the breaks I observed may have been non-real
17 breaks, machine breaks or breaks as the rock has
18 dried out or been transported.

19 Q. If we could move to
20 hydrostratigraphy, I guess I have already put that to
21 you, but I gather just to confirm, you agree with Dr.
22 Charlesworth and specifically disagree with Trow that
23 you can define this site in terms of five distinct
24 units.

25 A. Correct.

Q. I would like to look for a



1
2 opinion that below these cross-sections were you to
3 drill a well even deeper, you would find a continuing
4 trend towards less fracturing?

5 A. I cannot make an opinion as to
6 what I would expect below. In a general sense, one
7 might expect that.

8 Q. Do you get the same sense out
9 of the visual analysis of the cores that you
10 undertook?

11 A. I looked at Cores HC-4 and
12 HC-6. My recollection was that the fracture pattern
13 on these cores matched the record that was provided
14 by Trow. I also recall in-chief I indicated that the
15 cores when I looked at them were not fresh such that
16 some of the breaks I observed may have been non-real
17 breaks, machine breaks or breaks as the rock has
18 dried out or been transported.

19 Q. If we could move to
20 hydrostratigraphy, I guess I have already put that to
21 you, but I gather just to confirm, you agree with Dr.
22 Charlesworth and specifically disagree with Trow that
23 you can define this site in terms of five distinct
24 units.

25 A. Correct.

Q. I would like to look for a



1
2 little while at the general topic of hydraulic heads
3 and gradients. Could you get out -- I don't know, I
4 think you have an overhead for this. It is your
5 Figure B.3.4 which is at page 32 of Exhibit 617.

6 A. You would like the overhead
7 for that?

8 Q. Yes, if you would, please.
9 Is this the one that has been marked
10 separately as Exhibit B-621?

11 A. Correct. It has been marked
12 separately as that exhibit.

13 Q. First of all, I believe there
14 was some discussion with Dr. Kingham in your
15 evidence-in-chief as to how you drew those
16 equipotential lines, but I want to try to understand
17 it.

18 I gather that you and perhaps lots of
19 other hydrogeological investigators used some
20 artistic licence in drawing equipotential lines.

21 A. We used the control points and
22 between those control points there is some
23 interpretation, yes.

24 Q. If we look, just for example,
25 at the 130 contour, could you indicate that with the
pointer? I note that you have two control points.



1
2 little while at the general topic of hydraulic heads
3 and gradients. Could you get out -- I don't know, I
4 think you have an overhead for this. It is your
5 Figure B.3.4 which is at page 32 of Exhibit 617.

6 A. You would like the overhead
7 for that?

8 Q. Yes, if you would, please.
9 Is this the one that has been marked
10 separately as Exhibit B-621?

11 A. Correct. It has been marked
12 separately as that exhibit.

13 Q. First of all, I believe there
14 was some discussion with Dr. Kingham in your
15 evidence-in-chief as to how you drew those
16 equipotential lines, but I want to try to understand
17 it.

18 I gather that you and perhaps lots of
19 other hydrogeological investigators used some
20 artistic licence in drawing equipotential lines.

21 A. We used the control points and
22 between those control points there is some
23 interpretation, yes.

24 Q. If we look, just for example,
25 at the 130 contour, could you indicate that with the
pointer? I note that you have two control points.



1
2 You have got the watertable and you have got an
3 elevation of 133.18 in HC-4 and Piezometer 2 in that
4 well.

5 A. We can interpret 130 at
6 installation HC-4. We also note that installation 6
7 lies below that elevation and we have a point on the
8 watertable, yes.

9 Q. Just so I understand it, I
10 assume that one could also draw a straight line
11 between those two points.

12 A. Recognizing just those points,
13 yes.

14 Q. And you could also draw a line
15 of practically any curve you want, could you not,
16 with two data points like that. If you tried to
17 connect them you can draw any curve you want?

18 A. I hesitate to say yes.

19 In drawing these lines, I have
20 recognized that there is a geological
21 hydrostratigraphic sequence provided by Trow. In
22 drawing the contours I have presented, I was
23 cognizant of that hydrostratigraphic sequence.

24 So, that is my interpretation of where
25 those lines should be. Ignoring the
hydrostratigraphic sequence, I could draw any line



1
2 you want between two points, yes.

3 Q. I want to come to that because
4 I am interested in your comment in-chief and I think
5 I had it right that you would, by drawing this, you
6 would have expected to see horizontal flow through
7 the highly fractured shale, that is Unit 4, if in
8 fact it was there. I wanted to look specifically at
9 contour 120. That is the one that you have drawn to
10 indicate what you would expect if in fact there were
11 upward gradients from below to the highly fractured
12 shale.

13 A. That is the cross-hatched line
14 on Exhibit B-621.

15 Q. I am curious. We have already
16 talked about how you drew it, but could you not have
17 drawn this in such a manner that you could have
18 generated a horizontal flow picture in that highly
19 fractured shale if you wanted to? I am not
20 suggesting it is accurate. I am saying you could
21 have, could you not?

22 A. I am not entirely sure what
23 you mean. This is my interpretation based on Trow's
24 hydrostratigraphy of the potentiometric distribution.

25 Q. Let me suggest specifically
that if what you were trying to show was a component



1
2 of horizontal flow through the highly fractured shale
3 and a component of virtually a much more vertical
4 flow through the massive shale, you could have drawn
5 it in such a manner that there was more of a slope
6 on the line through Unit 3. This is hard to describe
7 but coming down from the watertable it could have
8 been sloped more towards HC-6, could it not, and then
9 when you hit the highly fractured shale it could have
10 been practically vertical. That's all I am
11 suggesting. I am not suggesting whether it is
12 accurate or not, you could have done that.

13 A. Correct.

14 MR. HODGSON: I am sorry, I can't
15 understand. I know it is my problem, but could I
16 have it clarified. The witness has agreed that the
17 line could slope more towards HC-6.

18 Additionally, I don't understand what
19 that means.

20 MR. TIDBALL: Q. I am hesitant to ask
21 the witness to draw, but perhaps you should.

22 MR. HODGSON: A dotted line.

23 MR. TIDBALL: Q. A dotted line or
24 something. I think I understand what you mean.

25 MR. PETRIE: A. How would you like me
to entitle the line?



1
2 you want between two points, yes.

3 Q. I want to come to that because
4 I am interested in your comment in-chief and I think
5 I had it right that you would, by drawing this, you
6 would have expected to see horizontal flow through
7 the highly fractured shale, that is Unit 4, if in
8 fact it was there. I wanted to look specifically at
9 contour 120. That is the one that you have drawn to
10 indicate what you would expect if in fact there were
11 upward gradients from below to the highly fractured
12 shale.

13 A. That is the cross-hatched line
14 on Exhibit B-621.

15 Q. I am curious. We have already
16 talked about how you drew it, but could you not have
17 drawn this in such a manner that you could have
18 generated a horizontal flow picture in that highly
19 fractured shale if you wanted to? I am not
20 suggesting it is accurate. I am saying you could
21 have, could you not?

22 A. I am not entirely sure what
23 you mean. This is my interpretation based on Trow's
24 hydrostratigraphy of the potentiometric distribution.

25 Q. Let me suggest specifically
that if what you were trying to show was a component



1
2 of horizontal flow through the highly fractured shale
3 and a component of virtually a much more vertical
4 flow through the massive shale, you could have drawn
5 it in such a manner that there was more of a slope
6 on the line through Unit 3. This is hard to describe
7 but coming down from the watertable it could have
8 been sloped more towards HC-6, could it not, and then
9 when you hit the highly fractured shale it could have
10 been practically vertical. That's all I am
11 suggesting. I am not suggesting whether it is
12 accurate or not, you could have done that.

13 A. Correct.

14 MR. HODGSON: I am sorry, I can't
15 understand. I know it is my problem, but could I
16 have it clarified. The witness has agreed that the
17 line could slope more towards HC-6.

18 Additionally, I don't understand what
19 that means.

20 MR. TIDBALL: Q. I am hesitant to ask
21 the witness to draw, but perhaps you should.

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23 MR. TIDBALL: Q. A dotted line or
24 something. I think I understand what you mean.

25 MR. PETRIE: A. How would you like me
to entitle the line?



1
2 DR. KINGHAM: I wonder if it is
3 possible to do it in words. It sounds to us as
4 though the witness was from the point of departure of
5 the watertable on 120, the line would proceed almost
6 to the intersection of HC-6 in the upper layer of the
7 highly fractured shale at which point it would
8 proceed vertically downward to the bottom. Is that
9 understandable, Mr. Hodgson?

10 MR. HODGSON: I have got it. Thank
11 you.

12 DR. KINGHAM: The record has it too.

13 MR. TIDBALL: Q. I wanted to relate
14 that back to your comment, Mr. Petrie, because I
15 thought your comment was that having drawn this, you
16 would have expected to have seen some component of
17 horizontal flow through the highly fractured shale
18 and I simply suggest to you that if you could have
19 drawn it another way, you could have got that.

20 MR. PETRIE: A. Had I drawn the line in
21 the fashion you suggest, specifically, I am
22 referencing using a vertical line across the highly
23 fractured shale, at HC-6, I then have to make a
24 pronounced bend to that line at the base of the
25 highly fractured shale Unit 4 such that I have a very
strong downward gradient beneath there.



1
2 I say that because you have to
3 accommodate the low pressure heads at the base of the
4 system being at HC-6, Piezometer 1 and at HC-8,
5 Piezometer 1.

6 Q. I appreciate that, yes. I
7 take it you would also say that you would have
8 expected to see upward flow so in fact the line
9 rather than bending off to the left on that figure
10 should have gone more in the direction of your cross-
11 hatched blue line.

12 A. That is correct.

13 Q. Keeping with this drawing, do
14 you have -- you don't have -- you have got the flow
15 direction, the groundwater flow direction marked with
16 an orange arrow. I am wondering where it is you are
17 saying the groundwater, given this depiction, you are
18 saying that the groundwater would be moving in the
19 vicinity of HC-8 and if I could draw your attention
20 to that, you have got two contour lines, 120 and 115.
21 If I draw an arrow between them I get virtually
22 horizontal flow exiting from the shale into the
23 overburden. Do you follow me?

24 I appreciate this is not that easy,
25 if you look at the contour lines the way they are
drawn.



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A. I believe you are referring to that portion of the figure which lies above the upper contact of the highly fractured shale.

Q. Yes, up above that contact. If you sort of look at a point mid-way between the contact between the highly fractured shale and the massive shale and the ground surface, a point somewhere in there in the vicinity of HC-8, I would think that if you drew flow lines here you would have flow going from the shale into the overburden, would you not?

A. It is possible, yes.

Q. All right, it is possible. It that what you would expect given your hydrostratigraphic interpretation?

A. The difficulty with relating the pattern of flow in the rock to the till at this point in part stems from the water level we have at HC-14. We have a watertable that is quite some distance below ground as defined at the installation in HC-14 of Piezometer No. 4. This installation lies in the general area of Trow's discharge zone.

Were this a discharge zone, one ought to have a watertable that is closer to the surface in which case I am going to have higher fluid levels in



1
2 the till. So, I do have some difficulty in trying to
3 draw a horizontal flow through there because I am
4 noting that the watertable with the pressure head at
5 the base of the till at HC-14 is low relative to
6 where I would have expected the watertable were this
7 in a groundwater discharge zone.

8 Q. I appreciate the difficulty of
9 asking you to comment on this, Mr. Petrie. I
10 understood your bottom line to be you don't believe
11 these units are here.

12 A. Yes.

13 Q. Using this for some purpose, I
14 would have also thought from your evidence, based on
15 your sort of conceptualization of the
16 hydrostratigraphy that you would have expected some
17 flow to continue sort of at the bedrock contact and
18 below rather than exiting from the shale into the
19 overburden.

20 A. There could well be a
21 component of flow into the till. It would be my
22 expectation we would have more in the rock.

23 Q. Now, I guess we should also,
24 for the record, note that there is a fair degree of
25 vertical exaggeration in this figure.

A. You can note that.



1
2 Q. What does that do to these
3 flow lines so we understand?

4 A. The horizontal scale is 1:4000
5 as indicated at the bottom left of the figure. The
6 vertical scale is 1:400. To make the vertical scale
7 1:4000 we would essentially condense the whole of the
8 vertical profile into, for example, one unit as
9 indicated on this scale.

10 By condensing that figure, the sub-
11 horizontal lines, for example, Contour 110, 115 and
12 120 become much more horizontal looking. You just
13 squash the figure down.

14 Q. At some level, Mr. Petrie, is
15 this figure, Figure B.3.4, a model of groundwater
16 flow at some level at that site, based on the
17 information you have got, hydraulic head data on
18 there?

19 A. I am not entirely sure I
20 understand your question.

21 Q. Is that figure, would it be
22 fair to say that that figure represents your concept
23 of what the regional groundwater flow would be at the
24 site?

25 A. The contour distribution of
the potentiometric data indicates the pattern of



1
2 hydraulic gradients within this system. Where we are
3 dealing with a silt or a sand or a porous media, I
4 again feel comfortable in indicating to the Board the
5 pattern of groundwater flow. We are dealing with a
6 fractured rock regime such that it is the geometry of
7 the fractures that control the direction of flow.
8 The gradient is the driving force. This figure
9 relates to the contour distribution of the driving
10 force.

11 So, on a regional scale standing away
12 back from the site, yes, I can say in a general sense
13 there is a component of lateral flow and a component
14 of vertical flow. I am noting that when you get to a
15 point off-site, HC-14, the flow appears to be
16 horizontal.

17 To draw precise flow paths, since I do
18 not know the geometry of the fractures, I cannot
19 indicate that.

20 Q. I understand that to be your
21 evidence, Mr. Petrie.

22 If we could start then at the broadest
23 scale and try to move in a little bit. First of all,
24 I take it would agree that groundwater movement in
25 the Queenston shale is generally towards Lake Ontario
in this location?



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A. Yes.

Q. We agree at this level and if we stand away back, I gather if we stand away back, perhaps I could refer to something in Dr. Charlesworth's reports, which might sum it up better. If we stand away back, we have got this general pattern. We have got one large arrow that is off towards Lake Ontario.

A. If you stand away back, you can, yes.

Q. Could I take you to Exhibit M-437, that is Dr. Charlesworth's Site F. Report, and refer you to page 4-1?

A. Page 4-1?

Q. Page 4-1 is in a section entitled "Groundwater Movement Hydraulic Gradients."

In the first paragraph Dr. Charlesworth tells us there is some general agreement about groundwater movement amongst the various investigators although there are differences with regard to detail. I wanted to draw your attention specifically to paragraph 2, where Dr. Charlesworth says:

"Most investigators agree that there are downward gradients beneath the



1
2 site indicating recharge conditions
3 and that a component of recharge goes
4 to a deep flow system within the shale
5 bedrock. There is also general
6 agreement on the existence of a
7 shallow active system within the
8 overburden or shallow bedrock with
9 movement in the upper few metres which
10 discharges to the surface water
11 drainage channels or swampy areas."

12 Specifically, Mr. Petrie, do you find
13 yourself agreeing with that paragraph or disagreeing?

14 A. I have difficulty with the
15 deep flow system to the shale and I think we all may
16 use the words but not have a precise definition of
17 what they mean. Flow does go to depth in some
18 fashion. Flow does go laterally in some fashion.

19 Q. I took it from your
20 conceptualization, your deep appears to be perhaps
21 somewhat deeper than what Trow envisages and perhaps
22 Dr. Charlesworth.

23 A. That is the difficulty.

24 Q. You are suggesting to the
25 Board, are you not, that there is a deep flow system
that is in fact at, or below, the deepest piezometers



1
2 we have at the site.

3 A. I believe I am in agreement
4 with Trow there where we have each referenced the
5 deep regional flow system that is recharged in the
6 area of the Escarpment and discharges to Lake
7 Ontario. I cannot recall Dr. Charlesworth's evidence
8 on that point.

9 Q. That was dealing with the deep
10 system. What about Dr. Charlesworth's opinion on
11 what he calls the shallow active system?

12 I believe, in evidence, Dr.
13 Charlesworth and Dr. Rowe, spent some time talking
14 about that and in fact, there were several exhibits
15 indicating components of flow.

16 A. In a general sense, I do
17 agree. There is a shallow groundwater discharge to
18 the streams.

19 Q. On site?

20 A. On the site. However, I would
21 like to point out that with respect to this cross-
22 section, this cross-section is aligned roughly along
23 a stream. So, when we are dealing with shallow
24 groundwater flow discharge into the stream, if I
25 could be somewhat schematic, we are really looking at
high points that lie out of the plane of this cross-



1
2 section and flow from there, discharging to
3 approximately an elevation marked ground surface
4 here.

5 Reference to the shallow flow system
6 discharging to the streams is not apparent from this
7 cross-section, given its alignment relevant to the
8 streams.

9 Q. Your evidence, I think is
10 relatively clear, Mr. Petrie, with respect to your
11 views on the local groundwater flow system. I
12 believe your opinion is that we just don't know where
13 it is going on a local scale.

14 A. Correct.

15 Q. Do things that happen on a
16 local scale affect the overall regional picture if we
17 stand back? In a regional sense, do they have any
18 impact on the regional flow towards Lake Ontario?

19 A. If you stand back far enough
20 you do not see the small-scale patterns I am
21 referring to, no.

22 Q. Can I ask you to get out
23 Exhibit M-469? That is Dr. Charlesworth's sketch of
24 the regional groundwater picture. You will recall I
25 asked him in cross-examination to make a sketch. He
then went away and overnight drew a new one.



1
2 A. Could you provide me with that
3 number again?

4 Q. Yes, M-469.

5 I am sorry, I should also have asked
6 you to get out Exhibit M-185, which is Morrison,
7 Beatty's Phase 3 Hydrogeologic Investigation for
8 National Sewer Pipe.

9 A. They have three reports.

10 Q. It is N-185, it is the one
11 Phase 3.

12 A. Yes, I have it.

13 Q. Could you turn to, it is
14 actually an appendix part-way through this document.
15 There is an appendix that starts with, I think it is
16 Appendix A. There is one large map, a small map and
17 then there is a depiction of the regional groundwater
18 flow system. The page, I believe, is A-2. That is
19 the one, yes.

20 If you could keep those together and
21 perhaps keep that one you had up on the overhead as
22 well, Mr. Petrie, because I am hoping out of all this
23 maybe some general picture will develop.

24 As I understand the two exhibits I
25 have asked you to get out, M-469 and Morrison,
Beatty's exhibit, Exhibit M-185, which is a Morrison,



1
2 Beatty report. Both of these are meant to depict
3 regional groundwater flow.

4 A. That is as I understand these
5 figures, yes.

6 Q. As I look at them, although
7 they are set out somewhat differently, although in
8 fact it would appear that they are at virtually the
9 same scale.

10 A. It does appear.

11 Q. They appear to be virtually
12 identical except insofar as the arrows are placed in
13 slightly different places.

14 A. The geometry of the block so
15 to speak, appears to be identical, yes.

16 Q. Morrison, Beatty then has a
17 second figure immediately below the regional picture.
18 I think it is also meant to be regional. It shows a
19 closer version of the Bayview landfill itself and
20 things immediately down-gradient.

21 A. At a different vertical scale,
22 yes.

23 Q. Do you agree or disagree with
24 these particular regional groundwater flow
25 depictions?

A. Starting with Exhibit M-469,



1
2 Dr. Charlesworth has marked Highway 403 on there. I
3 notice his arrow, his legend as probable flow path in
4 shale shows a pronounced gradient downwards with
5 respect to the overhead before the Board, we have the
6 Figure B.3.4, HC-14 shows more sub-horizontal flow.
7 I have another general statement. What we have here
8 is potentiometric distribution, i.e. the contour
9 distribution of the water levels. As I have
10 indicated earlier, were we dealing with porous media,
11 sand or silt for example one would be much more
12 comfortable contouring this distribution and putting
13 arrows at right angles to the contour distribution to
14 indicate the flow direction. We are dealing with
15 the fractured rock. The flow can only move in the
16 direction of the fractures.

17 The pressure distribution may be
18 different. I believe that is more what is happening
19 here. We have fractures within the system which do
20 provide for some movement horizontally. The flux
21 through those fractures is not such that it dominates
22 the patterns of water levels at the site. I
23 reference that to the piezometric data generated in
24 Exhibit B-214. There is a rather erratic pattern of
25 pressure head data with depth.

One can still conclude that there is



1
2 general downward gradients. However, reversals of
3 gradient within the rock system indicate to me that
4 fractures have some capacity to move water laterally
5 while a general trend is towards downward flow.

6 The two figures we have before us
7 address the regional groundwater flow system, my
8 remarks are more on the complex pattern of gradients
9 at the site.

10 Q. I think I understood that, Mr.
11 Petrie. What I am asking you about is the regional
12 picture. Is there anything you would disagree with
13 on a regional basis with the two cross-sections that
14 I have put before you?

15 A. On a regional basis for
16 Exhibit M-469 and the Morrison, Beatty Phase 3
17 document, there is groundwater recharging at Niagara
18 Escarpment passing to depth in the shale and
19 discharging to Lake Ontario. I am in agreement with
20 that as the regional flow system, yes.

21 Q. Would you comment -- to be
22 fair to you I wanted to ask you specifically about
23 the -- I guess the right-hand portion of those two
24 pictures from Highway 403 downwards. Are you in
25 agreement that regionally there is lateral flow
towards Lake Ontario?



1
2 Dr. Charlesworth has marked Highway 403 on there. I
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4 shale shows a pronounced gradient downwards with
5 respect to the overhead before the Board, we have the
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13 arrows at right angles to the contour distribution to
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towards Lake Ontario?



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A. Looking at the Phase 3

Morrison, Beatty document, and looking at 403 downwards, they have it essentially a pattern of flow to Lake Ontario.

I note, however, that they have a downward component of flow on those arrows. I am recalling for the Board that the well installations down-gradient of 403 and referencing HC-10; HC-11; and HC-12, there were some components of upward flow there.

Q. If we tried to look at that cross-section, looking at the Morrison, Beatty cross-section in particular, HC-10 and HC-11, and I know this is a particular cross-section and the points may not exactly fall on it.

As I understand it, HC-10 and HC-11 would fall somewhere mid-way between what we see denoted Highway 2 and Lake Ontario, approximately in that?

A. Yes.

Q. What about HC-12? I am not sure -- isn't HC-12 right on Lake Ontario?

A. That I don't recall. HC-16 is right on Lake Ontario.

Q. Would we assume that 10, 11



1
2 and 12 are sort of in the middle of that picture
3 between Highway 2 and Lake Ontario?

4 A. Referring back to our figure
5 location, 10, I note is on the immediate upslope side
6 of Highway 2, 11 and 12 are down-gradient.

7 Q. I see, so in fact, so if we
8 are going to place it there, we would put 10 just
9 practically at Highway 2 and 11 and 12 half-way over
10 to the lake?

11 A. Correct.

12 Q. You have noted on several
13 occasions of, I guess, weak upward gradients at those
14 locations?

15 A. Correct.

16 Q. Does that change the regional
17 picture? Are you suggesting to this Board that if
18 we looked at it regionally, we ought to draw the
19 arrow slightly upwards?

20 A. No, I am not suggesting that,
21 no.

22 Q. Now, could I take you then to
23 page 35 of your report, Exhibit 617?

24 A. Can I have that page number
25 again, please, Mr. Tidball?

Q. Yes. Page 35. The concluding



1
2 statement on the section, I think, that starts,
3 hydraulic heads, you say:

4 "CRA concludes that the available
5 water level data indicate that the
6 groundwater flow system is complex.
7 The water level data does not support
8 the hydrostratigraphic interpretation
9 provided by Trow."

10 Does that statement -- I am referring
11 specifically to the first sentence of that that the
12 groundwater flow system is complex -- does that apply
13 to the regional picture, Mr. Petrie?

14 A. It does not.

15 Q. If we wanted to be absolutely
16 precise, would it be accurate to say that we ought to
17 insert the word "local" before the word, the
18 expression "groundwater flow system"?

19 A. We are addressing the
20 groundwater flow system as defined by Trow, or the
21 hydrostratigraphic sequence as defined by Trow. It
22 is my understanding that their sequence was defined
23 more at the site, not a regional sequence.

24 Q. How would you define "local"?

25 A. I am referencing the domain of
the site down to 403. We are looking at depths in



1
2 the order of 60 metres at the most, more like 30
3 metres and less, so it is local to the site.

4 Q. Should we make some change
5 there? Are you content with the accuracy of that
6 statement as it sits?

7 A. I am addressing the data
8 provided by Trow. I am content with that statement.

9 Q. Now, could I turn to the
10 subject of hydraulic conductivity briefly? Could I
11 draw your attention to Dr. Charlesworth's Report, M-
12 437, specifically page 4-7, at the bottom of that
13 page in the second last paragraph under the heading
14 "hydraulic conductivity" Dr. Charlesworth canvasses,
15 I guess canvasses the available literature from other
16 investigators and simply draws it all together in one
17 place. Starting on that section he says:

18 "The work of Morrison, Beatty ..."
19 he references 2 and 3 and I think
20 that's their Phase 2 and 3 reports:

21 " ... indicated there was an decrease
22 in hydraulic conductivity with depth
23 and 10^{-3} centimetres per second at the
24 weathered surface, 10^{-7} centimetres
25 per second at depth."

He then goes on to canvass the opinion



1
2 of Ms Hewetson and Gartner, Lee and Trow.

3 I am wondering if you have any opinion
4 to offer on that particular subject. Do you think
5 the hydraulic conductivity decreases with depth?

6 A. I noted in-chief when I was
7 reviewing some of the data with respect to proposed
8 Site F there were reversals in the pattern of values
9 of hydraulic conductivity at depth. I believe I
10 noted on page 97, the third paragraph with reference
11 to Ms Hewetson's data that the trend and distribution
12 of hydraulic conductivities with depth is not
13 apparent from the Ms Hewetson data.

14 Q. You would agree it is not --
15 there is no trend or there is no evidence of a trend
16 to decrease with depth?

17 A. From the Hewetson data, yes.

18 Q. Specifically about the
19 Morrison, Beatty data, have you reviewed that?

20 A. I also believe I noted some
21 reversals of the pattern from the Morrison, Beatty
22 data. I am recalling installation OW-18. I have the
23 data provided on page 101, Exhibit B-671. The
24 borehole depth is recorded in the middle column and
25 one notes that the highest hydraulic conductivity at
that installation is in the lower-most borehole.



1
2 Q. So, it is your opinion that
3 there is -- with the available data you don't see a
4 trend to decreasing permeability with depth?

5 A. The trend was irregular, yes.

6 Q. Now, can we agree, Mr. Petrie,
7 that the shale is anisotropic in terms of hydraulic
8 conductivity?

9 A. Yes. You said anisotropic

10 Q. Anisotropic, yes, I always
11 have trouble with that. I take that to mean, Mr.
12 Petrie, that you would expect that the hydraulic
13 conductivity in a vertical direction, would be less
14 than the hydraulic conductivity in a horizontal
15 direction.

16 A. I would expect that. I would
17 caution that when drilling the boreholes, there is
18 obviously evidence that there are some horizontal
19 fractures. It is kind of difficult to get an
20 appreciation for the vertical fractures in drilling
21 vertical boreholes. We don't have a good feeling of
22 the degree of vertical fracturing within the system.

23 Q. Is it your professional
24 opinion that there would be extensive vertical
25 fracturing? Is that what you would expect to find?

A. Do you have a clarification on



1
2 the word "extensive"?

3 Q. All right, vertical fracturing
4 to the same degree that we see horizontal fracturing?

5 A. I would suspect that the
6 horizontal fracturing is more prevalent than the
7 vertical fracturing, yes.

8 Q. I thought, Mr. Petrie, that
9 was in some way related to the way the shale was laid
10 down?

11 A. Laid down in subsequent
12 geologic history, yes.

13 Q. Coming back to the question of
14 anisotropy, you have agreed with me that you think
15 the shale is anisotropic. Do you have any opinion on
16 the degree to which, I want to make sure I get this
17 right. Do you have an opinion on the degree to which
18 the vertical hydraulic conductivity would be less
19 than the horizontal conductivity?

20 A. I do not have an opinion.

21 Q. Is an order of magnitude
22 appropriate, in your opinion?

23 A. It is not unreasonable.

24 Q. Would two orders of magnitude
25 be unreasonable?

A. I find it difficult to imagine



1
2 a two order of magnitude contrast.

3 Q. Why is that?

4 A. It is a very pronounced
5 contrast.

6 Q. At some point in your
7 evidence, I am not sure if it is in your report or
8 during your evidence-in-chief, it may be both, you
9 noted that the hydraulic conductivity as determined
10 by Gartner, Lee at the Burlington landfill, ranged
11 over less of a range than that found by Trow and
12 other investigators. Do I have that right, Mr.
13 Petrie?

14 A. I recall something like that.
15 I would just like to check the text.

16 Q. I think you had something like
17 a six order of magnitude range for other
18 investigators and three orders of magnitude for
19 Gartner, Lee. I stand to be corrected on that.
20 Perhaps you could verify that.

21 A. Yes, I am noting on page 106,
22 the bottom paragraph, second sentence reads:

23 "A smaller range of values were
24 obtained here..."

25 "Here" referring to the Gartner, Lee
data for the Burlington landfill.



1
2 Q. I thought you had suggested
3 in-chief, and I am not sure and that is what I would
4 like to confirm, that you thought there was some
5 possibility based on that, that the shale at the
6 Burlington site was somewhat different than the shale
7 at Site F?

8 A. I suggested the possibility.

9 Q. Do you think it is probable?

10 A. The reason for suggesting that
11 possibility was based more on the pumping test data,
12 but then I have to point out that pumping tests have
13 only been conducted on proposed Site F. They have
14 not been conducted on the Burlington site.

15 The pumping test data gave me an
16 impression of hydraulic conductivity that does
17 contrast with the data available for the Burlington
18 site. One could also note that I believe the highest
19 number for slug tests, and I am just comparing the
20 Trow data to the Gartner, Lee data, were obtained on
21 Site F.

22 I also recall indicating in-chief that
23 the Trow data was focussed in trying to identify the
24 fractures within the rock. My impression is they
25 understood the distribution of the fracturing is
important in assessing the pattern of groundwater



1
2 flow and make no opinions as to how Gartner, Lee
3 assessed the rock.

4 The nature of their drilling and the
5 descriptions of their work indicate to me that they
6 weren't focussed exclusively on locating fractures
7 such that the permeability data they provide may not
8 be the same representation of the hydraulic character
9 of the rock as per the Trow data.

10 Q. Is the bottom one -- Mr.
11 Petrie, you are suggesting it is a possible
12 interpretation, but not likely?

13 A. I am suggesting it is
14 possible.

15 Q. You raised in the answer to
16 that last question, the question of the pumping test.
17 I gathered from your evidence on the pump test and I
18 am talking about Pump Test No. 1, that your
19 disagreement with Trow relates to, I guess the
20 location of the transmissive zone. Is that fair?
21 Trow interprets the results from PW-1 to indicate the
22 existence of a highly fractured unit at that spot.
23 You are suggesting that it is more indicative of a
24 weathered surface to the bedrock.

25 A. Trow interpreted the existence
of a highly fractured unit and from Exhibit H-220, we



1
2 have specific elevations of where they understood
3 that unit to be. My interpretation of the water that
4 was pumped from that hole was from the shallow
5 portion of the rocks.

6 Q. Your interpretation has to do
7 with where the water is coming from.

8 A. We also have a disagreement
9 with the value of the hydraulic conductivity
10 calculated from that, yes.

11 Q. I am trying to relate that to
12 your hydrogeologic conceptualization of the site, Mr.
13 Petrie. I would assume that you are using that to
14 say that that is indicative of what you would call
15 the weathered mantle.

16 A. At that point on the site,
17 yes.

18 Q. At that point on the site then
19 you are suggesting that if there is such a thing as
20 the weathered mantle, we are talking about something
21 in the order of five metres thickness?

22 A. I recall a number like that.

23 Q. We started with seven if you
24 recall and determined that some of that related to
25 the overburden and got it down to something like 4.8
metres.



1

2

A. I recall something like that,

3

yes.

4

Q. You were suggesting that that

5

is that exact point on the site.

6

A. Correct.

7

Q. I take it you are also

8

suggesting, and I draw your attention to page 113 of

9

the report, that overall, I am looking at the last

10

sentence of the first full paragraph:

11

"The exact vertical extent of

12

weathered and fractured bedrock mantle

13

is unknown."

14

You are suggesting that it could be

15

more or less than five metres at other spots on site?

16

Q. I take it from your discussion

17

two pages later, I must have the wrong page, I take

18

it from your infiltration calculations found somewhat

19

later, that you are suggesting that a thickness in

20

the order of 15 or 30 metres is not inappropriate.

21

A. The infiltration calculations

22

were generated in order to try to make some estimate

23

of the flux through the system. It is not intended

24

that those numbers define definitive geometry of the

25

site.

Q. What exactly are you



1
2 suggesting?

3 I understand your reluctance to put an
4 exact number on this and I certainly wouldn't hold
5 you to it. Couldn't you suggest a range? I gather
6 five metres is somewhere in that range. Is there
7 some range that would suggest what is reasonable for
8 this weathered mantle, you are suggesting?

9 A. We have two other numbers that
10 provide us with a good definition of the range. They
11 are the position of pumping wells 2 and 3. They, as
12 I recall, were completed to a depth of 15 metres
13 below ground. I could provide a more definitive
14 depth.

15 Q. Could you look at that,
16 please?

17 A. Yes. I think we would
18 probably need to refer to Exhibit H-220.

19 Q. H-220, all right. I recall
20 that that is somewhere in your Part B.

21 A. It is, page 29. I am not
22 entirely sure H-220 helps us because we had some
23 confusion as to which pumping well was which. I
24 could clarify a little. Ground elevation at HC-4 is
25 in the order of 138 metres.

Pumping Well PW-2 is located adjacent



1
2 to HC-3. HC-3 has a ground elevation of 140. I note
3 that the bottom of the well screen there, is 123.6.

4 So, something in excess of 15 metres
5 below rock, the bottom of PW-2.

6 Q. Are you suggesting there that
7 at that location then what we would call the
8 weathered mantle is some 15 metres thick?

9 A. Weathered and fractured
10 mantle, to that point, yes.

11 Q. Can you draw the same kind of
12 conclusion you did with respect to PW-1? If we look
13 at PW-1 I gather it was drilled to some considerable
14 depth but your opinion is you think all of the water
15 is coming from the top five metres of the shale.

16 Can some inference be similarly drawn
17 to PW-2?

18 A. That information was based on
19 the pattern of draw-down where we have a pronounced
20 break in the slope. It is my recollection we did not
21 have the same change in slope with the draw-down data
22 for PW-2 such that one could infer that the water
23 pumped from the well, PW-2 provided for the full
24 thickness of the open interval of that well.

25 Q. Could you refer specifically
to that, because I am trying to ...



1
2 A. I have before me, Exhibit
3 H-40A being the appendices to the Site F Report. I
4 am looking in ...

5 Q. I think we numbered those
6 pages at some point.

7 A. I have a number 7 on a page
8 that I was referring to. It is in Appendix 10
9 towards the back of the document. There are a series
10 of graphs plotting water level change with time.

11 Q. You are looking at page 7?

12 A. Page 8 would be more
13 appropriate. It is the record for the pumping well.

14 Q. This is the pumping well
15 itself?

16 A. Yes.

17 Q. I gather we would contrast
18 that to the graph at which page for PW-1? Page 2?
19 Page 3. I think you had an overhead for that.

20 A. It would be page 3, yes.

21 Q. You drew on the overhead, as I
22 recall it, a dotted line continuing off to the left
23 at page 3. The draw-down, you would assume if there
24 was some uniformity across the thickness of that?

25 A. Correct.

Q. That is more or less what we



1
2 are seeing at PW-2?

3 A. That is more or less what we
4 are seeing at PW-2.

5 Q. Do we draw any inference at
6 all from that slightly more pronounced change in
7 slope or somewhat more pronounced, I guess?

8 A. It is significantly less
9 pronounced than the change of slope recorded on page
10 3, being that for PW-1. One would infer from that a
11 decrease in permeability in the material as the cone
12 of depression expands.

13 In other words, as the volume of water
14 removed from the well is larger, increases, the
15 volume of the rock influenced by pumping is
16 essentially increasing. Then we note that the slope
17 of that line is a little more pronounced than the
18 initial data. It would record a slightly lower
19 transmissivity of the rock. One can infer that from
20 the information contained at the bottom of the graph
21 where we have headings being "Early Time" and "Late
22 Time." We note that the transmissivity for early
23 time is 3.9×10^{-5} metres squared per second and the
24 transmissivity calculation for late time is
25 1.2×10^{-5} metres squared per second.

Q. Does that say anything about



1
2 the transmissivity in the vertical plane in that 15-
3 metre depth, or does it have to do with the cone of
4 influence?

5 A. I cannot infer anything with
6 respect to the transmissivity in the vertical plane
7 from that information.

8 Q. But you can from PW-1. Why is
9 that? Is it because of the pronounced break?

10 A. It is, to my mind, a complete
11 break.

12 Q. While we are there, can we
13 look at the draw-down for pumping test 3?

14 A. Are we referring to page 11?

15 Q. Yes, I guess so, yes. In this
16 one there seems to be a change in slope that is
17 actually in another direction, it heads up, evens out
18 if you will, and becomes more horizontal.

19 A. One would infer from that
20 change in slope at some point a little further away
21 from the well, the rock is more transmissive than at
22 the point of the pumping.

23 Q. It doesn't again say anything
24 about the depth?

25 A. I would not wish to infer it.

Q. How deep are you saying this



1
2 indicates the existence of some mantle at PW-3 then?

3 A. I cannot make an indication
4 other than noting that the information generated is
5 only generated to the depth or to the elevation of
6 121 metres or 121.9, approximately 122 metres in
7 elevation. I cannot make reference to the hydraulic
8 conductivity or the rock transmissive capacity below
9 that depth based on the data we have before us on
10 this page 11.

11 Q. So, is there some minimum
12 number you would put on there?

13 A. One can take a minimum number
14 being equivalent to the elevation of 121.9.

15 Q. Compared to the surface level
16 elevation, if we look at the interrogatory, PW-3 is
17 adjacent to WAT-5.

18 A. WAT-5 has ground elevation of
19 127.5, which appears to be not entirely consistent
20 with the screen data for PW-3. I would hesitate to
21 extrapolate the ground elevation between those two
22 locations.

23 Q. So, you are hesitant to give
24 any depth at that particular well?

25 A. Correct.

Q. I gathered -- have you got



1
2 H-220, which you have included in your report, out
3 there, Mr. Petrie?

4 A. I have my report here, yes.

5 Q. I gather then with respect to
6 PW-2, other than the name of the unit and I think
7 that Trow has referred to it as the weathered and
8 moderately fractured Unit 2?

9 With respect to PW-2 you don't have
10 much disagreement with some depth of a fractured or
11 more weathered unit at that location?

12 A. PW-2 is adjacent to HC-3.
13 There is additional hydraulic conductivity data
14 generated for HC-3 pressure packer tests and slug
15 tests, as I recall.

16 Q. I just wonder simply with
17 respect to PW-2.

18 A. It appears consistent with my
19 understanding of it, yes.

20 Q. At page 108, you discuss the
21 tritium results and you -- let me ask you a general
22 question following from your discussion of the
23 tritium distribution, does the tritium data tell you
24 anything about the thickness of the weathered mantle?

25 A. Presence of tritium being
about 2.3 tritium units indicates post-1952 water.



1
2 In my opinion, where you have tritium and it has
3 entered the groundwater flow system in the last 35
4 years and penetrated to the depth at which it is
5 encountered, that to me reflects how active the
6 system is.

7 So, where you have tritium in my
8 opinion that is consistent with the weathered and
9 fractured mantle.

10 Q. So, if we look specifically at
11 HC-5 and HC-8, I forget where that data is, I have
12 written that in on your drawing.

13 A. As I recall it would be on
14 Part B, I believe we should be looking at -- page 48
15 provides the figure for the tritium data as
16 determined by Trow.

17 Q. Do I understand what you have
18 just said to me with respect to HC-5, you are saying
19 that at HC-5 it is reasonable to interpret this
20 weathered and fractured mantle down to a depth of
21 some -- I will try to get it off that page -- it
22 looks to be something in excess of 30 metres.

23 A. That is reasonable.

24 Q. With respect to HC-8, you are
25 suggesting that there is -- the weathered and
fractured mantle at that location could be something



1
2 less than perhaps five, maybe two metres?

3 A. That is correct. Those
4 conclusions are based solely on the tritium data.

5 Q. Yes.

6 Now, I want to come specifically to
7 your interpretation, your conceptualization of the
8 flow system at this site. I want to refer
9 specifically to your summation that I find at page
10 114 of Exhibit B-617.

11 Starting with -- ignoring for a
12 moment, the first paragraph there, I want to deal
13 separately with the next paragraphs numbered 1 and 2
14 and then your interpretation which follows numbered
15 1,2, and 3. Dealing first of all with the middle
16 part where you state:

17 "The groundwater flow system at this
18 site is characterized at the site by
19 one shallow groundwater flow system
20 dominated by lateral flow in the
21 weathered unfractured bedrock mantle
22 and two, a deep groundwater flow
23 system dominated by strong downward
24 gradients with significant lateral
25 flow at depth."

I want to ask you specifically about



1
2 those systems.

3 In your mind, starting more generally,
4 that is what you are saying, that is in the broadest
5 sense your concept of what is happening at this site?

6 A. Correct.

7 Q. In terms of contaminant
8 transport, Mr. Petrie, what is it that you are
9 telling this Board is the most important flow system?

10 A. A shallow system is the most
11 important in the sense that it is the first impacted
12 by exfiltration from the landfill. However, I cannot
13 dismiss the deeper flow system because I am very
14 unsure of the hydraulic characterization of that
15 site.

16 Q. Which do you think is the most
17 important in terms of flux, total mass of
18 contaminants?

19 A. I would expect the shallow
20 system to be most important in terms of mass.

21 Q. Significantly more important?

22 A. I hesitate to give that
23 answer. I would say it is more important.

24 Q. Now, the calculations that you
25 have done in the back of this exhibit, with respect
to infiltration rates at Site F, do they relate to



1
2 both of these units?

3 A. I am sorry, the calculations
4 you referred to are they ...?

5 Q. ... found later in the
6 document? I don't need to refer to them at this
7 point. I will be coming to there in time. Do those
8 calculations, which I think you did for a 15-metre
9 thickness and a 30-metre thickness, are you
10 suggesting they relate only to the component numbered
11 1 here?

12 A. The difficulty we have on this
13 site is coming up with a precise definition of the
14 hydraulic characterization. The depths you referred
15 to being the 15 metres and the 30 metres, we took to
16 provide allow us to make some estimation of the
17 potential infiltration at this site.

18 I did not intend that those numbers be
19 related specifically to the pattern of groundwater
20 flow you see before you.

21 As I have indicated, based on the
22 tritium data alone, we have some portions of the site
23 that are not hydraulically active, being HC-8 and
24 other portions of the site that are hydraulically
25 active. For example, at HC-5.

So, we are looking at a very irregular



1
2 active flow system. I hesitate to characterize it to
3 a specific depth across the site.

4 Q. We will come to the
5 infiltration data at some point later, but do the
6 infiltration figures that you derive, in fact, let us
7 go to the more general. Do the 50 to 100 millimetres
8 you suggest are appropriate at the site, does that
9 relate to both of these?

10 Are you suggesting that is
11 infiltration that moves both laterally in a weathered
12 mantle and to depth?

13 A. We calculated in a lateral
14 plane because we had sufficient hydraulic data,
15 albeit we used it conservatively to arrive at that
16 number and noted that the infiltration could be in
17 excess of the calculated number because it was my
18 feeling there was some additional flow out of that
19 schematic box to depth.

20 Q. Now, looking specifically at
21 number 2, the second thing you think the site is
22 characterized by:

23 "The deep groundwater flow system
24 dominated by strong downward
25 gradients..."

And you use the expression:



1
2 "... with significant lateral flow at
3 depth."

4 First of all, what do you mean by
5 "significant lateral flow"?

6 A. I mean that in some fashion,
7 strong downward gradients cannot be maintained. That
8 is my understanding of hydraulic gradients in rock.
9 Were they to be maintained, I would believe we would
10 have to have strong upward gradients at some point
11 further down-slope. I do not see it. There is some
12 hydraulic mechanism by which the site is under-
13 drained which accounts for the steep downward
14 gradients.

15 If you are going to put it simply,
16 suck the water down, you have to be able to move it
17 away laterally in order to maintain the sucking
18 action. It is that that I refer to with significant
19 lateral flow at depth.

20 Q. Do you need a lot of
21 groundwater movement at depth to generate the strong
22 gradients?

23 A. No, you do not.

24 Q. You could, in fact, have very
25 strong gradients pulling down, a very minute amount
of water?



1

2

A. If a minute amount of water
was all that was available, yes.

4

5

6

7

8

Q. Now, looking now at your
interpretation at the bottom of page 114 and I see
you have -- you conceptualize the site into three
distinct -- I hesitate to use the word "units" but
into three distinct portions.

9

10

11

12

13

The first is the weathered mantle we
have been talking about. The second is a thick lower
permeable zone and the third is a moderately
permeable drain or drains within that lower permeable
strata.

14

15

16

17

A. Correct.

Q. It struck me, looking at that,

Mr. Petrie, that your hydrogeologic interpretation
isn't that far off Trow's.

18

19

20

21

A. The difference between Trow
and myself is, I do not feel comfortable delineating
these zones. Trow did feel comfortable delineating
zones.

22

23

24

Q. But Trow also has some kind of
weathered and fractured unit at the top of the shale,
do they not?

25

A. They have a Unit 2 at the top
of the shale at a portion of the site.



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Q. Yes, and I assume you disagree
that it pinches out at some point on the site.

A. Correct.

Q. They have a Unit 3 which is --
they have called the massive shale?

A. Correct.

Q. You are suggesting that that,
some kind of unit like that has to exist as well to
generate those gradients?

A. There has to be a lower
permeability unit between their Unit 2, yes.

Q. They are suggesting the
existence of some under-drain, they called it the
highly fractured shale and have extended it off-site.

A. They have.

Q. You agree that that exists,
you just don't know where it goes?

A. Correct.

Q. You think it is deeper than
they are suggesting.

A. I am suggesting at or deeper.

Q. Look at the first one first,
the weathered mantle. We have already talked about
that to some extent.

We have talked about -- if I can just



1
2 sort of sum up, you don't know how thick it is. You
3 are suggesting that there the results from PW-1
4 suggested it could be five metres thick.

5 A. The one point there.

6 Q. The suggestion from PW-2
7 suggests it could be 30 metres thick.

8 A. Correct.

9 Q. The results from the tritium
10 testing at HC-5 suggested it could be something in
11 excess of 30 metres thick.

12 A. Correct.

13 Q. How does this zone vary from
14 Dr. Charlesworth's active zone? Where do you differ
15 from Dr. Charlesworth on that? You will recall Dr.
16 Charlesworth saying that his active zone, he assumed,
17 I don't want to misstate what he said, but I think,
18 you can tell me if you think this is what he said,
19 that it varied somewhere between 5 and 20 metres, but
20 he thought it was reasonable for Dr. Rowe to model 25
21 metres. Where are you in disagreement with Dr.
22 Charlesworth on that?

23 A. I do not believe we are in
24 disagreement with that general statement.

25 Q. I think I have already asked
you this, but just to confirm it, you are suggesting



1
2 that it is this zone, the variable thickness zone of
3 weathered mantle that carries the majority of the
4 groundwater at the site?

5 A. Correct.

6 Q. Would I also assume that you
7 make some assumptions about the extension of this
8 weathered zone up-gradient of the site?

9 A. I don't recall making ...

10 Q. I am sorry, I am inferring
11 that from everything you have said, do you?

12 A. There is no borehole dated up-
13 gradient.

14 Q. I understand that, Mr. Petrie.
15 Do you have any opinion on the existence of a
16 weathered mantle up-gradient of the site?

17 A. I would expect that the rock
18 is weathered in some fashion up-gradient from the
19 site, yes. I note that up-gradient from the site,
20 the site is overlain by till materials and further
21 up-gradient again, we are beneath the limestone rock.
22 We are dealing with a different geologic
23 characterization.

24 Q. I assume that when we talk
25 about weathering, we are talking about what I think
of weathering, if the soil in my backyard dries out,



1
2 that is weathering and there is some fracturing et
3 cetera. I assume that when the strata weather, they
4 weather at some point in geologic time when they are
5 exposed to the elements?

6 A. That is a fair assessment,
7 yes.

8 Q. Is it not just from a common
9 sense point of view sensible to assume that if there
10 is weathering in the vicinity of Site F at the
11 Queenston shale, there is probably weathering in the
12 surface of the Queenston shale throughout its lateral
13 extent?

14 A. Where it is exposed.

15 Q. Wasn't all of that shale
16 exposed at some time?

17 A. It would have to have been in
18 order to have more material laid down upon it, yes.

19 Q. I am just exploring your
20 suggestion that there might be some difference
21 because of the till that was laid down at the north
22 end of Site F.

23 A. There may be.

24 Q. You don't really know?

25 A. I have no borehole data to
depend on.



1
2 Q. Turning to the second part of
3 your interpretation, the thick lower permeable zone
4 with permeabilities ranging from 10^{-6} to 10^{-8} . We
5 have already talked about this being roughly
6 equivalent to Trow's massive unit. You would agree
7 with that?

8 A. Roughly.

9 Q. You make no assumptions about
10 thickness?

11 A. No, I do not.

12 Q. Do you have any opinion on how
13 thick that unit might be?

14 A. No, I do not.

15 Q. Presumably it is at least as
16 thick -- the bottom of it is at least to the bottom
17 of the lowest boreholes we have.

18 A. Most definitely.

19 Q. Because that is where you say
20 the under-drain could be?

21 A. Yes, it is at least to that.

22 Q. Would you expect a significant
23 amount of groundwater movement through that lower
24 permeable rock?

25 A. Again, I am not sure what you
mean by "significant."



1
2 Q. In terms of -- well, if we had
3 to break down, if we talked about -- if we talk about
4 100 drops of water coming in at the surface and you
5 have told me that you think a majority of that would
6 be -- would move laterally through the weathered
7 mantle, I suppose a majority of the 100 drops would
8 be 51.

9 Are you suggesting as many as 49 drops
10 could be pulled through the lower permeable material?

11 A. That would be speculative. I
12 am suggesting that much of the water would be
13 expected to move through that active system.

14 Q. Can you put any number on it
15 at all, Mr. Petrie? Do you have any opinion simply
16 from a first principles point of view?

17 A. To generalize, at least two-
18 thirds would be in the active system, to generalize.

19 Q. So, something less than one-
20 third would go through the less permeable zone?

21 A. That is fair.

22 Q. Finally, moving to the third
23 part of your interpretation, a moderately permeable
24 drain or drains within the sequence of thick lower
25 permeable strata. You are suggesting, as I
understand it, that that drain or those drains lie



1
2 somewhere at or below the deepest boreholes on site?

3 A. That is my expectation, yes.

4 Q. You are suggesting something
5 has to be there in order to account for the
6 gradients?

7 A. Correct.

8 Q. I take it that in answer to
9 the previous question with respect to the amount of
10 water that you expect to go down, you would expect,
11 in terms of the amount of contaminants we expect to
12 move down there, you would expect something less than
13 one-third of the contaminants would exfiltrate the
14 site?

15 A. In a general sense, yes, but I
16 do hasten to add we do not have a definitive
17 hydraulic characterization of that drain.

18 Q. I am talking about
19 contaminants getting to it as opposed to where they
20 go at that point.

21 A. You are dealing with a
22 relationship of the hydraulic characterization of the
23 drain developed in the less permeable strata. If
24 that drain were highly permeable, that provides for a
25 strong sucking action, but it also provides the
capacity to carry a large amount of mass away. If



1
2 that drain is only moderately permeable, then
3 obviously it could carry less away.

4 I believe in our examination of the
5 sensitivity analysis of the model, as conducted by
6 Trow, we demonstrated that. We raised the hydraulic
7 conductivity of the drain and raised slightly the
8 hydraulic conductivity of the intervening barrier
9 layer being Unit 3. You could pull more fluid down
10 through there, and still maintain the same water
11 level profile. More fluid is referenced back to the
12 infiltration. Essentially, you can push more water
13 into a system if you can pull it away from the
14 bottom.

15 I do not have an opinion on how much
16 water we can pull away from the bottom of this site.

17 Q. I note that you refer to the
18 drain as moderately permeable. I take it you don't
19 agree with Trow that there is some high permeability
20 zone.

21 A. Correct. I do not
22 the thickness of the drain.

23 DR. KINGHAM: On that very point, Mr.
24 Petrie, just so we understand clearly, a
25 hydrogeologist's drain and a plumber's drain, you
would understand your hydrogeological drain to have a



1
2 large lateral extent in two dimensions horizontally
3 as opposed to being a series of pipe-like drains
4 limited.

5 MR. PETRIE: It's easier to understand
6 that as having a large lateral extent. I would not
7 be particularly definitive as to what its geometry
8 would be. It has the capacity to move the water.

9 MR. TIDBALL: Q. I believe you
10 suggested in-chief, and I think you suggest in your
11 report and where you do your modelling that you
12 speculate that that under-drain extends out as far as
13 HC-10, 11 and 12?

14 MR. PETRIE: A. That speculation was
15 based on the distribution of gradients that we
16 measured at the site.

17 Q. And by extending the drain on
18 the hydrostratigraphic interpretation for the
19 purposes of FLONET, you generated what you say is a
20 better result?

21 A. We were able to more
22 reasonably reproduce the vertical gradients, yes.

23 Q. I wasn't sure what your
24 evidence was with respect to the extension of that
25 drain further, that being further down-gradient
towards Lake Ontario. Are you suggesting it would



1
2 continue to extend?

3 A. We based our interpretation on
4 the distribution of the gradients. HC-16 being right
5 on the shore of Lake Ontario, we do not see upward
6 gradients. A review of the borehole log does not
7 indicate significant fracturing.

8 At HC-11 there were some fracture
9 zones encountered. I hesitate to relate fracture
10 zones to hydraulically active fracture zones,
11 recognizing that Trow indeed had some difficulty in
12 doing that themselves.

13 Recognizing that there are fractures
14 at HC-11 and there is a component of upward flow
15 there, we extrapolated that drain to at least go to
16 that point.

17 Q. Would I be correct that it is
18 unlikely that it would just stop in terms of geologic
19 definition, that if you had some kind of a permeable
20 drain, some kind of permeable layer draining an area
21 it has to go somewhere, or otherwise it doesn't act
22 as a drain? You can't just stop at a point?

23 A. At HC-11, you are dealing with
24 lower elevations. You are moving fluid through a
25 drain to conceptualize. If the drain stops there,
water has to move upwards. If the rock is thinner,



1
2 then one can maintain a stronger upward gradient.
3 The drain could continue, but we don't see the upward
4 gradients at HC-16. We have interpreted the position
5 of the drain, or we have extrapolated it based on
6 Trow's interpretation that it ought to extend at
7 least to the position where we still see upward
8 gradient. We have made the interpretation of the
9 position of that drain. We started with Trow's
10 hydrostatigraphy and we sought to match the vertical
11 gradients that we see on the site. It therefore
12 suggests the possibility it could happen again. I
13 absolutely disagree with that.

14 Q. If there is, in fact, some
15 kind of under-drain in the vicinity of Site F, does
16 it necessarily have to be the same under-drain, does
17 it necessarily have to be at all related to HC-10, 11
18 and 12?

19 A. We have strong downward
20 gradients on the site, which indicates to me that
21 water is moving down in some fashion and that we have
22 to have a component of lateral flow to move that
23 water from beneath the site. If that drain just
24 stopped arbitrarily, let us stop it where Trow had it
25 stopped and stopping the drain where Trow stopped it,
I am referring now to the figure we had on page 54 of



1
2 our report. This figure shows Trow's
3 hydrostratigraphy and the background to the figure,
4 the coloured overlay is the distribution of the units
5 as they have modelled.

6 Looking at the dark brown unit, which
7 the legend indicates is the highly fractured shale,
8 we have extended it from the left of the figure
9 terminating at a point approximately 1,400 metres
10 from the axis.

11 By terminating the drain at that
12 point, their model showed groundwater discharge in
13 approximately that point. In other words, there
14 would have to be vertical hydraulic gradients at that
15 point, that point being the discharge zone.

16 There has been considerable discussion
17 at this hearing that that discharge zone, at least in
18 my mind does definitely not represent discharge from
19 the deep bedrock. So, if we are moving water
20 laterally away from beneath the site were we to
21 terminate that drain at some point, we would expect
22 to have to have upward gradients to provide for the
23 movement of water out of the end of that drain.

24 Q. And I took your evidence in-
25 chief, Mr. Petrie, to simply be that Trow didn't have
any basis to do that and it is just as reasonable to



1
2 extend it down to the vicinity of HC-10 and 11.

3 A. I suggest it is more
4 reasonable to extend it to HC-10 and 11.

5 Q. In that respect, the only
6 disagreement you have with Trow is where to end it,
7 not the only one, I am sure you have lots of
8 disagreements with Trow, but with respect to that end
9 of things, with the highly fractured, or some
10 fractured unit, you are just saying it is more
11 reasonable to extend it further down gradient?

12 A. You don't have the data to
13 support extending it all the way to Lake Ontario.

14 Q. Correct.

15 MR. TIDBALL: Mr. Chairman, that would
16 be a convenient place to break for lunch.

17 MR. LANCASTER: Before we do break
18 though, the Board should advise counsel that the date
19 set for the hearing of the public, the general public
20 is Thursday May 26th and Friday May 27.

21 The 26th times will be 1:00 p.m. to
22 5:00 p.m. and 7:00 p.m. to 10:00 p.m. in the
23 evening. That will be in the auditorium in the
24 Oakville Centre, which is just across the street.
25 That is the northerly building on the block.

The Friday session will be 9:00 a.m.



1
2 to 12:00 noon. This will be in the studio theatre in
3 the same building on the lower level. That is
4 Thursday, May 26th and Friday, May 27th.

5 We will adjourn until 2:00 o'clock.

6 MR. GARROD: Mr. Chairman, just for
7 clarification, I assume it is intended that any
8 member of the public who is interested in either
9 site.

10 MR. LANCASTER: Yes. If we need more
11 time we -- yes, it is intended for anyone of the
12 general public from anywhere, that wishes to speak.

13 We necessarily don't want the same
14 ones we have heard.

15 MR. GARROD: I am just wondering if it
16 was intended for the people to speak about one set or
17 the other, but they can speak about either site.

18 MR. LANCASTER: Anything they have to
19 say regarding it.

20
21 --- Luncheon recess at 12:40 p.m.

22
23 --- Upon resuming at 2:25 p.m.

24
25 MR. LANCASTER: Please be seated.

MR. TIDBALL: Q. Mr. Petrie, please?



1
2 Mr. Petrie, I had just a few questions
3 on the use of the FLONET model and then I want to
4 turn my attention in a different direction.

5 I first want to direct my attention to
6 your discussion of the model calibration which starts
7 at page 57 of Exhibit B-617. I draw your attention
8 specifically to the third numbered point on that page
9 which is that:

10 "The piezometers set in the highly
11 fractured shale Unit 4 at Well Nest
12 HC-4, HC-5 and HC-8, show poor fits
13 with the field data for both models."

14 I understood from your evidence you
15 used that as one of the reasons for saying that the
16 model doesn't accurately represent the flow system.

17 MR. PETRIE: A. "Reasonably" I
18 believe the word was, yes.

19 Q. I was just wondering, with
20 respect to that, can you get that coloured map out,
21 on page 54.

22 A. I have a copy. I don't have
23 an overhead of that.

24 Q. I realize it didn't reproduce
25 in the overhead. That Figure B.4.1 and I notice on
there, I believe it was one of your other criticisms



1
2 that where Trow, where the FLONET modeller for Trow
3 had placed the highly fractured unit on the grid was
4 below where Trow hydrostratigraphically has that
5 unit, have I got that right, or is it backwards?

6 A. Could you repeat it?

7 Q. Just looking at this figure,
8 the dark brown which is the portion of the FLONET
9 grid that was input with the "K" of the highly
10 fractured shale, is in fact lower in the cross-
11 section than the place it should be according to
12 Trow's hydrostratigraphy.

13 A. Correct.

14 Q. It was actually quite a simple
15 question, can that misplacement on there, account for
16 the fact that there is a poor fit?

17 A. Yes, it could.

18 Q. In fact, would it be what you
19 would expect if you had put that in the wrong place
20 and then tried to interpret head data off it?

21 A. I am not sure what to expect
22 if they put it in the wrong place.

23 Q. It was more of a curiosity
24 than anything else.

25 A. You would expect differences
between an expectation based solely on the



1
2 hydrostratigraphy than that which would generate from
3 the model given that it does not match.

4 Q. All right, just so that I
5 understand your evidence on that, you are saying the
6 misplacement could have accounted for the poor fit,
7 but you are not sure.

8 A. It could have.

9 Q. Now, you may -- I want to draw
10 your attention to two conclusions. One is on page 62
11 and is made with respect to the sensitivity analysis,
12 I am sorry. Your analysis of the Trow simulations
13 where you say if you look at page 62, the second full
14 paragraph and after Point 6, it says:

15 "In general, the Trow simulations
16 indicate that the hydrogeologic
17 systems at Site F is a complex system
18 that is very difficult to model
19 accurately."

20 If you turn over to page 129, I find a
21 similar statement made with respect to your
22 sensitivity analysis. Have you got 129 there?

23 A. Yes, I do.

24 Q. Point 4 is:

25 "The hydrostatigraphy of the site is
more complex than that interpreted



1
2 by Trow."

3 And then you go on to talk about the
4 poor fit encountered in the highly fractured shale
5 and the poor fit at HC-11 or HC-14. I was just
6 wondering, Mr. Petrie, whether those conclusions
7 ought not more properly to be that it shows that
8 either you have got the wrong model or that you are
9 inputting the wrong things to the model rather than
10 showing that the system is complex.

11 I don't think I take any disagreement
12 at all with your conclusion that the system is
13 complex. It is more the use of the model results to
14 say that it is a complex system.

15 A. By adjusting permeability data
16 within the system and still being able to simulate
17 the head and coming up with a measure of
18 significantly different rates for infiltration tells
19 me that in some fashion the system definitely is
20 complex.

21 That statement is not made solely with
22 respect to the head fit at any one point.

23 Q. It tells you that the system
24 is complex rather than unmodellable.

25 A. Correct. I have not said
here, I believe, that the system is unmodellable.



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Q. I hope the reporter got that.

3

MR. HODGSON: I bet he can't say it

4

now.

5

MR. TIDBALL: I am going to put that

6

in my compendium of sayings.

7

Q. All right, it tells you that

8

it is complex, it tells you the system is complex.

9

A. Correct.

10

Q. Is there a model that could

11

model this system?

12

A. There may indeed be models

13

that one would wish to apply to this system. I

14

hesitate to speculate on the results that those

15

models might show.

16

Q. I appreciate you are not a

17

modeller, Mr. Petrie, so I wouldn't ask you to

18

comment on any particular model, but from your

19

knowledge as a hydrogeologist, are there models that

20

are used for fractured media such as this?

21

A. You have made two statements

22

there. Are there models used for fractured media.

23

There are. How representative they are is always

24

part of the question. How reasonably can one

25

reproduce the fracture geometry and enter that as
part of the constraints are entry data within the



1
2 model. You make the statement to sites such as this.
3 Sites such as this, we do not know where the
4 fractures are with the degree of comfort that one
5 could enter the geometry of that system into a model.

6 Q. All right, so there are
7 fracture flow models.

8 A. There are fracture flow
9 models.

10 Q. Are there fracture flow models
11 that accommodate complex fracture flow?

12 A. One can enter complex fracture
13 geometry into such a model.

14 Q. Yes.

15 A. I will repeat my statement,
16 one can enter fracture flow geometry into such a
17 model. One is then in the position of trying to
18 calibrate those results to the field results.

19 Q. All right. I gather that Dr.
20 Rowe's model is some sort of fracture, the type of
21 model he used on Site F, is in some respects a
22 fracture flow model?

23 A. It is a fracture flow model,
24 however it is my understanding that Dr. Rowe did not
25 seek to indicate that because he modelled the certain
fracture spacing or frequency, but that indeed was



1
2 the fracture frequency or spacing. He introduced a
3 general fracture network. He did not seek to
4 simulate the exact fracture geometry. It is my
5 opinion that he does not know the exact fracture
6 geometry as I do not know it.

7 Q. A couple of questions about
8 your use of your remodelling of the -- using FLONET.

9 First of all, why did you choose, in
10 the model that finally had the best fit, the one that
11 we find on the coloured figure on page 131, why did
12 you choose an isotropic model? Why did you choose an
13 isotropic set-up as opposed to, for example,
14 Trow's Model 2?

15 A. The purpose of this modelling
16 was to see if we could reproduce the hydraulic
17 gradients in some fashion. Trow had provided the
18 Board with both an isotropic and an anisotropic
19 model. In generating this system, we found that the
20 isotropic picture was a little more easy to adapt to
21 the flow field, i.e. in terms of calibrating it to
22 those results. It was not intended to imply
23 therefore, that the hydrostatigraphy at the site is
24 as shown, or further, that the hydrostatigraphy at
25 the site is isotropic.

We sought only to attempt, using the



1
2 Trow discretization of the grid, using the Trow, that
3 grid to see if we could demonstrate that a better fit
4 could be achieved, better fit being water levels and
5 gradients. It is not an attempt to define the
6 hydrostatigraphy of the site.

7 Q. All right, I guess I maybe
8 don't understand completely how you do this. Was the
9 aim of this modelling to simply get a better fit than
10 Trow's Models 1 or 2?

11 A. We had undertaken the
12 sensitivity analysis and indicated that variations of
13 hydraulic conductivity could achieve a better fit. I
14 beg your pardon, entering in different values for
15 hydraulic conductivity could produce a similar fit.

16 Of all those fits that we ran of the
17 Trow simulations, we had a concern that the model
18 that showed a discharge gradient at HC-14 which was
19 inconsistent with the field data and the model did
20 not show a component of vertical flow at HC-11, which
21 was inconsistent with the field data.

22 So, our attempt therefore was to
23 examine by extending the drain and trying to adjust
24 the permeability values within the system in some
25 fashion, could we come up with a better picture of
the gradients within the system.



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Q. I would assume from that that there was a fair number of runs in the model?

A. You can assume that. I do not know what the number was.

Q. I gather that the aim of the exercise is to boil it down to the simplest, play with the colours on here to move the different coloured pieces around until you got something that gave you a better fit.

A. Yes.

Q. Would I be right to conclude that you didn't start with your conceptualized version of the hydrogeology, that is the weathered mantle, the more impermeable layer and then the under-drain or under-drains somewhere deeper than where Trow had them?

A. I don't recall we started in that place. We started, I cannot recall exactly how we started. We wanted to stretch the drain, we wanted to modify some of the hydraulic conductivities only with a view to reproducing the head. We did not try and attempt in this exercise in any way, shape or form to model our hydrogeologic conceptualization.

Q. Do you have an overhead of the



1
2 next figure there, Figure C.4.2?

3 A. I believe I do.

4 Q. What you have put up, Mr.
5 Petrie, is the calibrated result of the FLONET model
6 that you ran that gave you a better fit than either
7 of Trow's models.

8 A. Correct.

9 Q. All right, now I had in my
10 notes, I think, somewhere in-chief you said that this
11 result might be considered to be a reasonable
12 approximation of the regional flow system.

13 A. I don't recall those exact
14 words. I recall something to the effect that it was
15 a better fit of the vertical gradients. We are
16 seeking to match the gradients.

17 Q. All right. So, is it your
18 evidence then, Mr. Petrie, that this model isn't a
19 reasonable representation of the regional groundwater
20 flow system?

21 A. In order to make that
22 interpretation you would also have to consider the
23 values for the hydraulic conductivity input. I
24 hesitate to draw conclusions regarding the input
25 hydraulic conductivity values. It is, in my mind, a
better representation of the flow field than that



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2

developed by Trow.

3

4

It is not intended to be a definitive representation of the flow field.

5

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Q. Can you turn to page 130 in Exhibit B-617? I had thought that you had said it in-chief, but perhaps I am getting it from your report. Looking at the second paragraph, you say:

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"It must be emphasized that the calibrated CRA flow model does not confirm the hydrogeologic system model, but does give a reasonable approximation of the regional groundwater flow system at this site." I guess that is what I was thinking

17

18

A. It does give a reasonable approximation.

19

20

21

22

23

Q. Given our discussion this morning about the reasonableness of Morrison, Beatty's regional flow picture and Dr. Charlesworth's very similar picture, do you still agree with the statement there at page 130?

24

25

A. Specifically, the reasonable approximation of the regional groundwater flow system?



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Q. Yes?

3

4

A. With reference, your question
doesn't focus on regional or it does?

5

6

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Q. It focuses on regional. I am
curious as to how, what I have before me now is your
agreement with me this morning that the figure out of
the Morrison, Beatty report, and the Exhibit 469 from
Dr. Charlesworth, which were both the regional flow
system. I thought you agreed with me this morning
that -- at least I thought you agreed that that was a
reasonable picture of the regional flow system.

13

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A. The regional flow system as
provided on those two documents, you referenced a
minute ago incorporated the elevation of the Niagara
Escarpment. This is the same geometry, the same
property boundaries, or shape would be a better word,
as that used by Trow.

19

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We did not have the Niagara Escarpment
on this point. It would be my expectation that if
that was there, we might have the flow field that
looks a little more like a broad arrow going from the
escarpment to the lake which was consistent with the
arrows that I see in general on the Morrison, Beatty
figure which I have.

Q. Perhaps it is a problem with



1
2 terminology then, Mr. Petrie. I guess it is the use
3 of the word "regional." Is that where it lies? Is
4 this really a local groundwater flow picture?

5 A. We were seeking to reproduce
6 the vertical gradients in this portion of the site
7 where we have gradient data. Obviously, at the wells
8 recognizing that the depth of those wells is in the
9 order of 30 metres below the ground surface.

10 It would have been better to say that
11 that provides a reasonable approximation of the flow
12 field in the vicinity of the site.

13 Q. Can we change that then? A
14 reasonable approximation of the flow field in the
15 vicinity of the site?

16 A. Yes.

17 Q. Thank you. Now, I wonder if
18 you could leave that figure up there and I want to
19 focus specifically on the area that you have referred
20 to on that figure as the discharge zone. I
21 appreciate, Mr. Petrie, your evidence that you don't
22 think that this particular flow model is any better
23 than Trow's.

24 Do you think that it plus the other
25 two show that you can do anything with the FLONET and
still get a similar result?



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A. That is correct.

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Q. If we can just use this for discussion purposes, I want to talk specifically about discharge, the discharge of groundwater in the area south of Highway 403.

Now, first of all, can we agree that any landfill derived contaminants are going to follow the same flow path as groundwater in the areas of the 403?

A. In general, yes.

Q. The landfill isn't going to do anything to that?

A. The landfill, as proposed in this portion of the site, is not going to alter the flow field down-gradient of 403, no, it will not.

Q. So, the flow patterns that are now established will be the same flow patterns following establishment of the site south of the 403?

A. Correct.

Q. I take it that you don't disagree that the groundwater in the shale, both north and south of the 403 is highly saline?

A. Do you have a double negative in your question?

Q. Why don't we put it in the



1
2 positive? You will agree with me that groundwater in
3 the shale is highly saline?

4 A. In general, yes.

5 Q. Do you agree that there is a
6 freshwater rind south of the 403? That is the term
7 that has been used and I want to talk about that a
8 bit?

9 A. Yes.

10 Q. I think to do this properly,
11 it might be useful to get out one of Trow's cross-
12 sections from Exhibit 40. Could you get out Figure
13 7, Drawing No. 7 from H-40?

14 A. Drawing No. 7.

15 Q. Could you put that up, that
16 would be very useful.

17 Now, this is actually going to -- can
18 you confirm for me, Mr. Petrie, I want to concentrate
19 on the area on the right of this plan, that is the
20 area south of the 403 and can you confirm for me that
21 the uppermost layer in the right-hand part of that
22 cross-section is -- we see from the legend -- is
23 lacustrine sands.

24 A. That is what the legend says,
25 yes.

Q. Those are sands that were laid



1

2

down by some lake in geologic time?

3

A. Correct.

4

5

Q. Is it that long ago? I never
know what geologic time is.

6

A. Beyond our memories.

7

8

MR. LANCASTER: Before the start of
the hearing!

9

MR. PETRIE: I stand corrected.

10

11

MR. TIDBALL: Would you care to
speculate on when the end of the hearing will be?

12

13

Q. Below that the layer in the
legend we see is silt to clay-silt till?

14

MR. PETRIE: A. That is correct.

15

16

17

18

Q. That layer, in fact, extends
back under the 403 and all the way up to the vicinity
of -- in fact, up-gradient of HC-5 on this cross-
section so it is up-slope?

19

20

21

A. There appears to be some
slight difference in the symbols up-gradient from HC-
5, but I believe that is what it is.

22

23

Q. That is perhaps a third of the
way up the proposed site, something like that?

24

25

A. Perhaps.
Q. I want to refer specifically
to this, what has been called the freshwater rind.



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Are you able to indicate, perhaps with your pointer, for the Board, where the general vicinity of the wells that have been discussed in the area south of 403, where they are in cross-section?

A. It is my general recollection that south of Plains Road...

Q. Perhaps it might be useful to pull out Exhibit WB-227. That is the one that Ms Vigod filed, I believe, and that is the one that shows the water quality down from the domestic wells and it has a map where it shows where they all are.

Perhaps you could refer -- I am just suggesting that you refer to that map to answer the question.

DR. KINGHAM: Is that WB-227?

MR. TIDBALL: Yes, I believe it is. It is a summary of water-well sampling in Burlington. We have yet to hear evidence on that, Mr. Chairman. I think Mr. Bohan is going to prove that exhibit.

Q. Have you got that? I am looking at the third page of that exhibit, it shows the wells that are located in the vicinity of Site F.

Can you confirm for me that with the exception of, perhaps, one well, they all seem to be located between Plains Road and the CNR line?



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A. The majority seem to be, yes.

3

Q. Can you indicate on that

4

cross-section where that is?

5

A. Plains Road is -- I am

6

pointing to it. The CN track is also defined and I

7

am indicating that zone.

8

Q. It is in that area in there.

9

Now, I appreciate we don't have very

10

much evidence on those wells and perhaps we will by

11

the end of the hearing, Mr. Petrie. Would you expect

12

those shallow wells to be more or less intercepting

13

water in the lacustrine sands?

14

A. Based on the stratigraphic

15

sequence I have before me, yes. I would point out

16

that the shallow sands, the sands are at the surface

17

and we have the silt till material at depth. Maybe

18

some of the wells penetrate to depth in those

19

materials.

20

Q. Would you anticipate there

21

also being something of a groundwater resource in the

22

overburden to the south of Plains Road?

23

A. Yes, I would anticipate that.

24

Q. Again, in the lacustrine

25

sands?

A. That would be my expectation,



1

2

yes.

3

4

5

Q. Would that simply be because
the lacustrine sands would probably have a higher
permeability than the underlying clay till?

6

7

A. Relative to the silt and clay
silt till, yes.

8

9

Q. And those sands are being
recharged with rainwater?

10

11

12

13

14

A. Yes.
Q. Mr. Petrie, is there any
evidence to suggest to you that there is a discharge
of the saline, the highly saline waters in the
Queenston shale into that freshwater rind?

15

16

17

A. No real evidence, no.

Q. If you have got out Exhibit
WB-227.

18

19

20

21

A. I have that exhibit.

Q. Could you just have a look at
the drinking well data, which is actually found on
the page after the map?

22

23

24

25

Could you provide the Board with your
opinion on the quality of the water in those wells?

A. Respecting any constituent in
particular?

Q. With respect to drinking water



1
2 quality perhaps chlorides, that seems to be the one
3 that everyone focuses on.

4 A. The drinking water standard
5 for chloride is 250 milligrams per litre. I see one
6 value that exceeds that. I am looking at Sample 7 .
7 The entry for chloride is 413.

8 Q. I think if my memory serves me
9 correctly, you can check and that is up-gradient of
10 the landfill site.

11 A. Well 7 and 8 lie to the north
12 of Site F as I read it on the previous page. There
13 are no other entries in that column for chloride in
14 the box marked "Site F Data" that exceed 250
15 milligrams per litre.

16 Q. And that is in contrast to the
17 chlorides in the Queenston shale that can vary
18 anywhere through the thousands?

19 A. Can. There are some values
20 less than 1,000 but it can go up to the thousands.

21 Q. I would refer you also to the
22 chloride results. Have you looked at the groundwater
23 quality data from the Trow wells down-gradient?

24 A. Yes, I have.

25 Q. Perhaps you could get that
out. H-40A. An appendix towards the back.



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DR. KINGHAM: Appendix 12.

3

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5

MR. TIDBALL: It is in Appendix 12,
Mr. Petrie, and it hasn't been numbered, but it is
perhaps 10 pages in.

6

MR. PETRIE: Yes, I have that.

7

8

9

MR. TIDBALL: Q. I am looking
particularly at the results from HC-10, 11, 12 and
13.

10

MR. PETRIE: A. Yes, I have that.

11

12

13

14

15

Q. If we can just take one
example. If we look at HC-10, observation well or
piezometer number 3, which I believe is set in the
till, is it not? I think you can tell off that
cross-section.

16

A. I don't see HC-10.

17

18

Q. That is on the next cross-
section. It is on Drawing 6.

19

20

21

22

A. Looking at Drawing 6, I note
that Piezometer 3 at HC-10 appears to be around the
filled in circle and it is within the overburden
materials, yes.

23

24

25

Q. That is the chlorides at that
piezometer are 175 as measured in February, 1986?

A. Correct.

Q. And if you go down to the next



1
2 piezometer which is number 2, it appears to be at the
3 shale till interface?

4 A. It does.

5 Q. And the chlorides are 1,700?

6 A. Correct.

7 Q. If you go down a few more
8 metres to Piezometer 1, the chlorides are up to
9 1,960?

10 A. Correct.

11 Q. HC-11, that is back on the
12 cross-section you have up there.

13 A. It is, yes.

14 Q. We have got Piezometer No. 2
15 is set -- appears to be set in the till.

16 A. Correct.

17 Q. With a chloride reading of
18 1,580.

19 A. Correct.

20 Q. And Piezometer No. 1 is set in
21 the shale with a chloride reading of 2,400.

22 A. Yes.

23 Q. I don't know that we need to
24 go through HC-12 and HC-13, Mr. Petrie. Do you see
25 any evidence there of discharge of the saline -- the
highly saline groundwater up into the lacustrine



1
2 deposits?

3 A. If by "highly saline" you mean
4 the 1,000 to 2,000 milligrams per litre.

5 Q. What about up into the tens of
6 thousands that we see in other parts of the Queenston
7 shale?

8 A. I do not see numbers of tens
9 of thousands for chloride at HC-10, 11 -- I do at 12
10 and I do at 13.

11 Q. I believe when these questions
12 were put to both Mr. Sobanski and Dr. Charlesworth,
13 and I am not sure about who gave what answer, but I
14 don't know that it is critical.

15 Going through the factors that those
16 two gentlemen thought, that led them to believe that
17 there wasn't a discharge or a significant discharge
18 of groundwater from the shale, I believe the evidence
19 was something along the lines that you would expect
20 to see salt flats if there was that kind of volume of
21 salty water coming out. I take it you would agree,
22 would you, that there was no evidence of that kind of
23 discharge?

24 A. I don't know what you mean by
25 that kind of volume.

Q. I am recalling the evidence



1
2 and the evidence was simply that if there was a
3 significant volume of highly saline water discharging
4 from the Queenston shale surface somewhere in the
5 Aldershot community, you would expect to see it
6 evidenced by salts on the ground. I thought it was
7 as simple as that.

8 A. If by "highly saline" we are
9 talking 20,000 milligrams per litre most definitely.

10 Q. We don't see that?

11 A. We don't see that.

12 Q. Another factor that was
13 mentioned by one or both of those gentlemen had to do
14 with the conductivity in the creeks and I notice that
15 Trow has taken conductivity readings down Indian
16 Creek and that is to be found in Drawing 4 of Exhibit
17 H-40. Could you take a quick look at that? Do you
18 see any evidence on Drawing 4 of any discharge, any
19 saline discharge to the creeks south of Site F?

20 A. Of highly saline waters, no.

21 Q. I wanted to put to you
22 something that Mr. Feenstra testified to. During my
23 cross-examination of Mr. Feenstra, we got into the
24 whole question of the meaning of the results, the
25 analytical data from the University of Waterloo and
Ms Hewetson's thesis. I put the question to him that



1
2 if he assumed -- if he would make the assumption that
3 the Waterloo data reflected some movement of
4 leachate, I asked if it mattered to him, if he
5 thought it was important.

6 I refer you to page 10430 of the
7 transcript.

8 A. If I could have a copy of
9 that.

10 Q. Yes, it is in Volume 46.
11 Perhaps I could just read you a section and ask your
12 opinion on it to be absolutely fair to you.

13 Mr. Feenstra answers in the following
14 way:

15 "The concentrations are low and with
16 very few exceptions ..."

17 MR. HODGSON: I thought he was reading
18 an answer. I wondered what the question was.

19 There is a line somewhere in Tolstoy
20 about a deaf man shouting out answers to questions
21 that nobody asked.

22 MR. TIDBALL: Q. I am reading -- the
23 question from Mr. Hodgson was:

24 "If we assume for the moment that the
25 Waterloo data does reflect movement of
leachate, does it matter?



1
2 A. The concentrations are low and
3 with very few exceptions for any of
4 the chemicals identified do the
5 concentrations of volatile organics
6 exceed drinking water standards
7 established by other regulatory
8 agencies. The main -- I guess the
9 main consideration of the impact of
10 that groundwater contamination would
11 be two-fold. No one actually uses
12 groundwater from the deeper shale
13 formations for drinking water
14 supplies, mainly because of elevated
15 concentrations, natural concentrations
16 of chloride and sulphate and other
17 organic constituents.

18 Wells south of the site, south of
19 the CNR; there have been identified
20 some groundwater users at a distance
21 of 1.5 kilometres from the landfills.
22 The groundwater users in these
23 areas utilize groundwater from shallow
24 wells, either in the overburden or in
25 the very shallow part of the shale
bedrock in that area, and in that



1
2 shallow flow system the actual
3 groundwater chemical composition of
4 the groundwater, although not
5 pristine, it is certainly within
6 drinking water standards for chloride,
7 and I believe in most cases also for
8 sulphate."

9 Now, if you follow down on the next
10 page 10431, I just want to find the exact point.
11 There is no point in reading the entire portion
12 because it goes on for several pages.

13 If you go to page 10432, Mr. Petrie, I
14 want to put the second full paragraph, Mr. Feenstra
15 says:

16 "So, any discharge that does occur
17 (and he is talking about discharge
18 from the shale up into the overburden)
19 is very extensively diluted and that
20 degree of dilution which would be
21 several hundred times based on the
22 difference between the chloride
23 concentrations at depth and the
24 chloride concentrations in the shallow
25 groundwater zone, and which was also
referred to as the freshwater rind in



1
2 Mr. Sobanski's testimony that dilution
3 factor would also apply to any other
4 groundwater contaminants such as the
5 volatile organics that might have
6 actually made their way that distance
7 from the site."

8 Referring specifically to that
9 paragraph I wondered I wondered if you had any
10 comment on the whole question of dilution of any
11 contaminants and I think Mr. Sobanski referred to it
12 as some kind of equilibrium being set up between the
13 shale and the overburden.

14 A. I am just noting some of the
15 words on page 10432. Several hundred times based on
16 the difference between chloride concentrations at
17 depth and the chloride concentrations in the shallow
18 groundwater zone.

19 We have noted chloride concentrations
20 in the order of up to about 2,000. I am referencing
21 the record for HC-10 and HC-11. Dividing that by
22 several hundred gives you chlorides of less than 10.
23 We notice chlorides on Exhibit WB-227, and I am not
24 addressing locations 7 and 8, 7 and 8 being the up-
25 gradient ones. I notice numbers there in the order
of 50 and 60 and 30. So, several hundred times is



1
2 perhaps a little general, but obviously one could
3 make some extrapolation between chloride
4 concentrations in the shallow regime and at depth to
5 get a measure of the potential dilution.

6 Q. I guess what I wanted to come
7 to, Mr. Petrie, is what you think the implications of
8 this kind of scenario are with respect to the egress
9 of contaminants from Site F.

10 A. I don't understand your point.

11 Q. Are you suggesting, is it your
12 evidence before this Board that landfill derived
13 contaminants entering the flow system at Site F are
14 going to cause some significant impact in the
15 lacustrine deposits, the area we have been talking
16 about as the freshwater rind in Aldershot?

17 A. In answering that question I
18 would like to look first at the hydraulic
19 characterization of the site. We do not have a good
20 idea of the flux of groundwater from the site so that
21 we don't have a good idea of the contaminant mass
22 that may egress from that site.

23 Recognizing that there is a measurable
24 degree of dilution available based on the chloride
25 concentrations relative to this shallow groundwater
zone and the bedrock, that same dilution would apply



1
2 to any contaminants egressing from the site.

3 Q. Do you agree that there is --
4 I think it was Mr. Sobanski that first put this to
5 the Board, that there was something in the nature of
6 an equilibrium set up in this groundwater flow system
7 south of the 403. That is between the freshwater
8 close to the surface and the very salty water deep in
9 the shale.

10 A. I recall his reference to
11 equilibrium. I am not entirely sure it was a
12 chemical equilibrium he was addressing or hydraulic
13 equilibrium, a balancing of the fluid levels in the
14 system, I don't recall.

15 Q. Let me put it to you as
16 chemical equilibrium. Can you assume that is what he
17 meant? Do you have any comment on that?

18 A. Could you repeat your
19 question?

20 Q. Yes. Do you believe that
21 there is some kind of chemical equilibrium set up
22 such that there is an area of freshwater close to the
23 surface in the lacustrine deposits south of the 403
24 and do you believe there is an equilibrium set up
25 between that and the deeper more saline groundwater?

A. I believe there would be an



1
2 equilibrium of a sort.

3 Q. Mr. Petrie, do you believe --
4 I take it from that, equilibrium of a sort, that you
5 would agree that there isn't much in the way of a
6 significant saline discharge into those lacustrine
7 deposits now? I go back to an answer of a few
8 minutes ago where I asked you if there was any
9 evidence to suggest a discharge and you said no there
10 wasn't any real evidence.

11 A. I believe you said "highly
12 saline." With reference to the shallow bedrock, the
13 chloride contrasts are not so pronounced. There is
14 not evidence of major discharge from the bedrock
15 through the overburden materials at that point.

16 Q. I come back to a question that
17 I asked you a minute ago, do you think that there is
18 -- what do you think will be the impact of landfill
19 derived contaminants in that zone, if any?
20 Recognizing the uncertainties you have put with
21 respect to how contaminants might get from Site F to
22 that area. Once we get there, what do you think the
23 impact is going to be?

24 A. I cannot give an opinion on
25 that.

Q. We have a small bit of



1
2 confusion there. Is it that you are saying you do
3 not want to give an opinion on that?

4 A. Yes.

5 Q. All right, now if I could turn
6 to ...

7 DR. KINGHAM: I am sorry, did he say
8 he could not give an opinion on that, or did not want
9 to give an opinion on that?

10 MR. PETRIE: I do not feel I have a
11 good enough understanding of the site to provide an
12 opinion on that question.

13 MR. TIDBALL: Q. Do you need a good
14 understanding of the site, specifically at Site F, to
15 understand what is going to happen down in Aldershot?

16 MR. PETRIE: A. As a hydrogeologist
17 looking at the suitability of the site for
18 landfilling, it is my opinion that we need a good
19 definition of the hydrogeology at the site such that
20 you can make a recommendation with regards
21 landfilling, the suitability of landfilling based on
22 the hydrogeology of the site.

23 Q. Yes. I understand that, Mr.
24 Petrie, and I understand that to have been your
25 evidence all along. I guess what I am focussing on
is the other end of things.



1
2 Forget for the moment how it gets into
3 the shale and how it moves when it gets into the
4 shale. Let us make some assumptions and let us say
5 all right it is going into the shale and it is
6 travelling under the 403 and you have put before the
7 Board, your reliance on some evidence of upward
8 gradients at HC-10, 11 and 12. Are you not able to
9 form some opinion on the impact at that point?

10 A. I would not expect it to be
11 major.

12 Q. I guess I have a little
13 trouble with what exactly that means, Mr. Petrie.

14 A. I cannot give a definitive
15 opinion on what that impact would be. I do not
16 expect it would be a major impact.

17 Q. If I could then turn to a few
18 questions on groundwater chemistry. And just with
19 respect to the Bayview landfill site, I was trying to
20 come to some bottom line about what you were saying
21 about Ms Hewetson's thesis.

22 Am I right that what you are saying is
23 that you agree with Mr. Feenstra that with respect to
24 trichloroethane that you should discount those
25 results because of the result from some sort of
contamination of the sampling equipment?



1

2

A. That is a reasonable

3

interpretation, yes.

4

Q. But that you go on to say that

5

chlorobenzene and paradichlorobenzene could be

6

landfill derived?

7

A. I believe I make that

8

statement.

9

Q. Is that where we are? I

10

wanted to make sure that was your bottom line on

11

that?

12

A. Correct.

13

Q. Am I also right that you

14

didn't confirm the existence of chlorobenzene and

15

paradichlorobenzene in your most recent monitoring?

16

A. That is correct.

17

Q. Do the levels of chlorobenzene

18

and paradichlorobenzene down-gradient that were

19

determined and I think they go as far as MB-18 which

20

is south of 403, do they cause you any concern?

21

A. The fact that they are there

22

indicates to me that groundwater on the site had

23

travelled that far carrying contaminants with it.

24

Q. I would understand that with

25

respect to presence. I am talking about the levels

that we find there.



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A. I would like to refer back to the specific levels.

With respect to MOE drinking water criteria, there are no criteria, as I understand it, for the compounds you have just mentioned being chlorobenzene and dichlorobenzene. I am noting in...

Q. Mr. Feenstra's witness statement here ...

A. I don't have an exhibit number.

Q. It is 86A.

A. I am noting in Exhibit 86A on page 14 that Mr. Feenstra has provided for the Board drinking water standards for those two compounds being from the New York State Department of the Environment Conservation and the USEPA, that detected occurrences as reported by Ms Hewetson do not exceed those drinking water standards.

Q. Just to confirm it, we may have to go back to Exhibit E-214, that is the Hewetson thesis.

If you go to page 67 of that document, Mr. Petrie, that is -- on one page shows the results for 1,1,1-trichloroethane, paradichlorobenzene and chlorobenzene.



1

2

A. It does, yes.

3

4

5

6

Q. Referring to the bottom two graphs because it is your evidence that we ought not to look at the trichloroethane data. If you look at OW-18, what are we seeing for both?

7

8

9

A. I believe Ms Hewetson's data reported an average from one or two, two or more sets of data.

10

11

Q. Perhaps we should look at Mr. Feenstra's total data set. I hadn't thought of that.

12

13

A. I believe his data set is the complete data set.

14

15

16

17

18

Q. Could we refer then to MB-18? I believe that is found at -- I don't know what page it is, it is two pages before the page in Mr. Feenstra's witness statement you were just referring to.

19

A. I have it, yes.

20

21

Q. Chlorobenzene, at MB-18, was non-detected?

22

A. That is correct.

23

24

Q. It is 1,4-DCB. And 1,4-DCB is paradichlorobenzene?

25

A. Correct.

Q. The results range from



1
2 0.0085648 up to 0.0142 micrograms per litre?

3 A. Correct.

4 Q. That is to be compared, I
5 gather, then to a drinking water standard from the
6 United States Environmental Protection Agency of 75
7 micrograms per litre?

8 A. If one was to apply those
9 criteria from the United States, yes.

10 Q. Do the levels of
11 paradichlorobenzene at OW-18 cause you any concern?

12 A. With reference to the drinking
13 water standard, no.

14 Q. Mr. Petrie, do you know what,
15 -- looking at that thesis, do you know what
16 percentage of the total well depth that screens, the
17 multi-level devices cover in the total depth of the
18 borehole?

19 A. For example, a 30-metre hole,
20 what proportion of the hole is open to the screens.

21 Q. Yes.

22 A. I believe it is about 20 per
23 cent of the vertical thickness.

24 Q. I am wondering, based on that,
25 what you think the likelihood is that significant
zones of contaminant movement would be missed by



1
2 those devices? I guess it all goes down to the
3 reliability of that chemical data.

4 A. The one part it does, the
5 other part is I do not believe we have a good feel
6 for where the fractures are that carry the
7 contaminants such that I cannot make a definitive
8 opinion that the WAT wells, I believe you are
9 referring to, can be relied upon to give a definitive
10 indication of the groundwater quality at those
11 points.

12 Q. Can I, just so we have it
13 clear for the record, have you got E-214 there?

14 A. Yes, I do.

15 Q. If you look at page 6, would
16 you turn to page 6? There is discussion of the
17 construction methods and the types of borehole, this
18 is a description generally of the WAT boreholes. Can
19 you look at the second paragraph, last sentence:

20 "As most of these devices contain 12
21 sampling intervals between 23 and 45
22 per cent of the total borehole length
23 was monitored."

24 A. I am sorry, I have lost you,
25 which paragraph are you on?

Q. Second paragraph, last



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sentence.

A. Correct, I find you.

Q. Have you got it? So, if in fact that is right that between 23 and 45 per cent of the total borehole length is being monitored does that cause you to change the opinion that you have just given in any respect?

A. I believe we are not entirely sure which fractures at those points are being adequately monitored.

MR. TIDBALL: Mr. Chairman, this might be a convenient place for an afternoon break, if that is acceptable.

MR. LANCASTER: All right, 10 minutes.

--- Recess

MR. TIDBALL: Q. Before you get started, Mr. Petrie, I think it is Mr. Crutcher's turn.

It has been pointed out to me that Mr. McQuaid isn't here. I think it is only fair that we wait for him.

Mr. Crutcher, while you are waiting, I think you had an overhead, I am sure you do, B-617 -- I am sorry, B-617, page 109, what I want is the cross-section that shows the base of the landfill,



1
2 that shows the landfill base up in the air.

3 You do have an overhead for it, it is
4 marked as Exhibit B-617-B.7.1.

5 MR. CRUTCHER: A. I most certainly
6 remember that number.

7 Q. This is the one with the Point
8 H. I want to talk about design considerations, Mr.
9 Crutcher.

10 On page 151, you set out the four
11 considerations that you have to take into account in
12 trying to design a landfill at Site F. The first one
13 is that the weathered and fractured bedrock mantle
14 provides for lateral groundwater flow and I think you
15 used that exhibit to illustrate how you thought
16 groundwater was going to flow sort of under the front
17 of the site, if you will, under the perimeter drain,
18 and you gave some evidence as to the difficulties of
19 going deep enough to intercept it.

20 A. I did not use this particular
21 exhibit. I think I sketched one, if I am not
22 mistaken. This exhibit was used when trying to
23 delineate the effects of the flow system with the
24 Trow hydrostratigraphy as designed.

25 Q. If we can just leave that up
here, because it is the one that shows the landfill



1
2 base. I take it -- could you get that sketch back
3 up, I am wondering, it should be on that pad, I
4 assume.

5 A. Yes, I have it. It is Exhibit
6 B-628.

7 Q. I understood your evidence to
8 be that it is the arrow that we see there called
9 "Groundwater Flow Direction" that you were worried
10 about.

11 A. In what sense?

12 Q. Worried about in the sense of
13 not being able to intercept with the perimeter drain.

14 A. That is correct.

15 Q. Now, what effect, I want to go
16 back up to the exhibit that is on the overhead, Mr.
17 Crutcher, and I wanted to forget for a moment the
18 delineation of the shale units. Can you accept for
19 the moment that the delineation of the bedrock
20 surface is correct?

21 A. Yes.

22 Q. What effect does it have that
23 there is, in fact, a sort of increasing thickness of
24 till starting at a point something like one-third of
25 the way up the site and extending down into the toe
until we get to the toe where there is -- how thick



1
2 would the till be at say HC-8?

3 A. Something in the order of --
4 it looks something to me like about eight metres.

5 Q. In fact, if we look over
6 there, you have got four to six metres on Exhibit
7 B-628.

8 A. I indicate variable but you
9 refer to HC-8, four to six is a fair representation.

10 Q. What is the effect of four to
11 six metres of till, let us use that, let us say four
12 to six metres of till at the toe of the site that
13 gradually pinches out to a point one-third of the way
14 up the site, what effect does that have on
15 contaminant movement in the shallow zone?

16 A. From what part of the site?

17 Q. From the point of view of
18 trying to design a landfill site, what effect does
19 that till unit have? How do you take it into account
20 in doing your design?

21 A. We essentially have downward
22 to lateral migration within the shale unit. Where we
23 encounter the till unit, that unit would act, will
24 have the same basis of downward since it is not in a
25 saturated condition. We still would have downward
migration into the shale. I don't really think it



1
2 controls from a design perspective.

3 Q. Does it control, does the till
4 unit have the effect of, because of perhaps a
5 permeability contrast, of keeping whatever is down in
6 the shale in the shale? Let us say at the toe of the
7 site, let us be specific.

8 A. It depends on which
9 permeability you are using for the shale and what is
10 the permeability of the till and what is that
11 contrast. If you would like to give me a contrast, I
12 can answer that.

13 Q. Let us take, for example, you
14 use a permeability of what Mr. Petrie has called the
15 weathered mantle of something in the order of
16 2×10^{-4} . Mr. Petrie, can you confirm that is the
17 value?

18 A. That is the bulk permeability
19 of the upper till which we determined from the
20 pumping tests.

21 Q. Mr. Crutcher, or Mr. Petrie,
22 what do you think is a reasonable value for the "K"
23 of the till? Trow has used, I think, 10^{-6} perhaps.
24 We can check that easily enough.

25 A. I think it is 10^{-6} . I would
have to take a careful look at that. We did not, or



1
2 I did not specifically address that a great deal. I
3 believe it was 10^{-6} and I did not take any particular
4 issue with that.

5 Q. Let us assume for a moment
6 that we have a two order magnitude permeability
7 contrast and let us assume that we have some
8 infiltration into what you have called the bedrock
9 mantle at the north end of the site and it is moving
10 along, perhaps in the direction of the blue arrow
11 there on Figure B.7.1. What do you say the effect of
12 the till is?

13 A. On?

14 Q. On contaminant movement?

15 A. Assuming that we are using a 2
16 $\times 10^{-4}$ as the average permeability of the bedrock and
17 we are noting that it is highly variable, that was
18 the bulk permeability that we have used and it is not
19 a uniform permeability.

20 So, taking that as the assumption that
21 I have a uniform 2×10^{-4} and I have a uniform
22 1×10^{-6} till, the effect would be in fact, confining
23 of the contaminants that pass through the shale would
24 be passed beneath the till.

25 Q. If we get then, down to the
point which I think has been denoted "H" on that, we



1
2 have, as I remember the evidence, these three green
3 arrows stand for the possible pathways at that point.

4 A. Using ...

5 Q. That was based on the Trow
6 hydrostratigraphy, I appreciate that fully. At that
7 point, forgetting for the moment that it is a point
8 that seems to show one layer of shale petering out,
9 if you assume some continuity of a weathered mantle,
10 is it fair to suggest that it is going to keep
11 following the green arrow that follows along the
12 bedrock?

13 A. It will be going more to depth
14 and you note that the site is twice the size as is
15 shown on Figure B.7.1.

16 Q. It extends off to the left
17 that distance again.

18 A. So the contaminants to the
19 left will be further to the north, will be passing
20 deeper.

21 MR. HODGSON: Can I please have the
22 contaminants drawn. I find the arrows really
23 confusing.

24 MR. CRUTCHER: I have in fact drawn
25 that on B.6.2.a.

MR. HODGSON: But you also swung your



1
2 stick at the wall and I heard it scrape several
3 times. I would like to have it.

4 DR. KINGHAM: It probably would be
5 best to do it in this same colour, the expected flow
6 path of the leachate. Mr. Hodgson, your question had
7 to do with the leachate flow from the north of the
8 area.

9 MR. CRUTCHER: When I draw this I will
10 draw it ignoring the hydrostratigraphy as defined.

11 MR. TIDBALL: Yes, thank you.

12 MR. CRUTCHER: That is my difficulty
13 in using this particular exhibit because of that
14 configuration.

15 MR. HODGSON: I wonder, Mr. Chairman,
16 if I could just ask also that Mr. Crutcher, in doing
17 this, can he mark that line distinguishing which was
18 drawn by Mr. Petrie and which was drawn by Mr.
19 Crutcher in the future. It is the same colour.

20 DR. KINGHAM: Could you do that, Mr.
21 Crutcher?

22 MR. CRUTCHER: I am.

23 I got a little verbose here. What I
24 have indicated in dashed blue lines is movement from
25 further north on the site. The cross-section that we
have is the zone of till and I was referring to the



1
2 zone north of this particular cross-section.

3 I am indicating that flow would be in
4 that lateral and downward direction. I have labelled
5 it "Expected Flow Path of Leachate From Landfill" and
6 I also note, not considering Trow's hydrostratigraphy
7 -- Crutcher at the bottom.

8 MR. LANCASTER: I can read everything
9 but your name.

10 MR. CRUTCHER: I almost signed it,
11 that's what the problem was.

12 MR. TIDBALL: Q. Mr. Crutcher, at
13 page 151, we started off talking about the four
14 things that you think you have to consider to design
15 a landfill site at Site F.

16 I am wondering whether the existence
17 of the till at the front half of that site is
18 something that should be considered, is it a factor
19 that goes to design? Because you appear to ignore it
20 here and I am not suggesting that you did it
21 deliberately or any other way. I am wondering if it
22 is a factor.

23 MR. CRUTCHER: A. Using the
24 permeabilities that you have, the permeability
25 contrast, I really do not see that influences the
design. The base of that, where the till mantle is,



1
2 using a 1×10^{-6} our leachate collection will be a
3 little more efficient in that particular area. That
4 is essentially what I can see from the till at that
5 location.

6 Q. I also -- just to be
7 consistent, there isn't just till at one end of the
8 site, there is till at the other end as well; isn't
9 that right?

10 A. That is correct, but I believe
11 it is being excavated very close to the shale. It is
12 questionable, in fact, whether any fresh till will be
13 left.

14 Q. I wonder if you are sure about
15 that. Could you -- out of Exhibit H-40, could you
16 pull out Drawing No. 12? It is entitled "Surficial
17 Geology."

18 I think I have managed to get out a
19 drawing that hasn't been out since May or June.

20 A. What drawing are you referring
21 to?

22 Q. Drawing 12.

23 A. I have that drawing.

24 Q. I don't have Trow's design
25 documents here. I don't know whether you have them
here or not, Mr. Crutcher, and maybe it is something



1
2 you have to check. I notice that at the very north
3 end of the landfill site, there is something in the
4 order of in excess of 18 metres of till.

5 A. That is what it shows, the
6 first overburden thickness.

7 Q. I assume they are not
8 excavating all of that, is that your understanding?

9 A. Not at that particular
10 location, but I was referring further down. We peter
11 out of the till quite quickly and in fact it is a
12 fairly major excavation in that particular area. I
13 reviewed the depth of the excavation versus the
14 boreholes and we were very close to the bedrock
15 intersection just a little south of HC-1. That is
16 what I was referring to.

17 I believe Mr. Hiraishi also talked to
18 this particular matter where he indicated he was not
19 exactly sure where the interface between the till and
20 the shale was exactly going to be, mainly due to a
21 lack of data.

22 Q. While you have got that up
23 there, it actually might be useful for other
24 purposes. If you look there, it does give us the
25 exact depth of till at HC-8, which is 5.7 metres.

A. Yes, that is what it says.



1
2 Q. Could you confirm that as you
3 go further up the site, in the vicinity of HC-3,
4 there is something like 1.2 metres of till there
5 today?

6 A. That is correct.

7 Q. So, what we have here, Mr.
8 Crutcher, is for up to about the half-way point of
9 the landfill site, we have -- it is like a wedge of
10 till that peters out to somewhere in the vicinity of
11 the half-way point. Can you agree with that?

12 A. Yes, I am not sure on the
13 design. You would have to check on the design, the
14 actual base contours and see whether, in fact, that
15 till is left in place based on the design.

16 Q. We know in the area of HC-8
17 and just looking at your base that you have
18 superimposed on the cross-section, in fact at HC-8
19 there is going to be 5.7 metres plus because HC-8 is
20 in something of a valley and there is infill there.

21 A. Yes, that is in the range that
22 I have indicated, four to six metres was typically
23 what we were looking along the toe.

24 Q. Now, can I take you to the
25 next page of your report, page 152?

I want to take you specifically to the



1
2 last paragraph where you talk about the liner.

3 Now, I draw your attention
4 specifically to the first sentence in the last
5 paragraph. It says:

6 "Installation of a liner allows for a
7 substantially reduced and predictable
8 leachate loss from the landfill."

9 I wanted to know exactly what you mean
10 by "substantially reduced and predictable." First of
11 all, what is it substantially reduced from?

12 A. We undertook to attempt to
13 estimate the exfiltration from the landfill site that
14 was presented within this report. That, those
15 numbers we had provided and we were estimating
16 anywhere, slightly on the conservative side, 50 to
17 100 millimetres. We undertook to estimate the
18 exfiltration with a liner. I believe the number was
19 something in the order of a little over three metres.

20 Q. It was 3.15, wasn't it?

21 A. You remember numbers better
22 than I, 3.15. We were referring to those particular
23 numbers.

24 Q. So, it is a reduction from 50
25 to 100 down to three, let us just call it three.

A. Correct.



1
2 Q. So, that is a substantial
3 reduction. The predictability relates to the fact
4 that you can predict, quite accurately, that there is
5 going to be three millimetres of egress. That is
6 what you are talking about there.

7 A. The ability to predict the
8 migration through the liner is based on the ability
9 to understand or know the permeability of the liner
10 itself. That would be a highly tested, engineered
11 liner. In fact, you would have a high confidence in
12 the liner itself, such that we would have tested the
13 liner to make sure we met 1×10^{-8} or less. As such,
14 that gives us a high level of confidence. That is
15 what I was referring to as being predictable.

16 Q. Predictability the way you
17 are talking, relates to the liner. It is the
18 predictability of the liner.

19 A. That is correct.

20 Q. It is not the predictability
21 of the landfill as a whole, it is as it relates to
22 the liner.

23 A. In this particular context,
24 yes.

25 Q. The three millimetres that
gets through that liner, the flow path that it



1
2 follows is just as unpredictable as you have
3 suggested on all of your other evidence.

4 A. That is correct

5 Q. Mr. Crutcher, you have had
6 involvement with the liner at Keele Valley. I don't
7 know, have you had experience with other liners as
8 well?

9 A. To some extent, yes. We were
10 responsible, I was responsible for the design of a
11 PCB containment facility in London where we used a
12 clay liner and synthetic liners.

13 Q. How long would you expect a
14 liner of the type you are proposing for Site F, and I
15 realize we are going to get into that in the design
16 document, but the 1.2 metre liner. How long would
17 you expect that to last?

18 A. The only concern I would have,
19 I would not have a concern with the permeability of
20 the liner. I would have a concern of the attenuation
21 capability of the liner that would eventually be used
22 up, but with the permeability which controls the flux
23 or flow through the liner, I do not put a life to
24 that.

25 In fact, that is why we typically
recommend the clay liner on the basis that we have a



1
2 higher confidence in its life rather than a synthetic
3 where we cannot determine the actual life.

4 Q. Are you content, Mr. Crutcher,
5 that a liner can last long enough to allow you to
6 collect the difference between 50 to 100 and three to
7 allow you to collect that for as long as it needs to
8 be collected?

9 A. Yes.

10 Q. How long does that need to be
11 collected?

12 A. I would go back to the same
13 basis that I was using at Site D where the
14 concentrations in that leachate are of little
15 concern.

16 Q. Can you put any numbers on
17 that?

18 A. To be consistent, I would
19 expect 20 to 30 years after site closure.

20 Q. So, that is how long you need
21 to have the liner last?

22 A. Yes. In that order.

23 Q. After that, it doesn't concern
24 you?

25 A. Depending obviously upon the
concentration and I qualified it when I was talking



1
2 about Site D that you would have to measure the
3 concentrations within the leachate and if they are of
4 little concern, then I am not concerned with the
5 integrity of the liner.

6 Q. Then I take it that the fourth
7 sentence in the same paragraph on 152 where it says:

8 "This alternative to the design places
9 less reliance on the natural geologic
10 system."

11 That is also somewhat time-related, is
12 it not?

13 A. I am sorry, what page or you
14 on?

15 Q. I am on page 152, and the same
16 paragraph I was before, the fourth sentence says:

17 "This alternative to the design places
18 less reliance on the natural geologic
19 system."

20 A. Yes, I have that.

21 Q. The less reliance is for the
22 life of the liner, is it not?

23 A. That is correct.

24 We are equating the life of the liner to at least the
25 life of the need of the liner.

Q. I take it then in that



1
2 statement you are not suggesting in a generic sense
3 there is anything wrong with relying on the natural
4 geological system. It is site-specific to your
5 interpretation of Site F, is it?

6 A. That is correct.

7 Q. Now, with respect to
8 infiltration and it is going on from page 152, I am
9 not sure if it was you, Mr. Crutcher, or you, Mr.
10 Petrie, that spoke to this in-chief.

11 A. It was Mr. Petrie who spoke to
12 it in-chief.

13 Q. Perhaps then I could address
14 the questions to Mr. Petrie.

15 Mr. Petrie, could I draw your
16 attention to the first full paragraph on page 153 of
17 Exhibit B-617? That paragraph and the following
18 paragraphs have to do with infiltration. In the
19 middle of this paragraph, you state that you consider
20 that the range of exfiltration, I guess we should be
21 consistent with the terminology, given by Trow, are
22 unreasonably low. That is the 2.5 to 22.4 and you
23 went over that in-chief.

24 MR. PETRIE: A. Correct. It would be
25 more correct to say that the one millimetre is
unreasonably low. I find the range low.



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Q. So, it is the one millimetre that is unreasonably low, the range is low. What would you think about the 22.4 on its own?

A. I believe that is low.

Q. You believe that to be low. Is it your evidence that it is impossible that the infiltration would be that low?

A. I use the words "unreasonably low." I have difficulty envisaging a one millimetre infiltration in this system.

Q. That has to do with your experience and other people's experience with other landfills around the Province of Ontario?

A. These numbers don't relate to it -- I beg your pardon, we have used the word "exfiltration." I believe the number of one millimetre was generated by Trow and I am not sure if that was for a system that they modelled with the landfill. So, these estimates range from one millimetre, which, as I recall, was Trow's Model 2, which did not have the landfill in it, and 22.4, I believe, was their Model 1 with the landfill. There is some inconsistency as to where those numbers came from.

Q. I believe -- perhaps you could



1
2 check -- but I believe the 22.4 is in fact Trow's 14
3 millimetres or 13.7 millimetres with a higher
4 gradient to account for the landfill.

5 A. I could check, that does sound
6 correct.

7 Q. I just want to be sure that
8 what you are saying is clear. What you are saying is
9 that it is just -- it is your professional opinion
10 that is just out of the range.

11 A. That one millimetre is
12 unreasonably low, it is my opinion.

13 Q. And that 22.4 is low?

14 A. Is low.

15 Q. Possible?

16 A. It is not unreasonable, it is
17 low.

18 Q. I had one very quick question
19 on the paper that you have included by Luxmoore.
20 There is a reference to it on page 154.

21 A. Yes.

22 Q. Was that paper done, I am
23 reading it and trying to understand that it was --
24 there was some reference in the paper to it being
25 done in subsoil, shale subsoil, I think you said in-
chief, or you had spoken to the author or someone who



1
2 had something to do with it.

3 A. We spoke to the author and he
4 referred us to the geologist who had done some work.

5 Q. What, in fact was it? Was it
6 in fact rock or was it soil?

7 A. I believe in Tennessee when
8 they are talking about weathered rock and subsoil the
9 terms are used a little interchangeably in that they
10 are dealing with a warmer, more arid climate so the
11 differentiation between subsoil and weathered rock is
12 difficult to make. The word "subsoil" is definitely
13 indicated within this Appendix D, or 4.

14 Q. Of the 50 to 100 millimetres
15 that you think is reasonable in terms of a range of
16 infiltration, how much of that do you think is going
17 to what Dr. Charlesworth called the very shallow
18 system? We talked about that a little earlier today
19 in your evidence about it being discharged to the
20 stream valleys, et cetera.

21 Is there some proportion -- when you
22 talk about 50 to 100 millimetres, are you talking 50
23 to 100 into the shallow system, as you defined it,
24 which is into that weathered mantle?

25 A. I have difficulty in defining
the domain of any of the shallow or deep flow



1
2 systems. We arrived at the number 50 to 100
3 millimetres after reviewing -- referring to the
4 figure where we introduced that schematic of the site
5 on page 156.

6 Having reviewed those numbers, we
7 believe that an infiltration or exfiltration of 50 to
8 100 millimetres is plausible.

9 From beneath the landfill we are not
10 looking into that which flows into the streams. So,
11 it is that which goes into this block of rock that we
12 would define by this rectangular shape.

13 Q. I am trying to -- I can't
14 recall the exhibit number, but as I recall Drs.
15 Charlesworth and Rowe, towards the end of the
16 evidence, they came down to the expected flow paths
17 and I think they were numbered A,B,C, or 1.2,3, it
18 doesn't really matter. There was a component, A, I
19 think what Dr. Charlesworth refers to as the very
20 shallow system. There was then a component B which
21 is the lateral flow that Dr. Rowe modelled and there
22 was a component D which was to depth; correct? A.

23 Correct.

24 Q. If we try to put this into
25 that framework, you are suggesting that the 50 to 100
millimetres, his components B and C or just B.



1
2 A. Conservatively, we have
3 estimated it as B.

4 Q. As all B?

5 A. We recognize that some may go
6 to depth.

7 Q. Is there, just focussing for a
8 moment on what Dr. Charlesworth called component A
9 and that is the very shallow, the discharge to the
10 creeks on the site. Is there any analogy that can be
11 drawn between this site and Site D? You recall we
12 talked at the very end about Site D where you said
13 that you believed that 50 millimetres of
14 infiltration was reasonable at Site D, but that the
15 bulk of that -- something in the order of 40
16 millimetres was going to be recharged to the
17 streams. Moving laterally in the shallow flow
18 systems and recharging to the streams, is there any
19 comparison between these two?

20 A. The comments I made with
21 reference to Site D were based on my interpretation
22 of the hydrostratigraphy. At Site D we have a tight,
23 unweathered upper till. That layer to me provides a
24 measure of the amount of infiltration, or gives me a
25 feeling for the amount of groundwater flow that can
pass through that layer. I felt that number 9.6



1
2 millimetres or 10 millimetres rounded out, was low.
3 I felt that were more flow to enter the system it
4 would be moving laterally in the weathered upper
5 till.

6 With respect to Site F, I do not have
7 a good feeling for the hydrostratigraphic delineation
8 at the site. I cannot provide a delineation such
9 that I am not comfortable trying to separate flow
10 which goes into the system which may discharge to
11 streams, may move laterally within the rock, or may
12 move to depth.

13 The bulk of the data which we have
14 reviewed respecting the hydrostratigraphy water
15 levels, et cetera, et cetera, is generated off the
16 cross-section that we have seen at numerous times
17 from HC-4 to HC-8. That cross-section of the liner
18 along a low portion of the site, i.e. along the
19 stream bed.

20 So, the higher ground on either side
21 of that which may provide for some sort of flow to
22 streams, we are really looking at a block or rock
23 which is based -- it's uppermost elevation is
24 generally consistent with the lower points on the
25 site. There is an elevation contrast laterally
across the site which I do not have at Site D.



1
2 Q. There isn't some similarity in
3 the two sites in the sense that there also appears to
4 be some kind of confining layer at Site F?

5 A. The use of the word "layer"
6 implies a degree of continuity. We have looked at
7 the information available and we are not comfortable
8 with defining "continuity" at the confining layer, to
9 quote your words.

10 Q. Have you got 156 turned up
11 there?

12 A. Yes, I do.

13 Q. Is there an overhead for that?

14 A. As I recall, we had one.

15 Q. Mr. Petrie, this is your water
16 balance calculation. As I understood this ...

17 A. Excuse me, it is a schematic.
18 It is not intended to provide a precise water
19 balance.

20 Q. As I understood that, you
21 simply used this to arrive at some comfort with the
22 use of 50 to 100 millimetres of exfiltration. Is
23 that putting it on about the right plane?

24 A. We did do it the other way
25 around. Initially we felt that one millimetre was
an unreasonably low estimate for infiltration. The



1
2 higher numbers provided by Trow, we referenced, I
3 believe, 22.5 was what I considered a low value in
4 itself.

5 At this point we recognized that there
6 was considerable uncertainty regarding the
7 hydrostratigraphy, or hydraulics of the system such
8 that I could not make a prediction based on my
9 understanding of the hydraulics what the infiltration
10 or the flux of groundwater through this system would
11 be.

12 In order to arrive at an estimate,
13 albeit a conservative estimate, we took the bulk
14 hydraulic conductivity developed from the analysis of
15 the pumping test data. We applied that hydraulic
16 conductivity variably through a 15-metre or 30-metre
17 block of rock. Using the hydraulic gradient and
18 referencing in Figure A, the upper portion of this
19 figure, using the upward gradient of 0.03, that being
20 the ambient gradient at the site, we arrived at a
21 calculated flux through that system as indicated by
22 arrow b of the numbers you see before you for the two
23 thicknesses. Divided by the 1250 metres being the
24 length of the site, we arrived at an equivalent
25 exfiltration of the two numbers you see before you,
being 22.7 and 45.4 millimetres per annum.



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We then imposed a landfill on that system, assumed a six metre head for the liquid within the landfill. The effect of that is to modify the lateral gradient, i.e. we were 0.03 and now 0.05.

Applying the same calculations, we come again to an equivalent exfiltration of the numbers you see before you of 37.8 to 75.7 millimetres per annum. That was intended to provide a measure of what may be happening at the site.

I also noted some assumptions that arrow a, being the arrow which goes into the top of the rectangle, i.e. exfiltration from the landfill was greater or equal to arrow b such that everything either went down and laterally -- I am talking in very general terms when I talk down and laterally or the component continued further to depth such that arrow a may have a value equal to, or in excess of that, which is indicated as equivalent exfiltration.

We noted those numbers and came to the conclusion that -- I am just looking for the words, I believe it is on 157 at the very bottom that we arrived at a conservative estimate from the base of the landfill exfiltration could range from 50 to 100 millimetres per year.

It might have been more appropriate to



1
2 take a broader scale, say 25 to 100. I chose 50 to
3 100.

4 Q. Just so I understand it and
5 there were some questions from Dr. Kingham, I
6 believe, in examination-in-chief, there was no magic
7 to the six-metre mound, Mr. Petrie, that is just the
8 mound you need to get the gradient you have got
9 there?

10 A. We started the other way and
11 said what might be gradient b and noted that is
12 equivalent to a six-metre mound, there is no magic to
13 a six-metre mound.

14 Q. That is why it implies, there
15 was some confusion I recall in-chief where there
16 appeared to be different answers between you and
17 Mr. Crutcher and I rationalized them in my mind to
18 simply say what it was it had to assume some degree
19 of engineering and some degree of failure, but that
20 really had nothing to do with the calculation.

21 A. That is correct.

22 Q. You needed to assume a six-
23 metre mound to get the gradient of 0.05.

24 A. We recognize that by imposing
25 a landfill on the system, we recognize the gradient
has to change in some fashion. I believe Dr. Rowe



1
2 performed his modelling and used a number of 0.08 for
3 the lateral gradient and I believe he had one or two
4 more figures after that.

5 Q. That would have given you
6 considerably more lateral flow, wouldn't it?

7 A. It would, it occurred to Mr.
8 Crutcher that that would be equivalent to a mound
9 that was pretty high in the landfill.

10 I do not believe that the design
11 leachate elevation in the landfill has been provided.
12 It is not in the hydrogeologic report.

13 Q. If the mound was lower, you
14 would use a correspondingly lower gradient and
15 correspondingly less flow laterally, that would be
16 the result?

17 A. That would be the result.
18 However one might, in going through these numbers in
19 order to look at the system conservatively, have
20 considered a measure of failure one might have to
21 make the mound build up in some fashion.

22 Q. What you have got up there is
23 simply the amount of flux you can push through this
24 15 or 30-metre layer.

25 A. With the hydraulic
characteristics.



1
2 Q. You assume that is what is
3 coming in the top?

4 A. Right.

5 Q. In that respect, it is very
6 similar to what Dr. Rowe did, is it not?

7 A. The logic is similar, I
8 believe.

9 Q. I recall he called it
10 continuity of flow, I think he used that. He had a
11 similar sort of design and that is how he came up
12 with one or two millimetres. I forget exactly.

13 A. The difference then is the
14 hydraulic conductivity that Dr. Rowe used.

15 Q. The difference between you and
16 Dr. Rowe is that you used 2×10^{-4} and he used
17 4.5×10^{-6} .

18 A. That sums it up, I believe.

19 Q. On the figure here if we
20 change the "K" to 2.5×10^{-6} we get an exfiltration
21 rate down closer to what Dr. Rowe has?

22 A. Yes.

23 DR. KINGHAM: Can you just clarify one
24 further point on that? I know we have gone into this
25 in some depth, but I would just like to know finally,
when you talk about exfiltration, what are you



1
2 assuming if anything about the relevant portions of b
3 and d? We understand your relationship between a and
4 b and c and d because you set those out.

5 What other proportions of b and d as
6 for example with the case at Site D where you did
7 have the proportion that was some 80 per cent lateral
8 versus 20 per cent vertical, if my memory serves me
9 correctly. It was 9.6 millimetres down versus
10 assumed infiltration of 50 millimetres. Do you have
11 an assumption about that?

12 MR. PETRIE: No, we are putting the
13 fluid a into the top of this rectangle, providing the
14 calculations which give us a value for b. I am
15 noting that I believe b, a is either equal to or
16 greater than b. If a is greater than b, then the
17 additional fluid flow is to this direction. I have
18 not made an indication of what I think the balance of
19 those amounts would be.

20 DR. KINGHAM: Do you have an idea of
21 that?

22 MR. PETRIE: No, I do not.

23 MR. TIDBALL: Q. Could we go back to
24 this morning, Mr. Petrie, and I thought that pursuant
25 to a discussion this morning we got it down to -- it
was your -- I don't want to put too high a level on



1
2 it, some sort of best guess that if you had to say
3 what was going laterally in this 15 or 30 metre
4 layer, and what is going to depth, you said at least
5 two-thirds would be moving laterally.

6 MR. PETRIE: A. I did note it as a
7 best guess, yes.

8 Q. Just a couple of more things
9 about this figure. I take it that you are not
10 considering any underflow, any throughflow or
11 whatever you call it, flow from up-gradient through,
12 that is component c.

13 A. Component c is flow into the
14 box from up-gradient and it would go right across the
15 box. No, I am not considering that.

16 Q. You are just balancing out c
17 and d somehow?

18 A. If a exceeds b, then
19 additional water from arrow a has to be passing out
20 the bottom so that if I could be just a little
21 schematic we would have a component going to c and a
22 component going to d. C could therefore only have a
23 component going to d. In total, c could only go to
24 d.

25 Q. That is what I understood. I
just wanted to be sure I had it correct.



1
2 Could I then turn to a couple more
3 areas before we finish today, Mr. Petrie.

4 On the question of monitoring, in your
5 -- I can't recall at the moment whether it was in
6 Part B or Part C, you agreed with the monitoring
7 methodology as put forward by Mr. Feenstra and I
8 think you did us all the favour of writing them down.

9 A. I am trying to locate.

10 Q. It starts at page 86.

11 A. Yes, I have it.

12 Q. I have noted in-chief you were
13 careful to say that it would be a unique approach.
14 It would be something that hasn't been done in
15 Ontario.

16 A. Those were quotes from Mr.
17 Feenstra in the transcript and I do agree with him.

18 Q. You do agree with that?

19 A. Yes, I do.

20 Q. I took it from what you said
21 that you agreed with Mr. Feenstra that this was the
22 approach that would have to be used at Site F.

23 A. Yes.

24 Q. If this Board were to approve
25 Site F it is this approach that should be used to
monitor it?



1
2 A. Correct. I do note however,
3 that it was my opinion that the amount of data
4 generated from the site would be such that one might
5 be able to make some more definitive statements
6 regarding the hydraulics or the characterization of
7 the materials.

8 Conversely, one may not. One
9 obviously would have a lot more data and I felt this
10 data would be most usefully obtained prior to making
11 the assessment.

12 Q. I understood that, yes. Now,
13 I then go to page 146, which is your Part C portion
14 on monitoring, and you conclude there that by the use
15 of these three criteria, is it proper to call them
16 sort of criteria that defines a successful monitoring
17 program, Mr. Petrie?

18 A. You could call it that.

19 Q. With respect to the first
20 criterion you assumed, concluded, that you wouldn't
21 be able to delineate the contaminant pathways.

22 A. I am concluding that at this
23 point in time the contaminant pathways have not been
24 delineated.

25 Q. I guess, having said that you
agree with Mr. Feenstra that that is the appropriate



1
2 way to monitor the site, what it is you think, why it
3 is you think that you wouldn't be able to delineate
4 each of the pathways and I am not suggesting there is
5 one pathway. I assume from what Mr. Feenstra said
6 that he had that program to design to delineate all
7 of the pathways no matter how many there were.

8 Why is it that using the approach that
9 he sets out you wouldn't be able to do it?

10 A. Obviously, until it was done I
11 would hesitate to speculate on the results of what
12 that investigation may be. There has been a vast
13 amount of work done at this site and it is still not
14 clear in my mind, it is not clear in my mind at all
15 that we have been able to delineate the pathways with
16 the degree of confidence that one could then focus a
17 monitoring program.

18 It is my opinion that in order to
19 focus a monitoring program, the hydrostratigraphy and
20 the patterns of groundwater flow should be delineated
21 first such that in going in to undertake a monitoring
22 program you have target horizons already identified.

23 The monitoring program as recommended
24 by Mr. Feenstra is, in my mind, aimed at attempting
25 that delineation in the first place.

Q. Yes, I understand that, Mr.



1
2 Petrie. Given, I understand your opinion that is
3 something that ought to be done before approval is
4 considered. If in fact, Site F were to be approved,
5 is it your opinion that using Mr. Feenstra's
6 approach, using the number of wells he is talking
7 about and the types of activities that would take
8 place within each well, that is coring and
9 identifying fracture zones, packer testing and pump
10 testing; is it your opinion that you would still be
11 uncertain as to the contaminant pathways?

12 A. I would hesitate to speculate
13 on the results that haven't been generated. In my
14 opinion, you would have a much more thorough
15 understanding of the system. Whether that would
16 allow you to be definitive I cannot tell you.

17 Q. Can you ever be definitive?

18 A. In terms of making a
19 recommendation to this Board regarding the
20 suitability of a monitoring program, I would like to
21 be able to be more definitive than we are at present.

22 Q. Now, continuing on page 146, I
23 want to just touch briefly on the two other criteria.

24 The second one has to do with
25 background water quality. The third one has to do
with identification of indicator parameters.



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Mr. Petrie, do you disagree that it is possible to identify indicator parameters at this site?

A. No, I do not disagree that it is.

Q. It can be done?

A. It can be done. If you recognize the degree of difficulty in dealing with it, there is a large degree of uncertainty to interpreting the existing data, but I do believe it should be able to be done, yes.

Q. If that is able to be done, can you agree that you could establish the background for those parameters?

A. Given the amount of data we have on this site, one would like to be in a position to do that now. I am not in a position to do that now with the data that I have.

Q. Down the road, if in fact this site is approved and we have to establish a monitoring program, do you agree that we can establish the background, you agree that we can come up with a suite of indicator parameters, can we establish background for those parameters?

A. I believe we can, yes.



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Q. In fact, the indicator parameters you use would be synthetic organics which you wouldn't expect to find in background.

A. There would be other parameters I would use for confirmatory control, but, yes.

Q. Finally, Mr. Petrie, if you could turn to page 148 of Exhibit 617, I had a few questions about contingency plan.

Specifically with respect to purge wells, can you confirm, Mr. Petrie, that it is your evidence that purge wells could control contaminant movement in that weathered mantle?

A. I believe that is what we state here.

Q. That is based on the effectiveness of PW-1?

A. It is based on the fact that you can pump water from the system. I am not entirely sure that PW-1 gives us a clear picture of how the system responds to pumping.

Q. But you believe we can pump water from what we call the weathered mantle?

A. I believe you can pump water from the weathered mantle.



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Q. Therefore, we can pump
contaminants out?

A. You would have to, one concern
I have with the purge wells is one would have to be
able to demonstrate that they would be effective. In
other words, are you entirely sure that the
monitoring data you would have would lead you to
initiate the purging or give you a good feeling that
the hydraulic control that the purge well provides is
indeed the amount of control you need.

Your initial question, yes we can
purge, we can remove water from the system.

Q. I take it you also agree that
with monitoring we can establish some indicator
parameters and can establish background, it follows
we could establish trigger levels, could we not?

A. I believe it does. I would
like to repeat my concerns that we have had a large
amount of data for this site and we still have a
measure of uncertainty. I would have expected that
from the amount of available data and the history of
monitoring in the area that the degree of uncertainty
should be much less at this time so I therefore
cannot be definitive on those points that you raise.

MR. TIDBALL: Mr. Chairman, those are



1
2 my questions on Site F at the present time. I may
3 have a few more, given some time to think about it.
4 I have, I think, a few hours left on the whole notion
5 of acceptability of what makes things acceptable and
6 coming back to both sites D and F.

7 This would be an appropriate time to
8 break if that is convenient for the Board.

9 MR. LANCASTER: Under those
10 circumstances, yes.

11 DR. KINGHAM: I wonder if before we
12 do, can you remind me what drawing it was that showed
13 the thickness of till overlying the different sites?

14 MR. HODGSON: You were looking at
15 Figure 7 earlier.

16 MR. PETRIE: A cross-section for Site
17 F -- which site are you referring to? Twelve, as I
18 recall.

19 MR. TIDBALL: It is 12. It is called
20 "Surficial Geology" and it shows the overburden
21 thickness.

22 DR. KINGHAM: That's the one I wanted.

23 MR. LANCASTER: We will adjourn until
24 9:30 on Monday morning.

25 MS CRONK: Excuse me, Mr. Chairman,
just before you rise, I wonder, sir, if the Board



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2 could provide some indication to counsel to assist us
3 in scheduling as to what your intentions are with
4 respect to sitting either end of Easter week? There
5 are scheduling matters some of us have to deal with.

6 MR. LANCASTER: We won't be sitting
7 Easter Monday. What about the Friday of that week,
8 being the 8th of April? I would like to make up the
9 Monday. I think we indicated, or someone indicated
10 they did not wish to sit on the Monday.

11 DR. KINGHAM: Does anyone have
12 difficulty with the April 8th Friday following that
13 Monday? Not preceding the Monday, following the
14 Monday? That would be the 8th of April.

15 We certainly wouldn't want to sit on
16 the 1st of April. Should we plan to sit on the 8th
17 of April then, to make up the missing Monday?

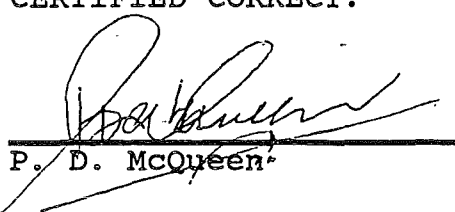
18 MR. LANCASTER: Mr. Estrin, does that
19 give you any problem?

20 MR. ESTRIN: That is fine.

21
22 --- Adjournment at 4:25 p.m.

23
24 CERTIFIED CORRECT:

25


P. D. McQueen