

CA-88-02

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-0025;

— and —

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

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

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

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

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

— and —

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

— and —

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

— and —

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

VOLUME: 110

HELD AT: Oakville, Ontario

DATE: March 22, 1988

OFFICIAL REPORTERS

NETHERCUT & COMPANY LTD.

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20 plan control of the sanitary landfill site;
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BEFORE:	H. H. Lancaster, Q.C.	-	Chairman
	Dr. D.J. Kingham	-	Member



Nethercut & Co. Ltd.

Toronto, Ontario

Hearing conducted at The Oakville
Granary Commercial Centre, 105 Robinson
Street, Oakville, Ontario, on Tuesday,
March 22, 1988.

VOLUME 110

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, F. Perrier and L. J. Griffiths	for National Sewer Pipe Limited
L.F. Longo	for Azova Investments Limited
M.J. McQuaid, Q.C. and C.J. Tzekas	for the City of Burlington
C. Mansfield	for the Ministry of Natural Resources
P. Renaud	for Cumis Limited



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Toronto, Ontario

APPEARANCES (Cont'd):

1	.		
2	C. Stevenson		for Framgard Holdings,
3	P. Hancock		Fosseri Investments
4			Limited, Seriphos
5			Investments Limited and
6			Topic Investments
7			
8	J.H. Olah		for the Halton Region
9			Conservation Authority
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185 Richmond St. W.
Toronto, Ontario
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Per: P. D. McQueen



Oakville, Ontario
March 22, 1988

1 --- Upon Commencing at 9:30

2 MR. LANCASTER: Good morning. Please be
3 seated.

4 MR. McQUAID: I'm sorry, Mr. Chairman,
5 at least one of the witnesses -- I am told they are on
6 their way down.

7 ANTHONY J. CRUTCHER, (resumed):

8 JOHN M. PETRIE, (resumed):

9 EXAMINATION IN CHIEF BY MR. McQUAID, (continued):

10 Q. Mr. Petrie, I think when we
11 adjourned last evening we had just finished the section
12 coming down to page 70. That was dealing with certain
13 aspects of landfill design consideration and then the
14 contingency program. I think we were at page 70 in
15 Section B of B-618, the monitoring portion.

16 MR. PETRIE: A. Can I just pick up on
17 one thing that Dr. Kingham mentioned yesterday, the
18 pumping test and the point of time at which some of
19 these data points were evaluated? If I can just find
20 the relevant overheads, if I might.

21 Starting with the upper granular unit,
22 with reference to page 42 of the text of Exhibit B-618,
23 the second complete paragraph that starts:

24 "The time recovery graph for PW-2..."

25 The next sentence reads:



1 "Examination of this graph by CRA
2 indicates that recovery data appear to
3 have been collected from the pumping
4 well for a four-hour period only,..."

5 That information is determined from pumping test -- I
6 shall just mark the overhead and then return it. I
7 have marked in the overhead which is entitled "Theis
8 Recovery for Upper Granular Unit", I've marked down at
9 the left that $t = 2,940$ minutes and I've indicated $+t$ ".

10 What I am focusing on is trying to manipulate that
11 calculation to arrive at a number that is approximately
12 13. The last data point on this graph, the last being
13 to the far left as I read the scale on the vertical
14 axis indicates to me that t/t " has a value of
15 approximately 13. So if I consider that $t = 240$
16 minutes being four hours, adding 2,940 and 240 and
17 dividing by 240 gives me a value of 13.3.

18 What I've done is relate that value,
19 that value being 13.3 to the last data point on the far
20 left recorded on that figure and I am just playing with
21 the number 240 minutes or variations thereof, I come up
22 with based on this figure, it is my estimation that
23 water level recovery data collected from this well for
24 a period of four hours following the termination of
25 pumping. By playing with my calculator again we can



1 arrive at a time for which the first data point was
2 developed. Reading the top of the graph we notice that
3 that data point is somewhere between 1,100 and 1,200
4 being the value of t/t'' . If we take a value of t''
5 being 2.5 min and do the same calculation, $2,940 \div 2.5$
6 divided by 2.5 it comes out to 1,177. It is my
7 estimation that this first data point being the far
8 right one was recorded approximately two-and-a-half
9 minutes after the termination of pumping.

10 DR. KINGHAM: So we just understand
11 this, the bottom line is the well was pumped for
12 something in the order of ...

13 MR. PETRIE: Two days, 48 hours.

14 DR. KINGHAM: And allowed to recover for
15 something in the order of four hours and it had not
16 -- this particular well had not recovered after four
17 hours?

18 MR. PETRIE: Correct.

19 DR. KINGHAM: It would take some
20 considerable time according to that graph before it
21 would recover?

22 MR. PETRIE: I cannot make predictions
23 on the slope of that line beyond the data point. One
24 would expect it to return to its initial level.

25 DR. KINGHAM: But you did make an



1 observation yesterday that it looked as if that line
2 would not go back down to zero?

3 MR. PETRIE: Not at the slope shown.

4 DR. KINGHAM: Could we turn to the
5 other...

6 MR. McQUAID: Q. Before we do that can
7 we mark this one, sir? Can you just mark the $t = 2,940$
8 $\text{min} + t''$, that is the left-hand entry or let me put it
9 that way, the t'' ? There is a point there at 13.3.

10 MR. PETRIE: A. I can circle 13.3 and
11 relate it to that point.

12 Q. Would you do similarly the 2.5
13 min?

14 A. Right.

15 DR. KINGHAM: I think we're up to 629.

16 MR. LANCASTER: Exhibit B-629 which is
17 the Theis Recovery graph.

18 --- EXHIBIT NO. B-629: Theis Recovery Curve for Upper
Granular Unit

19 MR. PETRIE: Should I indicate the
20 source of that figure? It is not contained within our
21 report.

22 MR. LANCASTER: We were just discussing
23 that.

24 DR. KINGHAM: It appears to be Appendix
25 10 of H-39A.



1 MR. PETRIE: Correct, I will mark that
2 as well. I have marked B-629 entitled "Theis Recovery
3 for Upper Granular Unit." The source as indicated on
4 that figure is Appendix 10 of Exhibit H-39. On that
5 exhibit I have indicated that for a value of t'' the far
6 left point has time where pumping stopped off 13.3 is
7 equivalent to 240 min. For the first data point being
8 the far right data point entered on that graph, the
9 time after pumping stopped being t'' is approximately
10 2.5 min.

11 I completed the same exercise for the
12 second graph being "Theis Recovery for Lower Granular
13 Unit." I am noting that the last point, being the
14 farthest left one on that graph appears to lie at a
15 value of t'/t'' of approximately five, that is taking the
16 far left figure and the calculation which gives me the
17 time for which that point was collected is -- I have
18 indicated on a figure entitled "Theis Recovery for
19 Lower Granular Unit" with reference to the far left-
20 hand point that if -- I am trying to evaluate the
21 symbol t'/t'' being equal to a value of five given the
22 pumping test duration of 1,440, adding 360 minutes to
23 that and dividing by 360 gives a value of five.

24 The last data point recorded on this
25 figure indicates to me that 360 minutes or six hours



1 after a 24-hour or 1,440 minute pumping test the water
2 level had recovered to approximately its original pre-
3 pumped water level. The first point on this graph I
4 have evaluated the same calculation. It gives a value
5 of t'' as approximately half a minute. That gives a
6 valuation of $1,440 + \frac{1}{2}$ min divided by $1/2$ min gives a
7 number of 2,881 being the value for t'/t'' and reading
8 that point of the vertical axis it is 2,800 looks
9 approximately at that point.

10 DR. KINGHAM: Again so we understand
11 this, you talked yesterday about the efficiency of the
12 well as being reflected by this Theis Recovery curve.
13 We understood from that that it could have been pumped
14 harder because you observed from this graph that it
15 responded after the pumping stopped very quickly,
16 restoring five metres or more of the head it had lost.
17 You are not upset or surprised by the fact that it had
18 recovered fully when t'/t'' was five. That indicated to
19 you that that was an aquifer that fed itself back very
20 quickly?

21 MR. PETRIE: You've made two statements
22 there. With respect to the first one on efficiency, I
23 noted that within half a minute the water level had
24 come from more than six metres below its original level
25 to less than one. That well may not have been able to



1 have been pumped harder as the well is right now.
2 Additional well development which is aimed at clearing
3 out the fine material that may be adjacent to the well
4 screening may allow the well then to be pumped harder.
5 It is an inefficient well as it is. I do not know what
6 efforts were made to develop the well. Additional well
7 development efforts may be such that you have a much
8 more efficient well therefore you could then pump that
9 well more hard.

10 With respect to the first point,
11 recovering to -- the second point, with respect to the
12 water level returning to its original water level is
13 independent of my notes about well efficiency. I think
14 the water levels within the aquifer at that point were
15 rising following development of the well and we have
16 seen the effect of it here such that the water level at
17 the point immediately prior to the pump being turned on
18 was not a stable water level. Had the pump been turned
19 on a day later the water level I believe would have
20 risen through that period still trying to reach a
21 stable level. The efficiency and the returning to
22 above static level are not related.

23 MR. LANCASTER: We will mark that
24 B-630.

25 --- EXHIBIT NO. B-630: Theis Recovery Curve for Lower
Granular Unit



1 MR. PETRIE: I have marked as Exhibit
2 B-630 a figure marked "Theis..." or a graph marked
3 "Theis Recovery for Lower Granular Unit." I note in
4 the top left-hand corner that again the source of this
5 graph is Appendix 10 of Exhibit H-39A. I believe that
6 addresses Dr. Kingham's questions of yesterday.

7 MR. McQUAID: Q. Can we return to
8 B-618 and to page 70, the section beginning "Monitoring
9 Program"?

10 MR. PETRIE: A. This section addresses
11 the monitoring program, as I understand it, as proposed
12 by Mr. Sobanski. During cross-examination Mr. Sobanski
13 provided a more in-depth review of his monitoring
14 program. In cross-examination I am referring to
15 transcript Volume 34, page 7406 and he made a number of
16 markings on Exhibit H-213. My following points on page
17 70 summarize the recommended monitoring program, as I
18 understand it, from listening to the cross-examination
19 and reviewing the relevant transcripts. We note on
20 those five points the monitoring installations that Mr.
21 Sobanski is suggesting. Point No. 1, monitoring at
22 four existing observation well nests for a total of 11
23 piezometers. Two, the installation of as many as 57
24 additional piezometers at 15 locations. Three,
25 monitoring both pumping wells PW-1 and PW-2, monitoring



1 the on-site farm well located on the northwest side of
2 the property and No. 5 is monitoring five existing off-
3 site domestic wells, four located along First Line Road
4 and one to the north of the site.

5 Turning the page, I note that this
6 comprises a potential total of 76 groundwater quality
7 monitoring points and implies a larger amount of
8 uncertainty associated with the hydrogeologic
9 characterization of the site. It is my opinion that 76
10 groundwater quality monitoring points is a large
11 number.

12 In Part C of our report we provide a
13 monitoring program that we suggest is more appropriate
14 for this site. We note here in the second paragraph on
15 page 71 that consists of 24 groundwater monitoring
16 points. The following paragraph notes that no
17 discussion was addressed by Trow to monitoring the
18 performance of the hydraulic trap.

19 In cross-examination it was indicated by
20 Mr. Sobanski that hydraulic monitoring, i.e., water
21 levels would be undertaken at existing and proposed
22 monitoring installations. I note that it is not known
23 how leachate levels within the landfill are to be
24 monitored.

25 Referring to the bottom -- the following



1 paragraph:

2 "With respect to groundwater quality we
3 note that Geocon has shown in
4 general..."

5 I am reading from the first complete sentence of the
6 last paragraph on page 71:

7 "...in general there are elevated levels
8 of chloride and sulphate at the site."

9 Values of chloride up to 1,000 mg/l for on-site wells
10 and 600 mg/l for domestic wells. As discussed in
11 testimony by Dr. Charlesworth, chloride levels at this
12 site can show fluctuations of up to -- that number is
13 in error -- of 700 per cent. Seven hundred is not
14 correct. Independent of that percentage variation we
15 go on to note that CRA recognizes that for this site
16 chloride may not be a useful indicator of contamination
17 given the present levels which may exceed MOE drinking
18 water objectives (250 mg/l) and the apparent seasonal
19 variation. CRA would recommend that a more extensive
20 groundwater sampling program be implemented at the
21 initiation of landfilling to establish background water
22 quality and trends at the site.

23 The last paragraph reads:

24 "A suite of target parameters for future
25 monitoring would be identified following



characterization of the leachate."

Q. Could you just indicate to the Board your opinion respecting the ability to establish this suite of target parameters for future monitoring?

A. It can be done if one analyzes the leachate for a general scan of inorganic constituents and organic constituents. Focusing on that scan with reference to the existing groundwater quality data it is my opinion that one could identify some target parameters which are present at significant levels within the leachate which have a degree of mobility that warrants their monitoring in the groundwater and then monitoring the groundwater.

In addition, having characterized the leachate, those constituents of the leachate that are concerned from a health risk or high toxicity level irrespective of their mobility might also be included within the groundwater monitoring program. So you are looking for mobile constituents within the leachate that are present, not present or present at very low levels within the groundwater and you are also looking at some constituents which pose a more severe health risk irrespective of their mobility. Those comments focus on both inorganic and organic constituents.

The general inorganic constituents being



1 chloride and sulphate, phenols would typically be
2 analyzed. We also note as I have here with respect to
3 chlorides that chloride alone may not be the most
4 useful indicator. I would recommend that chloride
5 levels be determined.

6 Q. All right then, you are going to
7 give us that calculation. Will you be able to do that
8 at some time over the breaks today?

9 A. I believe so, yes.

10 Q. Then going over to page 73 we see
11 a summary of Section B. I wonder if you could just
12 quickly go through those and take the text as read, if
13 you could just paraphrase the key points for us.

14 A. Certainly. Section B provides a
15 summary of the key points -- sorry -- Section B.8
16 provides a summary of the key points of Section B and
17 just note that Section B looked at the geologic setting
18 of the site, the groundwater, the hydrostratigraphic
19 sequence at the site, hydraulic gradients, groundwater
20 flow system, evaluation of contaminant migration,
21 landfill design considerations, contingencies and the
22 monitoring program. We note that the following (we are
23 back on page 73) summarizes where CRA differs from Trow
24 in the assessment of Site D. The weathered upper till
25 is most unlikely to comprise a pathway of significant



1 contaminant migration. Mr. Crutcher has addressed the
2 engineering options available for that event.

3 Point No. 2, slug tests do not provide
4 the most meaningful determination of the hydraulic
5 conductivity of low permeable strata. I note over the
6 top on page 74 that additional testing was undertaken
7 by CRA and as reported in Part C in which laboratory
8 permeability tests were undertaken.

9 Point No. 3, the response of pumping,
10 specifically the incomplete recovery observed following
11 the pumping test in the upper granular unit indicates
12 that this unit is not a continuous blanket extending
13 west from the site and further, that the value for the
14 hydraulic conductivity determined from the pumping test
15 may be higher than an average for the site.

16 Four, the water level recovery data
17 following the pumping in the lower granular unit
18 indicate that the well -- that a well in this unit
19 could be pumped at a higher rate and create a greater
20 cone of influence than implied by Trow.

21 Point No. 5, purge wells could be
22 constructed into the waste and pumped to control
23 excessive leachate mounding.

24 Point No. 6, the operation of a purge
25 well system to control contaminant migration in the



1 granular units will not have a discernible influence on
2 groundwater levels in the area adjacent to the site.

3 The landfill design, point No. 7, as
4 proposed by Trow does not effectively provide for a
5 hydraulic trap everywhere across the site but we note
6 that with minor modifications to the existing design
7 can ensure that trap can be effectively implemented.

8 Point No. 8, with regard to the
9 monitoring program, that the proposed, as I understand
10 it, potentially as many as 76 groundwater quality
11 monitoring points is overly extensive. In addition,
12 leachate mounding within the landfill was not addressed
13 by the program, as I understand it.

14 Point No. 9, level and variation of
15 chlorides indicate that this parameter, chlorides
16 alone, may not be the most useful indicator for this
17 site, that a suite of indicator parameters would have
18 to be developed. That provides our summary of Part B
19 of our report.

20 Q. Then following the format we go
21 into Section C which describes the concerns and
22 comments that you have made and actually gives the
23 recommendations that CRA is making in these various
24 sections. We start at page 77, hydrogeology.

25 A. The first point in our Part C



1 focuses on the geologic interpretation of the
2 distribution of the upper granular unit. As we note in
3 the top part we are in general agreement with the
4 geologic interpretation of Trow. Specifically we wish
5 to focus more on the distribution of the upper granular
6 unit. I have two overheads of this distribution. By
7 way of reference I am just locating the cross-section
8 locations, A-A' extending generally in the compass
9 north direction while B-B' is following along the
10 alignment of the bedrock valley at the site. Cross-
11 section A-A' is done on exactly the same base being the
12 geologic data that we saw earlier as Figure -- it was
13 Figure B.2.3a from page 20 of our report. What this
14 figure shows is that that previous figure didn't, this
15 figure being Figure C.2.1a, is the interpreted position
16 of the granular units. We note the upper granular unit
17 being a thin, isolated lens at HC3-85. We see the
18 upper granular unit at a different elevation at HC2-86.
19 We see upper granular unit between wells HC2-85 and
20 Comcor or CC-OW-2, a line of upper granular unit
21 extending between those wells. That is the only upper
22 granular unit we see on this section.

23 We note that the lower granular unit is
24 identified between CC-OW-2 in the centre of the figure
25 at HC2-85 and at MB-OW-3 and CC-OW-1. Essentially it



1 is a lens again on this cross-section and it
2 approximates the position of the bedrock valley, i.e.,
3 the low point in the bedrock in the centre of that
4 drawing, that drawing being C.2.1a. The centre of that
5 drawing approximates the northern boundary as the site
6 is indicated at the top portion of the figure.

7 Can I just point out one thing here? We
8 have the position of the bedrock identified at CC-OW-2,
9 the lowest bedrock elevation encountered on the site.
10 The following cross-section, the bedrock position was
11 not identified correctly at this well. I just want to
12 pick up that quickly. I am referring to Figure C.2.1b
13 being page 79 of our report. The third well in from
14 the left is entered by CC-OW-2. I neglected to modify
15 the bedrock topography to reflect the position of the
16 bedrock at that point.

17 Q. What would we see if it was
18 corrected, please?

19 A. I beg your pardon. I have marked
20 on Figure 2.1b page 79 in red dots the corrected
21 bedrock profile. It dips down to the appropriate
22 elevation under CC-OW-2 and then rises to the next well
23 to the right being the east, being HC4-85.

24 MR. MCQUAID: Mr. Chairman, I guess
25 since we have altered that overhead we should mark this



1 as an exhibit, sir, and then we will get copies for the
2 Board and everyone else.

3 MR. LANCASTER: B-631.

4 --- EXHIBIT NO. B-631: Geologic Cross-Section B-B',
5 Figure C.2.1b

6 MR. PETRIE: I should also note that the
7 earlier cross-section I provided -- it escaped my
8 memory at the time -- I should have advised the Board
9 that the same point could be marked for Figure B.2.3b
10 being page 21 of our report, the same bedrock profile
11 is provided in both figures, the same error was made on
12 both figures, the same omission.

13 MR. McQUAID: Q. Now, as corrected by
14 631 then these two cross-sections A-A' and B-B' give
15 CRA's interpretation of the geology; is that correct?

16 MR. PETRIE: A. The geologic sequence
17 at the site.

18 Q. Could you, by reference to the
19 text or verbally, indicate to us what is the end result
20 then in terms of your conclusions with respect to the
21 geology?

22 A. As shown on Figure C.2.1b being
23 page 79, cross-section B-B', this cross-section is
24 aligned along the axis or approximately along the axis
25 of the bedrock valley at this site. We note the
distribution of the lower granular unit, it underlies



1 the site from west being the left-hand side of this
2 figure, east being the right-hand side of this figure.
3 It completely underlies the site on this section.
4 Recalling section A-A', being the previous overhead the
5 lower granular unit appeared to be restricted to, in
6 that axis, to within, approximately within the confines
7 of the bedrock valley. We are noting here that for a
8 cross-section aligned along the bedrock valley the
9 lower granular unit appeared to be continuous beneath
10 the site. We note that there is a variation in the
11 thickness of this unit, the thicker portions of this
12 unit encountered at HC4-85 and it thins to the eastern
13 end of the site being HC1-86. We also note from the
14 lithologic descriptions of the lower granular unit that
15 generally it is fine, referring to CC-OW-2 where it is
16 identified as silt and silty clay. OW-4-85 is defined
17 as fine, silty sand. We also have three occurrences or
18 three isolated lenses on this section for the upper
19 granular unit, one which would be at the far west on
20 HC1-85 as a thin sand lens, the second one being
21 thicker, encountered at CC-OW-2 contains silt, sand and
22 gravel. The third one encountered at the borehole HC4-
23 85 being sandy gravel.

24 We provide on page 81 a figure showing
25 the distribution of the upper granular ...



1 Q. Excuse me, could I stop you just
2 for a moment? Did you say there were four or three
3 occurrences of that upper granular unit?

4 A. I am counting the lens I see on
5 Exhibit B-631 indicating the upper granular unit. I
6 see one at HC1-85. I see a second encountered at
7 CC-OW-2. I see a third encountered at HC4-85. Three
8 is the number.

9 Q. So if you mentioned four earlier
10 it should be three?

11 A. If I was referring to the upper
12 granular unit it should be three, correct. I just see
13 a typographical error on the first line on page 80.
14 That line reads "The distribution of UCU..." It should
15 read "UGU" being the upper granular unit. That
16 distribution is shown on the figure on the following
17 page which I shall put before the Board. I have put
18 before the Board a figure marked C.2.2 being page 81 of
19 our report entitled "Distribution of the Upper Granular
20 Unit." We note on the legend at the bottom left-hand
21 corner the boreholes drilled variably by Trow, Gartner
22 Lee, Morrison Beatty or Comcor. To the right we have a
23 cross-hatched I or circular symbol which is the
24 approximate limit of upper granular unit bracketed CRA.
25 The reason for bracketing CRA is apparent from the



1 figure where we have a sweeping curve. I will just
2 trace the curve being from a mid-point on the left side
3 of the site generally east-west through the site to the
4 approximate mid-point extending south and then east to
5 west extending off-site to the west along the central
6 southern portion of the site. I note from an arrow
7 indicated at the right-hand side that that line is the
8 interpreted extent of the upper granular unit taken
9 from Trow being Drawing 18 of Exhibit H-39. We note
10 that on that figure we have three occurrences of the
11 upper granular unit. A large central one underlying
12 the middle portion of the site, looking like a sort of
13 quasi figure 8 shaped lens. To the west or left along
14 First Line Road we have an occurrence of the upper
15 granular unit that extends off-site to the west some
16 unknown amount. Thirdly, we have a small occurrence on
17 the southeast corner of the property extending further
18 off-site to the east, again by an unknown amount.

19 Q. Those are -- are those coincident
20 with the three that you referred to back on the
21 overhead, page 79?

22 A. They ought to be.

23 Q. Left to right?

24 A. If we look at cross-section B-B',
25 on cross-section B we have a thin occurrence at HCl-85.



1 HCl-85 is at the northwest corner of the site. You can
2 see a portion of the granular unit there. At CC-OW-2
3 and extending -- I am referring to cross-section B so
4 extending to the east along cross-section B we have an
5 occurrence at CC-OW-2 extending eastward from that
6 point but it is not encountered at HC5-84. Cross-
7 section B-B', HC5-84 is projected onto the cross-
8 section. I guess ideally the cross-section has gone
9 from CC-OW-2 to HC5-84. HC5-84, the upper granular
10 unit is not encountered.

11 We come across a second portion of the
12 upper granular unit being at HC4-85 where we had 30
13 centimetres of material. That is so indicated at
14 HC5-84 of the cross-section B-B' on page 79. An
15 occurrence at this point, an occurrence between ...

16 Q. Could you just mark them 1, 2, 3
17 on the overhead and then we will have them? They
18 relate then back to the three that you described for us
19 on page 79. Mr. Chairman, I guess I should ask that
20 that be marked as B-632.

21 MR. LANCASTER: Yes, B-632.

22 --- EXHIBIT NO. B-632: Figure C.2.2, page 81 of
23 Exhibit B-618 with
Mr. Petrie's markings.

24 MR. PETRIE: I have marked as Exhibit
25 B-632 Figure C.2.2 from page 81 of Exhibit B-618. I



1 have marked on that figure in red point No. 1, point
2 No. 2 and point No. 3 which correspond to the three
3 occurrences of the upper granular unit identified on
4 cross-section being Figure 2.1b which is geologic
5 cross-section B-B' on page 79. You will note that the
6 plan view provides the more meaningful presentation of
7 the distribution of the cross-section of the upper
8 granular unit because in the cross-section which is a
9 line from -- cross-section B being from CC-OW-2 to
10 HC5-84 to HC4-85. It might appear there are three
11 isolated -- two isolated lenses of that occurrence. In
12 plan view we have interpreted that to consist of one
13 body with an irregular shape such as the cross-
14 sectional alignment went through part of that
15 irregularity.

16 DR. KINGHAM: Mr. Petrie, why would you
17 decide to place the dashed lines where you have given
18 that you have three wells widely spaced at the bottom
19 that might define, for lack of a better term, a banana-
20 shaped figure lying across the bottom? You have two
21 wells across the middle of that waist of the upper
22 granular unit, if I can call it that, HC6-84 and
23 HC5-84. Why would you not have decided, for instance,
24 to have connected those two together as a definition of
25 an absence of an upper granular unit? I guess what I



1 am seeking here is how do you decide to draw the lines
2 the way you have drawn them?

3 MR. PETRIE: On geological evidence
4 alone it is possible to join those two, those two being
5 the absence of the upper granular unit at HC5-84 and
6 the absence of the upper granular unit at HC6-84, in
7 which case body 2 of the upper granular unit as
8 outlined on Exhibit B-632 and body 3 would then be two
9 separate occurrences. However, I am referring ahead at
10 this point. When PW-2 was pumped, I am referring to
11 PW-2 being located adjacent to HC2-85, that being
12 completed in the upper granular unit. A water level
13 change was recorded at HC2-86. Based on the pumping
14 test data which we have to address in Part C it is my
15 opinion that body has to be connected.

16 MR. McQUAID: Q. If I could refer you
17 to page 80 you comment on the difference, as I
18 understand it, between your interpretation as we see on
19 that plan view at page 81 and the Trow outline of the
20 upper granular unit?

21 MR. PETRIE: A. Correct. The third --
22 the second and third paragraph, I beg your pardon --
23 the third paragraph addresses that point. The Trow
24 upper granular unit delineation as we have transposed
25 it from Drawing 18 of Exhibit H-39 essentially



1 encompasses both those bodies. I say essentially, it
2 is not exactly. By both those bodies I am referring to
3 the two lens of the upper granular unit indicated on
4 Figure C.2.2 that underlies the western two-thirds of
5 the site.

6 The points at which we differ, the most
7 significant point being at HC6-84 where the geologic
8 record indicates to us that the upper granular unit is
9 not encountered. Trow have been more conservative in
10 their delineation of the upper granular unit
11 recognizing that, as I understand it, there are
12 domestic wells to the west of the site which are
13 completed in the overburden. It is not inconceivable
14 that granular strata on the site could extend further
15 west.

16 The other point at which we differ is we
17 see at HC1-85 15 centimetres of strata which
18 conceivably -- which we believe could represent the
19 upper granular unit. I do not recall Trow's opinion
20 specifically on that 15 centimetres but I would note
21 for the Board that 15 centimetres is rather thin. I
22 would also note that we have shown a more extensive
23 unit to the south, being the southwest corner of the
24 site where we have HC3-85 and we are referring to 20
25 centimetres of strata. That material is described



1 briefly as boulders. Whether that again describes the
2 upper granular unit is a debatable point. Where it is
3 not debatable though we had thicker occurrences of sand
4 at HC4 and specifically HC2-85.

5 I would like to provide for the Board a
6 distribution of the upper granular unit as provided by
7 Dr. Charlesworth. I am putting before the Board Figure
8 6 from Exhibit M-438 entitled "Extent of Upper Granular
9 Unit, Site D, Milton." The first point I wish to note
10 from this figure that Dr. Charlesworth has provided to
11 the Board what he believes is a minimum and I will read
12 the words from the legend "inferred minimum extent",
13 the inferred minimum extent referring to these two
14 isolated bodies; one underlying the portion of the
15 centre of the site and the second one on the western
16 site property boundary. He has also indicated an
17 inferred maximum extent. He has referred to the
18 available data and for those areas where he is
19 suspicious, one by the absence of data or that the
20 materials encountered at an appropriate elevation may
21 comprise the lateral extent of the upper granular unit.
22 He has so indicated by the cross-hatching. If I could
23 just refer back to our earlier figure I will try and
24 overlay. I recognize they are not exactly the same
25 scale.



1 What I am indicating by this overlay is
2 that the extent of the upper granular unit and CRA has
3 defined it from Figure C.2.2 is somewhat more extensive
4 than the minimum interpretation provided by
5 Dr. Charlesworth. It does not coincide with the
6 inferred maximum extent of Dr. Charlesworth. It is not
7 particularly easy to see which figure is which there.
8 If I put back Figure C.2.2 and just indicate to the
9 Board where the bigger differences are. Dr.
10 Charlesworth has not included well HC3-85 within his
11 inferred minimum extent of the upper granular unit. It
12 does lie within his inferred extent of the maximum
13 extent. Just to repeat that point, CRA have indicated
14 on Figure C.2.2 HC3-85 lies within the upper granular
15 unit. Dr. Charlesworth indicates it lies beyond his
16 inferred minimum extent but within his inferred maximum
17 extent.

18 The other difference with respect to
19 Dr. Charlesworth is with his inferred maximum extent he
20 coincides a little more closely with Trow on the
21 western portion of the site, i.e., from under the
22 western half of the site and moving further westward
23 the upper granular unit may be continuous. I do not
24 agree with that on geologic grounds. As we come close
25 to the pumping test data I will also indicate that I do



1 not agree that the upper granular unit underlies the
2 site in the form of a blanket extending from the
3 central to beyond the western property boundaries.

4 Q. That gives us the positions then
5 with respect to the upper granular unit. I just ask
6 you now to do the same thing with respect to the lower
7 granular unit.

8 A. Figure C.2.2 on page 81 provides
9 our interpretation of the interpreted extent of the
10 lower granular unit -- I beg your pardon, that is
11 Figure 2.3. Wrong page, 82. Figure 2.3 on page 82 is
12 entitled "Distribution of Lower Granular Unit." We
13 have not undertaken, as Dr. Charlesworth did for the
14 upper granular unit, an inferred minimum and maximum
15 extent. We have provided our interpretation of the
16 extent of this unit. One would note that it is aligned
17 roughly parallel in an east-west line through the site
18 and that its extent both northward and southward from
19 the site is limited. We had not undertaken to provide
20 a figure of the -- an outline of the bedrock valley
21 because I indicated on the cross-sections that the
22 occurrence of this unit seems to be restricted to the
23 approximate alignment of the bedrock valley. I
24 unfortunately forgot to make an overhead of the same
25 figure from Dr. Charlesworth's Exhibit M-438. His



1 Figure 8 being the extent of the lower granular unit,
2 it is the very last page of M-438.

3 Q. Could you just hold it up and we
4 will try and follow it?

5 A. I am noting we have quite a
6 different interpretation. However, I wish to point out
7 that the 1984 boreholes, most of them -- I might be
8 correct by saying all of them did not penetrate to an
9 appropriate elevation to intersect the lower granular
10 unit. So, if one was to ignore the '84 boreholes and
11 consider that they were not a data point, then our
12 interpretation is not so dissimilar to that provided by
13 Dr. Charlesworth. He has indicated for the '84
14 boreholes that he has no data and he did not include
15 those points with no data in his inferred minimum
16 extent of the lower granular unit. We have been
17 slightly more liberal in the way we have wells that go
18 to the appropriate elevation and we have indeed
19 encountered it, it being the lower granular unit, we
20 have extrapolated between those boreholes. I am
21 referring again to HC5-84. We have extrapolated the
22 lower granular unit beneath that borehole further
23 westward. That point can be shown by referring back to
24 the appropriate cross-section.

25 I have put Exhibit B-631 before the



1 Board which is Figure 2.1b from page 79. It is cross-
2 section B-B' aligned along the bedrock valley and we
3 note for example borehole 5-84 does not extend to an
4 elevation consistent with the lower granular unit. We
5 have extrapolated the lower granular unit beneath that
6 borehole. I believe Dr. Charlesworth in indicating his
7 inferred minimum extent of the unit was being very
8 conservative in what the minimum extent might be. I am
9 not trying to contrast my interpretation with
10 Dr. Charlesworth's minimum extent.

11 Q. Back at page 80 you summarize the
12 lower granular unit as seen on page 82 by indicating
13 that it is continuous beneath the site in an east-west
14 direction. "However,..." I am reading from the last
15 sentence on page 80:

16 "However, this unit has a limited north-
17 south distribution."

18 A. Correct, and those are the compass
19 directions; north, south, east and west.

20 Q. On page 83 you address the
21 hydrostratigraphy and we see references to the
22 weathered upper till on page 83, unweathered till at
23 page 87 and the upper granular unit at page 89.

24 A. Correct. With reference to the
25 hydrostratigraphy at the site we have provided two



1 cross-sections for which the geologic data, just the
2 interpretive geologic information is shown. I have put
3 before the Board Figure C.2.4a from page 84 of our
4 report being cross-section A-A' entitled "Hydrogeologic
5 Cross-Section A-A'." We have removed all the geologic
6 definition at each borehole in order to provide the
7 hydrogeologic data. We note that we have the
8 interpreted position of the hydrostratigraphic units in
9 the weathered upper till, the upper till, the lower
10 till and within the lower till we see the upper
11 granular unit and the lower granular unit and a
12 gravelly till encountered within the bedrock valley at
13 one point. We also see the alignment of the bedrock
14 valley and note that this cross-section is aligned
15 approximately across the axis of that valley. We
16 provide the water level data on this figure as
17 indicated at the base of the figure being the
18 potentiometric elevations from April of 1986 as
19 recorded by Trow in Appendix 5 of Exhibit H-39A. We
20 note at borehole HC5-84 we have, for example, a high
21 water level, a high water level being 184.46 of the
22 shallow piezometer. The deeper piezometer has an
23 elevation of 181.60. We also noted at HC3-86 a higher
24 elevation in the upper weathered till, that elevation
25 being 182.97 and the lower till, the elevation being



1 180.88. Similarly, at HC2-84, more north of this
2 cross-section, elevation 183.33 in the weathered upper
3 till and an elevation at the bedrock contact, possible
4 bedrock contact of 182.3. The point of this
5 piezometric data is just to indicate in a general
6 fashion that which we discussed in Part B in
7 referencing the vertical hydraulic gradients. We note
8 that in general the water levels or piezometric
9 elevations in the upper till, that being the weathered
10 or unweathered upper till, are in excess of those
11 measured in the lower till. This was not the case
12 everywhere across the site but we note that in general
13 terms the upper till has higher water level, therefore
14 within the vertical plane groundwater flow is directed
15 downwards to the lower till.

16 I noted in the text in Part B that there
17 were some inconsistencies in that relationship.
18 Dr. Charlesworth addresses that in some detail himself.
19 On page 47 I referred to borehole HC4-85 which is shown
20 on the next cross-section. I am putting before the
21 Board the next cross-section, being Figure C.2.4b which
22 is hydrogeologic cross-section B-B which was entered in
23 the same manner as the earlier one, the previous
24 figure. The geologic record of each borehole was not
25 presented, we just have this hydrostratigraphic



1 sequence for the site, again the weathered upper till,
2 the upper till and the lower till and within the lower
3 till we see the granular unit, upper granular unit and
4 the lower granular unit. At HC4-85, we notice at
5 HC4-85 that the water level in the lower granular unit
6 is lower than that encountered at the till on the base
7 of the section. The relevant numbers are 181.12 for
8 the lower granular unit and 181.22 for the base of the
9 lower till adjacent to the bedrock.

10 We can contrast that with that which we
11 see at HC3-86 for example where the lowest piezometric
12 elevation in that borehole being the one -- I am
13 referring to the one at the very bottom, 181.54, with a
14 higher elevation than that encountered at the adjacent
15 borehole CC-OW-2. For the lower granular unit there
16 the elevation is 181.42. Elsewhere in the system at
17 HC1-86 we see exactly the same water level for a screen
18 that straddles the lower granular unit at HC1-86 and a
19 second screen which straddles the bedrock contact at
20 HC1-86. So within the lower till there is some
21 variation within the vertical plane in the direction of
22 flow and I refer to that on page 47. In the upper till
23 groundwater flow is directed downwards to the lower
24 till sequence. I use the word "sequence" there meaning
25 the lower till and the enclosed granular units.



1 I should like to point out again the
2 error I made with respect to the bedrock profile at
3 CC-OW-2. There should be a local dip in the bedrock
4 profile as I indicated previously was the case for
5 Exhibit -- as I previously indicated on Exhibit B-631
6 being the figure from page 79, Figure C.2.1b.

7 Referring back to the text on page 83,
8 the value for the hydraulic conductivity for that
9 weathered upper till was assigned by Trow and that
10 value was 1×10^{-5} . They assigned that value
11 recognizing there was some uncertainty with the
12 hydraulic characterization of fractured clays and I
13 indicated that it was conservative. I have indicated
14 in Part B of our critique of the Trow report that we
15 believe that it is a conservative number. We note that
16 the data provided by Trow developed from the tritium
17 analysis that they undertook led them to calculate a
18 value for the hydraulic conductivity of the weathered
19 upper till in the order of 10^{-7} cm/sec. So, Trow had
20 indicated in their own fashion that they believed their
21 10^{-5} was a conservative number.

22 Recognizing that we obtained from Trow
23 some samples of the core from the upper till strata at
24 Site D in order to obtain laboratory determinations of
25 the hydraulic conductivity of the strata. I am



1 referring now on page 83 to one sample of the weathered
2 upper till which was obtained by CRA and submitted to
3 Golder Associates for laboratory permeability
4 determination.

5 Q. Can you just refer us to which
6 item that is on the revised page? Is it on page 86
7 revised?

8 A. I am referring to Table C.2.1R,
9 that is page 86R, the "R" referring to revised.

10 Q. Yes.

11 A. I am noting that under
12 hydrostratigraphic unit, the fifth entry down there is
13 (1), the note at the bottom describes it as weathered
14 upper till. We note the borehole number from the far
15 left being HCl-86. We have the depth below ground for
16 which this sample was obtained. Moving over four
17 columns, we have vertical hydraulic conductivity in
18 centimetres per second. We have a value there of
19 1.11×10^{-7} . Referring back to the text on page 83 we
20 note with reference to that number that this result
21 indicates that a value of 1×10^{-5} , as assumed by Trow
22 for the weathered upper till, is conservative. I ought
23 to note also that that value, 1×10^{-7} , is very close
24 to the value provided by Trow for their interpretation
25 of the tritium data. I just wish to refer to that page



1 in Part B of this report where I discussed that.

2 On page 36 of Part B being Exhibit
3 B-618, towards the bottom of the second paragraph, the
4 first complete paragraph, we have an entry there,
5 3×10^{-7} . That was the vertical hydraulic conductivity
6 calculated by Trow for the tritium data. I had a
7 concern with the vertical hydraulic gradient they used
8 in that calculation. I employed a slightly different
9 value and on the top of page 37 we see, based on the
10 numbers I used, I calculated hydraulic conductivity of
11 5.2×10^{-7} , that being the top of page 37. I wish to
12 contrast that with the value obtained from the
13 permeability testing of 1.1×10^{-7} .

14 I wish to point out, in addition, that
15 we are dealing with weathered clays that may or may not
16 be fractured or with a variable degree of fracturing.
17 Visual inspection of the sample did not indicate any
18 original fractures. The sample that was submitted was
19 of a diameter in excess of that which is used for
20 testing. So the sample is trimmed in some fashion
21 with a scalpel. One views the sample, because of the
22 sample age there may be fracturing or degradation of
23 the sample because of the drying process. Having
24 trimmed the sample we did not see any evidence of that
25 which would cause us a concern so we undertook the test



1 on this sample. However, recognizing that we are
2 dealing with variable weathered and perhaps fractured
3 materials we can only report the value of 1.11 as being
4 relative to that sample. It is consistent with the
5 tritium data and I recognize that a value of
6 1.11×10^{-5} is indeed conservative with regard to the
7 weathered upper till.

8 I note on the top of page 87 that for a
9 conservative hydraulic conductivity of 1×10^{-6} , I am
10 referring now to the weathered upper till, an effective
11 transport porosity of 0.02, that value 0.02 was derived
12 from consideration of the data provided by
13 Mr. Feenstra; that being a preliminary review, the
14 initial stages of a research investigation at Sarnia, a
15 horizontal hydraulic gradient of 0.005. The average
16 linear groundwater velocity of 0.079 metres per year is
17 calculated. I wish to contrast that to the value
18 provided by Trow and wish to point out again that Trow
19 considered the data by which they arrived at their
20 average transport, their average groundwater velocity
21 was indeed conservative. The values are quite
22 different. I am referring to Exhibit H-39, Table 10 on
23 page 88 where Trow report at the top of that table
24 which is headed "Summary of Linear Groundwater
25 Velocity" and they note that they provided this



1 calculation for the condition when no leachate
2 collection system in operation. For the weathered
3 upper till the linear groundwater velocity is 13 metres
4 per year as calculated. I just wish to contrast that
5 to the 0.079 which I have provided here on page 87.

6 Q. That calculation represents your
7 opinion of the linear groundwater velocity?

8 A. Correct, but I wish to point out
9 or repeat what Mr. Crutcher referred to yesterday that
10 we do not believe the weathered upper till to provide
11 for a major pathway for contaminant migration. It is
12 relatively easily engineered around. One does not need
13 to base one's assessment or the need to undertake or
14 to be concerned with this horizon on one's calculation
15 of the transport velocities, recognizing that there is
16 some uncertainty attached to addressing fractured
17 materials. That uncertainty is addressed at the
18 engineering phase of the works whereby the excavation
19 itself would be inspected and as Mr. Crutcher addressed
20 yesterday, there are some engineering options to
21 address that uncertainty during the construction phase
22 or the excavation phase. Following the investigation
23 if there were some problems identified remedial
24 measures could be implemented.

25 Q. Would you continue then and give



1 us your views with respect to the properties of the
2 unweathered upper till?

3 A. My reference to the unweathered
4 upper till on page 87 of my report, I wish to point out
5 that the reason for undertaking this additional testing
6 is we were uncomfortable with the Hvorslev data
7 generated by Trow. We did not believe it to be in
8 error, we believed it to be conservative rather than
9 the presentation from Milton where they felt a higher
10 number in the order of 10^{-7} may have been more
11 appropriate. The reason for our discomfort was, one,
12 we had only Hvorslev data or slug test data which I
13 have indicated to the Board may not be the most
14 meaningful test in low permeable strata.

15 Secondly we were dealing with material
16 which had 20 per cent clay and 40 per cent silt. Just
17 summing those numbers, we are looking at materials
18 which has 60 per cent silt and clay. It was my opinion
19 that such materials are of low permeability.

20 We also recognized that tritium profile
21 within the upper till indicates that tritium cannot
22 penetrate this material rapidly. I also note that I
23 unfortunately forgot to include in Part B of this
24 report, Trow in undertaking the pumping tests at PW-1
25 and PW-2 sampled the pumped waters for tritium. On



1 both those occasions they noted the absence of tritium.
2 The absence of tritium being referred to as 2.3 tritium
3 units which indicates the dividing line between pre and
4 post-1952 water. I would just like to refer to those
5 pages since I did not do so earlier in my testimony.

6 It appears to be page 61 of Exhibit H-
7 39. We are just noting at the top, I think halfway
8 down page 61 of Exhibit H-39 under the heading "Lower
9 Granular Unit" I note there a tritium content of 0.18
10 tritium units and I agree with Trow's conclusion at
11 that point that the water in this formation is older
12 than 1952. For the bottom paragraph on page 61 under
13 the heading "Upper Granular Unit" the water sample
14 collected from PW-2 during the pump test conducted on
15 the upper granular unit had a zero tritium level, the
16 last sentence reading:

17 "The water in this formation is older
18 than 1952."

19 So, just repeating my concerns; when we are dealing
20 with material of 20 per cent clay, 40 per cent silt, my
21 expectation of such material is a low permeable
22 material. I had some concern with the Hvorslev
23 numbers, I did not think them unreasonable, I suspected
24 that the permeability of these strata might be low,
25 lower than that intimated by Trow. I also noted that



1 we did not have tritium penetrating to the granular
2 strata. That again gives me a degree of comfort that
3 the upper strata are indeed or are suspected to be low
4 permeable strata. We also note that the upper, the
5 unweathered upper till at this site is the base of the
6 landfill, i.e., the proposed landfill will be excavated
7 to the top or into this strata such that this strata,
8 the unweathered upper till is the primary layer
9 protecting the site from leachate migration. That is
10 not addressing the hydraulic trap which is aimed at
11 making sure that the direction of flow within the
12 unweathered upper till is vertical within the landfill,
13 recognizing that were that system to fail one might
14 have downward flow from that system and the unweathered
15 upper till provides the primary geologic layer
16 preventing or slowing the rate of potential migration.
17 We felt it most useful for the Board to provide some
18 additional numbers for the vertical hydraulic
19 conductivity in this strata which we feel would provide
20 us with a more definitive interpretation of the
21 vertical hydraulic conductivity.

22 To that end we obtained some of the
23 samples I referenced from Trow. The samples that we
24 obtained, indicated on page 86 are -- the left-hand
25 column on that table refers to the borehole numbers and



1 we note that the first two are obtained from HC5-85.
2 The -85 refers to the time at which -- the year in
3 which the well was drilled. I am just quickly going
4 to go to the appendices and indicate to you when that
5 borehole was drilled. The appendices, being H-39,
6 indicate to me that HC5-85 -- I beg your pardon, I
7 don't see the date here. I believe it was early in the
8 year. Perhaps I can find that in the Trow report and
9 advise you after the break. It is my recollection that
10 the 85 series were drilled in the spring or the summer
11 of 1985.

12 Reading further down that scale we have
13 some '86 wells which, as my recollection, were drilled
14 in the early spring or late winter of 1986. We
15 recognize that samples were old, we also recognize from
16 a visual inspection of the materials they had dried in
17 some fashion. They were not what I would call fresh
18 samples by any way, shape or form.

19 We took these samples to Trow -- I beg
20 your pardon -- we took these samples from Trow to
21 Golder Associates. We have used Golder in the past for
22 laboratory determinations of vertical hydraulic
23 conductivity. They have provided a useful service to
24 us. It is also our opinion that they do represent a
25 well respected geotechnical laboratory. We asked



1 Golder on the appropriateness of undertaking this test.
2 We had pointed out to them that, one, the samples were
3 dry, that is obvious from a visual examination and,
4 secondly, the samples were old. I did provide to them
5 the approximate age of those samples. They inspected
6 the samples and they felt having completed their
7 inspection which included the shaving of the samples to
8 shave away the most dried material such that they
9 reduced the sample size to that appropriate for their
10 test apparatus they felt they could get a reasonable
11 value for the hydraulic conductivity for all samples
12 except one. Our expectation was, that is CRA's and
13 Golder's, that if the sample is old and dry that the
14 structural change to such a sample would be cracking in
15 some fashion such that were one to have a crack through
16 the sample obviously during the test procedure water
17 could pass through that sample more quickly. That
18 speed of flow, to put it in simple terms, is related to
19 a hydraulic conductivity. We would expect that a
20 sample that is fractured right through it would result
21 in a high hydraulic conductivity. Inspection of the
22 samples, except for the one I indicated, suggested that
23 they were not -- they had not deteriorated to such a
24 state that testing was not warranted.

25 For the sample that they considered



1 inappropriate, i.e., there was some structural
2 deterioration of the sample, that is reported as CRA
3 sample No. 1. HC5-85 was the borehole from which it
4 was obtained. I will just outline to the Board where
5 these boreholes are. I will just make reference to
6 Figure C.2.3. I am not addressing the fact we have the
7 lower granular unit here, I am just addressing the
8 borehole locations, 5-85 located in the central portion
9 of the eastern one-third of the site. We note there
10 are two samples from that location. Two-86 is located
11 at the central portion of the southwest one-third of
12 the site and 1-86 is located at the property perimeter
13 at essentially the southeast corner, that is the
14 compass bearing, the southeast corner. There was no
15 reason for choosing that distribution of wells. The
16 choice of samples was somewhat limited by that which
17 were available in the Trow warehouse. Those samples
18 had been stored for some period of time and the numbers
19 were not clearly legible on some of the sample
20 containers. I considered it pertinent to make sure we
21 had samples that were exactly from the point indicated
22 on the container. Some of the samples I could not feel
23 comfortable that I knew which borehole they were from.
24 I collected those samples in conjunction with Trow.
25 They were also not entirely comfortable that we could



1 read the borehole locations on the sample containers.

2 Q. The end result of having examined
3 the labels resulted in these that we see on 86-3?
4 These are located at the locations?

5 A. I'm sorry, 86-3?

6 Q. Eighty-six-R, I am sorry.

7 A. Yes, this is the end result. If
8 we look down the left-hand side we have the six samples
9 and their sample numbers, CRA-1 to 6. I referred
10 earlier to CRA-5, that being located in
11 hydrostratigraphic unit 1 which is the weathered upper
12 till. I am focusing my remarks now on those samples
13 being 1 through 4 and sample 6 which relate to the
14 unweathered upper till. As I indicated before, one of
15 the samples Golder considered that its structural
16 integrity was such that they may not be able to get a
17 reasonable number from it, on that sample we remolded
18 it. To put that in layman's terms, the soil sample was
19 completely saturated, I guess rolled out in some
20 fashion that its structural integrity was totally
21 modified. It was then reconstituted in a similar shape
22 and inserted into a container. This testing is often
23 done to mimic in the laboratory the procedure of
24 installing a clay liner. I say that in general terms.
25 I am not a geotechnical engineer. If one was to



1 install a clay liner the action of remolding a sample
2 in the laboratory mimics in some fashion the field
3 action such that a remolded permeability was expected
4 to be indicative of the hydraulic conductivity of an
5 emplaced clay liner. We just note from CRA sample No.
6 1 that the vertical hydraulic conductivity of this
7 remolded material was 6.83×10^{-9} . Focusing on samples
8 2, 3 and 4 we have hydraulic conductivities
9 respectively for this material of 6.95×10^{-9} ,
10 1.45×10^{-8} , 2.59×10^{-8} and you can see an entry
11 towards the base of that table, geometric mean
12 hydraulic conductivity unweathered upper till, $1.38 \times$
13 10^{-8} cm/sec and there is a small notation adjacent to
14 that reading at the bottom of the notes. At the bottom
15 of that table we note that it does not include the
16 remolded sample. So, that value, 1.38×10^{-8} refers
17 only to the three samples of the till being samples 2,
18 3 and 4.

19 Sample No. 6, we also had a concern it
20 would not provide a reasonable value. We just
21 undertook a grain-size analysis on that. I would like
22 to refer you to the grain-size analyses which are
23 reported as the third and fourth columns from the far
24 right on Table C.2.1R being page 86R, the percentage
25 clay and we can include the remolded sample in



1 addressing the percentage clay. We see 20 per cent,
2 19.5, 20, 26 and for sample No. 6 we see 26 per cent
3 also. That is a clay per cent. We also see under per
4 cent clay and silt reading downwards from that column
5 for samples 1, samples 2, sample 3, sample 4 and sample
6 6, we note 53.5, 59.8, 62.0, 79.0, and 75.5.

7 I just wish to contrast those clay per
8 cents or grain-size data with that which was provided
9 earlier in Part B of our report being page 24. Twenty-
10 four is Table B.2.1 entitled "Summary of Grain-Size
11 Distributions Upper Till Unit" from Exhibit B-618. We
12 note the geometric mean towards the bottom of that
13 table for the clay is 20.6 per cent. Just casting your
14 eye down the table on page 86R we note the 20, 19.5,
15 20 and the two values for 26. Noting the silt per cent
16 ideally in order to compare it to 86R we should be
17 adding the geometric mean silt to the geometric mean
18 clay and we come to a value in excess of 60 per cent.
19 We notice that the per cent clay and silt, reading down
20 that table, 53.5, 59.8, 62.0, 79.0 and 75.5. It is my
21 opinion that based on these grain-size data that the
22 samples collected for the laboratory determinations of
23 vertical hydraulic conductivity are similar to the
24 grain-size data provided by Trow being representative
25 samples of till units from across Site D and some



1 immediately adjacent to the site.

2 A concern was raised in cross-
3 examination that dried materials do not provide a
4 representative value of the hydraulic conductivity and
5 it is my recollection that Dr. Rowe estimated that in
6 his opinion the values reported, being those values
7 that one can see at page 86R, may be too low and not
8 appropriate for the fresh or field samples. It was our
9 initial expectation, as I provided to the Board that a
10 dried sample could lead to some degree of fracturing.
11 We had expected a laboratory hydraulic conductivity
12 from the lab to be higher than the field if it were not
13 to be representative of the field or in such
14 conditions. We approached Golder on that point again
15 and we repeated our discussions. It was patently
16 obvious that they do not have experience dealing with
17 samples a year to two years old and I expect that most
18 laboratories do not have experience in dealing with
19 dried samples because of the uncertainty associated
20 with the changes that may occur as a function of
21 drying. They again indicated they would have expected
22 the laboratory data to be similar to the field data or
23 higher than the field data.

24 Recognizing that concern and recognizing
25 in general that we wished to provide the Board with a



1 reliable value for the hydraulic conductivity of the
2 unweathered upper till we undertook to drill an
3 additional borehole in order to obtain a fresh sample.
4 That borehole was drilled on Highway 25, being the
5 highway along the eastern side of the site and I am
6 just locating the approximate position of that borehole
7 on Figure C.2.3 and noting that it is adjacent to
8 HC7-84. Highway 25 was chosen for reasons of ease of
9 access. We wished to undertake this work quickly when
10 we made the decision that it was indeed appropriate.
11 In order to do that it was, as I understand it, access
12 was more easily obtained through MTC and Burlington.
13 We approached them one day and we had them out there
14 the next morning to give us clearance with regard to
15 underground servicing and we were able to relocate a
16 driller from a program which we were working on anyway.
17 We asked him to go there, we twisted his arm, asked him
18 to go there and drill this one borehole. Our
19 instructions to the technician were to make sure he was
20 very sure he was between this point and this point. I
21 was unable to be in the field at this point and locate
22 this borehole for him. I also note the driller we used
23 was the same one used by Trow for a number, if not all
24 of the boreholes. He recognized this location, HC7-84
25 and could identify that number on the borehole so they



1 had drilled adjacent to that on the west of the road
2 allowance of Highway 25.

3 It was not until after we had submitted
4 the samples to the laboratory and reviewing the grain-
5 size data available to me as reported on page 40 taken
6 from Trow. Just let me find that table again. Page
7 24. If I could refer the Board back to page 24, being
8 Table B.2.1, we have an entry at the bottom, being
9 borehole HC7-84, i.e., the same borehole which we
10 located adjacent to. We notice we have a sample depth
11 of 1.6 metres, that is metres below ground. Moving
12 over to the far right we have a value of 35.5 for the
13 clay per cent. It was apparent from examination of
14 that table that a clay per cent of 35.5 is the highest
15 clay per cent recorded. Referring back to 86R, we have
16 recorded the data obtained from this borehole at the
17 bottom of the page where we have a small notation
18 which, reading from the notes at the bottom, it says
19 reported 9/03/88, the 9th of March, '88 we received
20 these results. You will note we called the borehole
21 CRA-1-88. The samples indicated as Shelby tube No. 2.
22 Shelby is a description of a sampling device, this
23 cylinder of metal that is pushed out the bottom of the
24 borehole. The cylinder of metal is generally about
25 one-and-a-half feet long, one-and-a-half to two feet



1 from which the sample was retrieved. The sample depth
2 from which Shelby tube No. 2 was collected, the depth
3 below ground is 4.27 metres to 4.88. By way of
4 contrast I wish to note that at page 24 the sample
5 depth there was 7.6 metres below ground.

6 DR. KINGHAM: Excuse me, are you
7 referring to HC7-84?

8 MR. PETRIE: I believe when I read that
9 out I read the number in error. I am sorry, I am still
10 on the wrong page. I will repeat what I said the first
11 time as I have reported it here. I was correct the
12 first time.

13 Page 24, Table B.2.1 indicates that at
14 HC7-84 the sample which has a clay per cent of 35.5 was
15 obtained from a depth below ground of 1.6 metres. I am
16 just contrasting that to the sample depth for the
17 sample which I have described here as ST-2 being Shelby
18 tube 2, the sample depth there is 4.27 to 4.88 metres
19 below ground. The reported vertical hydraulic
20 conductivity from that test is 9.21×10^{-9} cm/sec. I
21 note there in the adjacent column the clay per cent is
22 29.5 and the per cent clay and silt is 69.5. Comparing
23 those two numbers with the numbers reported above being
24 from samples Nos. CRA-1 through 4 and also CRA-6 that
25 the clay per cent of 29.5 is in excess of the values



1 limit for HC5-85, I may have been incorrect. That
2 number reads 25.9.

3 MR. McQUAID: Q. Can I just stop you
4 and I am showing you a letter from Golder Associates on
5 Golder Associates' letterhead, letter March 9th, 1988.
6 Can you identify that as the results that you received
7 from Golder on or about that date for the fresh sample
8 that you were talking about?

9 MR. PETRIE: A. That is correct. We
10 have the date there March 9th, 1988 which is the same
11 date recorded in the notes at the bottom of the table
12 on 86R.

13 MR. McQUAID: Mr. Chairman, I will give
14 that to the Board. It really is an addition to the --
15 I was going to say if the Board wanted to we could mark
16 it as an exhibit but it really is an addendum to the
17 appendix which we see at Appendix tab B. If you wanted
18 us to get three-ring binders, a three-ring punch on it
19 and insert it in those books that would be an
20 appropriate location for it.

21 Q. Am I right in that, Mr. Petrie?

22 MR. PETRIE: A. Correct, yes.

23 MR. McQUAID: I will do that over the
24 break. I was just going to file these, sir, and
25 suggest we take a break.



1 reported although we note it is three-and-a-half per
2 cent more clay than 26.0, for example. The 69.5 being
3 the per cent clay and silt in Shelby tube sample No. 2
4 lies within the range of percentage clay and silt
5 numbers reported earlier.

6 We also note on the far two right-hand
7 columns that refer to the liquid limit and plasticity
8 index, these are interpretive tests. They are not
9 precise physical measurements. We note at the top of
10 the page for HC5-85 that the liquid limit number was
11 29.5, the plastic index was 8.9. The two numbers
12 immediately below that each have the notation of a
13 small star which again was reported on the 9th of
14 March, 1988. In discussions with Golder they felt it
15 appropriate just to redo that to confirm for themselves
16 some measure of the consistency of these materials,
17 these materials being the fresh sample obtained from
18 CRA-1-88 and the dried or old samples being samples
19 Nos. 1 through 6 reported initially. I just wish to
20 indicate to the Board that those numbers, those numbers
21 being the range of liquid limits provided and the range
22 of plastic indexes provided looking right down those
23 columns are essentially similar.

24 Mr. Crutcher has just indicated that
25 when I read the first number out, that being the liquid



1 Q. The other document I just ask you
2 to identify for us, Mr. Petrie, is a letter of the same
3 date from CRA to me and in that you are locating -- you
4 are locating on the third sheet of that document where
5 this fresh sample was taken on the road allowance?

6 MR. PETRIE: A. That is correct. Could
7 I just note that on the figure attached to this
8 document that it is listed as BH-1-88. I also referred
9 to it as CRA-1-88.

10 MR. LANCASTER: Mr. McQuaid, could not
11 both of these be put in the book?

12 MR. McQUAID: I believe so, yes. I
13 don't know what you want to do for the record, whether
14 we might mark them.

15 MR. LANCASTER: Perhaps we should to
16 keep them in the proper order of time. B-633 will be
17 the letter of Golder's of March the 9th.

18 MR. HODGSON: Mr. McQuaid hasn't handed
19 out letters to everyone. It's a letter of March 9th,
20 '88.

21 MR. PETRIE: I see it's addressed to
22 Dr. Petrie. I would prefer that to be Mr. Petrie.

23 MR. LANCASTER: The letter to
24 Mr. McQuaid would be B-634.

25



1 --- EXHIBIT NO. B-633: Letter dated March 9, 1988 to
2 Mr. Petrie from Golder
Associates

3 --- EXHIBIT NO. B-634: Letter dated March 9, 1988 to
4 Mr. McQuaid from CRA

5 DR. KINGHAM: If we are going to keep
6 those numbers in that sequence I want to keep mine
7 separate. So B-633 and B-634. You were planning on
8 breaking now, were you, Mr. McQuaid?

9 MR. McQUAID: Yes, I was, sir.

10 DR. KINGHAM: I wonder if before we do
11 that I could ask Mr. Petrie if he could assist me in
12 understanding the charts C.2.4a and b. These are the
13 hydrogeologic cross-sections, Mr. Petrie. As I look at
14 these and try to understand what is happening in the
15 groundwater flow between the various piezometers it is
16 in general fairly clear except that when I look at this
17 diagram, being Figure C.2.4a and look at HC2-86 I see
18 something that makes sense to me and something that
19 doesn't. I wonder if you could explain it. First,
20 looking between piezometers 1, 2, 3 we see that the
21 lowest water level of those three is in the upper
22 granular unit which suggests that it may be the case
23 that water is flowing towards the upper granular unit;
24 is that correct?

25 MR. PETRIE: Based on those water level
data specifically, yes.



1 DR. KINGHAM: Can you tell me what it
2 means in the three piezometer levels, starting with
3 piezometer 3, that is 3, 4 and 5 which shows the
4 highest of these readings is in the middle. Does that
5 mean the water is flowing away from that piezometer
6 towards the other two? What sense do we make of that?

7 MR. PETRIE: That is a literal
8 interpretation of the water level data. These three
9 wells drilled by Trow have a number of installations in
10 the one borehole such that I had a concern when I
11 originally looked at this data that the well seals
12 isolating any one piezometer from any other is open to
13 some degree of question. When I note water level data
14 like that it occurs to me that perhaps there could be
15 some question with regard to the integrity of the seals
16 at those locations such that these water levels may not
17 be the best representation of the vertical, pattern of
18 vertical flow at that point.

19 I would also suggest that dealing with
20 low permeable materials that the water levels fluctuate
21 on a longer-term basis such that at another point in
22 time a subtle change in the water levels may lead you
23 to this, it might be a different conclusion regarding
24 the pattern of vertical flow. My point in referencing
25 this figure was to note that within the upper till you



1 have water levels that are higher than within the lower
2 till and between those two till sheets the pattern of
3 flow is downwards. In the till sheets the pattern of
4 flow is a little more difficult to elucidate.

5 DR. KINGHAM: Then turning to Figure
6 C.2.4b I see that pattern reflected pretty well
7 everywhere except at HC3-86. I wonder if there is any
8 significance to that that the Board should know about.
9 In particular between piezometers 2 and 3 there is a
10 one-metre difference from the lower till to the upper.

11 MR. PETRIE: I believe I have checked
12 that on more than one occasion and it is the reported
13 value. I have a suspicion of a value that low within
14 this till. It is clearly inconsistent with the
15 hydraulic conductivity data and my understanding of the
16 pattern of vertical flow between this till, being the
17 upper till and the lower till.

18 DR. KINGHAM: Are you telling us that
19 you find that value questionable?

20 MR. PETRIE: Correct.

21 DR. KINGHAM: Thank you very much.

22 --- Recess

23 MR. McQUAID: Thank you, Mr. Chairman,
24 Dr. Kingham, I'm sorry I had a call with "urgent" on
25 it.



1 Q. Mr. Petrie, just picking up in the
2 document, we had been discussing the unweathered upper
3 till at page 85 -- 86, I'm sorry -- at page 86 and
4 particularly 86R. Then we pick up the text over at
5 page 87 and we filed with the Board the data you had
6 received from Golder, B-633 and the locational exhibit,
7 B-634. I wanted you, if you would, just to pick up in
8 the text and having discussed 86R and indicate to us
9 what your conclusions were as a result of these tests
10 on the unweathered upper till and its properties.

11 MR. PETRIE: A. We note that it is our
12 conclusion that the vertical hydraulic conductivity of
13 the unweathered upper till has a mean value of
14 1.4×10^{-8} cm/sec. We did not have a concern with this
15 number, however a concern was raised. As I indicated
16 to the Board we undertook to test an additional or
17 fresh sample which we did. That fresh sample provided
18 us with the lower value being 9.21×10^{-9} cm/sec and
19 confirmed in our minds that the first data set, that
20 which was initially provided in the report, more
21 specifically CRA-2, 3 and 4, as indicated on page 86R
22 provided us with the value of the hydraulic
23 conductivity of the unweathered upper till.

24 Q. Right, and I see that reference to
25 1.4×10^{-8} in the second sentence of I guess the fourth



1 -- sorry -- the third paragraph on page 88.

2 A. Yes. We note the mean vertical
3 hydraulic conductivity of 1.4×10^{-8} is considered by
4 CRA as representative of the unweathered upper till. I
5 should note by way of contrast that the value supplied
6 by Trow, specifically 8×10^{-8} cm/sec is, in my
7 opinion, a conservative value for the unweathered upper
8 till.

9 Q. Then you make a comment at the
10 bottom of page 88 about the downward velocity and there
11 is a calculation there in metres per year. Would you
12 just indicate to the Board how you arrived at that
13 number?

14 A. Yes, the value reported there is
15 0.015 metres per year. The calculation that generates
16 that number is essentially the Darcy equation. We are
17 using an initial value for the K of 1.4×10^{-8} cm/sec.
18 We are using a vertical hydraulic gradient of 0.85.
19 That number is taken from the Trow report. We are
20 dividing that by a value of 0.25 being the effective
21 porosity for this material, correcting for the unit
22 change, results in a downward velocity of 0.015 metres
23 per year. I wish to repeat that that is for an
24 unremediated failure of an engineered landfill. The
25 engineered system as designed, the hydraulic trap would



1 have upward flow across this unit. In the event of a
2 failure that is not remediated flow may then be in a
3 downward direction and that provided my estimate of the
4 groundwater velocity across this till unit in this
5 situation.

6 DR. KINGHAM: I missed one of the
7 numbers. Point 015 metres per year is for a vertical
8 hydraulic conductivity of 10^{-8} cm/sec?

9 MR. PETRIE: One point four x 10^{-8} . I
10 wish to contrast that with the number provided by Trow
11 in their report being H-39. That number is found on
12 Table 10 being at page 88. This table is headed
13 "Summary of Linear Groundwater Velocity." There are
14 two portions of this table, the first one being no
15 leachate collection system in operation. Looking at
16 the second entry on that table we have unweathered
17 upper till. Just running your eye across to the far
18 right we have a linear groundwater velocity of 0.09
19 metres per year. The only entry in that calculation
20 which is a multiplier of the hydraulic conductivity and
21 the gradient divided by the porosity, the only value I
22 have changed is the 8.8×10^{-8} in Trow's value for the
23 unweathered upper till. I have replaced that with 1.4
24 $\times 10^{-8}$ cm/sec. My calculation provides me with a
25 number of 0.015 metres per year. Trow's calculation



1 provides them with a value of 0.09 metres per year.
2 That is in the event of a failed leachate collection
3 system.

4 I might just point out while I am on
5 page 88, Table 10, the bottom portion of that table
6 addresses the leachate collection system in operation.
7 We have the unweathered upper till, looking at the very
8 last line of that figure, of that table. We note that
9 the direction of groundwater flow is upward into the
10 landfill. Using the numbers provided by Trow they have
11 calculated 0.02 metres per year. I have not but will
12 do so now using exactly Trow's numbers but inserting a
13 value of 1.4×10^{-8} calculate the velocity that I would
14 -- calculate the velocity for the leachate collection
15 system in operation, the upward flow into the landfill,
16 the average linear groundwater velocity. I get 0.0035
17 metres per year. I would just like to check that. I
18 get a second number when I check it. I shall do it a
19 third time.

20 MR. McQUAID: Q. What are the factors
21 you are using?

22 MR. PETRIE: A. I am multiplying $1.4 \times$
23 10^{-8} cm/sec, I am multiplying that by 0.2 being the
24 hydraulic gradient and I am dividing it by 0.25 being
25 the effective porosity. That in centimetres per second



1 is 1.12×10^{-10} . I beg your pardon, that is metres per
2 second, 1.12×10^{-10} and converting that to metres per
3 year I end up with the first number I had, 0.0035
4 metres per year.

5 Q. All right. Now, there are two
6 numbers that occur to me that we might continue to
7 develop. One would be what the weathered upper till
8 number would be. You changed that earlier in your
9 evidence just before the break. You changed the
10 hydraulic conductivity in fact. You would have a
11 different figure from that which we see on page 88 with
12 the leachate collection system in operation?

13 A. Correct. I will just find the
14 numbers that you refer to, Mr. McQuaid. They are
15 contained on page 87 of Exhibit B-618. The numbers are
16 for the hydraulic conductivity 1×10^{-6} cm/sec,
17 transport porosity of 0.02. We should multiply by the
18 gradient first, 0.005 and divide by 0.02. That
19 calculation would read $1 \times 10^{-6} \times 0.005$ divided by 0.02
20 gives, by my calculation, 0.79 metres per year. I
21 would contrast that with the first entry on the table,
22 that table being Table 10 at page 88 of Exhibit H-39 of
23 the weathered upper till, the linear groundwater
24 velocity, the numbers I have provided on page 87 of my
25 report, I have calculated them on page 87 of our



1 report. In the first paragraph we note that the
2 average linear groundwater velocity of 0.079 metres per
3 year is calculated. I believe the question may have
4 referred to what would the groundwater flow be with the
5 leachate collection system in operation.

6 Q. I wondered if that changed
7 correspondingly while we were at this point.

8 A. It would indeed. The calculation
9 which would provide me with the end result would be $1 \times$
10 10^{-6} cm/sec. We will use Trow's value for the
11 hydraulic gradient here, that is the hydraulic gradient
12 into the trap, that is the lateral hydraulic gradient
13 into the trap during the operation of the landfill,
14 that being 0.04 and dividing that by effective porosity
15 of 0.02 gives, by my calculation, a value of 0.631
16 metres per year. It may be appropriate just to keep
17 that to two decimal places, 0.63 metres per year and
18 contrast that with a value of 130 metres per year
19 recognizing that Trow's value was generated in part
20 using an effective porosity, the fracturing in the
21 clays being 0.01 gives a much higher velocity using the
22 porosity that I have used which was developed in part
23 by Mr. Feenstra from research studies that he provided
24 to the hearing that were available to him from Sarnia.
25 A value of 0.02 has a pronounced effect on that



1 calculation and provides a lower velocity.

2 Q. All right then, going back to the
3 unweathered upper till you have calculated or compared
4 now the CRA numbers we see on page 88 of 0.015 metres
5 per year. You told us how you got those numbers and
6 you contrasted that with Trow on page 88, the figure,
7 if there was a failure and if the hydraulic trap was in
8 operation?

9 A. Yes. If there was a failure ...

10 Q. That was the 0.09 metres per year;
11 correct?

12 A. I have recalculated that. That
13 value being 0.09 we recalculated that number employing
14 a hydraulic conductivity of 1.4×10^{-8} . That gives the
15 number of 0.015.

16 Q. We have those numbers on the
17 record. I don't think we have to go through them.
18 What I wanted to ask you was you have now given us the
19 CRA numbers, the Trow numbers. Is there a comparable
20 number from Dr. Charlesworth?

21 A. I believe so. Dr. Charlesworth
22 provided more than one number under various failure
23 scenarios. It is not entirely clear to me which of the
24 failure scenarios he felt was the most reasonable. I
25 think I would be very cautious in extrapolating from



1 his table of results.

2 Q. Is this the table summary that we
3 will be discussing a little later in your witness
4 statement?

5 A. Yes, it is.

6 Q. We will leave that one for now.

7 DR. KINGHAM: Just before we leave this
8 area though, I don't understand your calculation for
9 the leachate collection system in operation. I believe
10 you told us that for an unremediated situation the
11 upper weathered till groundwater velocity would be
12 0.079 versus Trow's 13 metres per year. That is what
13 you told us before the break. You have told us since
14 the break that for the leachate collection system in
15 operation where Trow showed a linear groundwater
16 velocity of 130 metres per year you came up with the
17 number of 0.063. I would have expected it to be a
18 straight ratio if all other parameters are the same.
19 Would it not then be 0.79 rather than 0.63, the number
20 you just gave us or has something changed? What I want
21 to know is whether you are comparing the same thing
22 both times.

23 MR. PETRIE: No, I am not. The change
24 between my value of 0.079, the significant number that
25 changes is the hydraulic gradient which for the no



1 leachate collection system in operation, I have used a
2 value of 0.005. For the leachate collection system in
3 operation, again referring to the weathered upper till,
4 I have used Trow's number being 0.04. So the
5 difference in those numbers is more than a factor -- I
6 beg your pardon -- less than a factor of ten.

7 DR. KINGHAM: Quite right. You have in
8 fact taken four-fifths of your 0.79 to come up with
9 your 0.63?

10 MR. PETRIE: Correct.

11 MR. McQUAID: Q. Then continuing over
12 to page 89 could you indicate to us, Mr. Petrie, what
13 your conclusions were with respect to the upper
14 granular unit?

15 MR. PETRIE: A. My conclusion based on
16 the apparent incomplete recovery following the test
17 pumping I conclude that the upper granular unit is not
18 a continuous permeable strata beneath much of the
19 western portion of the site. I conclude that the upper
20 granular unit is a lens and I note further that this
21 interpretation from the pumping is consistent with our
22 interpretation of the distribution of this unit based
23 on the geologic record provided. That interpretation
24 is shown on Figure C.2.2 on page 81 of Exhibit B-618.
25 We show a large lens under a mid-portion of the site.



1 The upper granular unit also extends off-site from
2 First Line Road or a portion of First Line Road and a
3 smaller occurrence at the southeast corner, the
4 property boundary adjacent to Highway 25. I note
5 lastly at that paragraph on page 89 that it is
6 conservative of Trow to interpret that the upper
7 granular unit provides a continuous permeable blanket
8 beneath and west of the site. The hard data being the
9 pumping test data and the geologic data indicate to me
10 that this unit is a lens. It is my opinion therefore
11 that to consider the distribution as Trow has done
12 provides them with a conservative estimation of the
13 distribution of this unit. Given that that
14 distribution is provided by Trow as part of the input
15 assessment or assumptions into the impact assessment as
16 we come to later, it will be my opinion that the impact
17 assessment is likewise conservative.

18 Q. All right. Then those are CRA's
19 observations in this portion of the report on these
20 various units that are described. You go on at page 89
21 to make comment on the groundwater flow system and as I
22 see over at page 90 you seem to be referring to the
23 Drawing 16 in the Trow document, H-39.

24 A. Correct. I will just put that
25 document up. I have put before the Board Drawing 16



1 from Exhibit H-39, the local bedrock potentiometric
2 contour map.

3 Q. In the first paragraph, you
4 indicate in the second sentence:

5 "As demonstrated by Trow flow at the
6 bedrock contact is towards the south and
7 southeast."

8 A. Yes. Could I just note initially
9 that this section is addressing the groundwater flow
10 system at the site? At this point in our review we
11 have noted that upper unweathered till -- let me
12 correct that -- unweathered upper till, it has a very
13 low hydraulic conductivity of 1.4×10^{-8} . This
14 contrasts strongly with the permeability of the lower
15 till which Trow have assigned a value of 2×10^{-6} .
16 Essentially we have a two order or a factor of 100
17 times contrast in permeabilities between the upper till
18 and the lower till.

19 Secondly, within that lower till there
20 are granular units. The upper granular unit I have
21 interpreted as a lens. The lower granular unit has a
22 distribution essentially linear across the site being
23 from the east to the west approximating the position of
24 the bedrock values at this site. We also note the
25 absence of tritium in the granular units as evidenced



1 from the pumped -- sampling of the pumped water from
2 PW-1 and PW-2. We also note that the groundwater
3 quality in the granular units and I'm referring now to
4 the data provided by Dr. Charlesworth, shows elevated
5 levels of chloride and sulphate parameters. We are
6 noting there that this is not pristine groundwater with
7 respect to those parameters. We are noting the absence
8 of tritium, we are noting the very low hydraulic
9 conductivity of the uppermost unit and I make the
10 statement there on page 89 that the pattern of
11 groundwater flow on the site is controlled to a large
12 extent by the unweathered upper till. This unit
13 comprises a thick, uniform, low permeable layer which
14 mantles the site. Within this unit hydraulic gradients
15 are directed downwards.

16 With respect to the pattern of
17 groundwater flow at the site it is this till that
18 exerts most control, this till being the upper till.
19 We note that within the lower till gradients in a
20 vertical plane are less steep. There are some
21 reversals in gradient. There is expected to be a
22 component of horizontal flow within this lower till and
23 within this lower till that also would include a
24 granular unit, the upper and lower. Noted earlier in
25 our critique of the Trow document we felt they could



1 not be conclusive with respect to the flow directions
2 in the granular units. I indicated at that time that
3 the pattern of flow in the bedrock may provide the best
4 indication of groundwater flow beneath the upper till
5 at this site. That refers to this drawing here, "here"
6 being Drawing No. 16 from Exhibit H-39.

7 I recall when I reviewed this document a
8 minor inconsistency in one of the contours that perhaps
9 I should correct for the sake of clarity. I am
10 referring to the piezometric data for HC8-84 being on
11 the bottom of the map on the site southern boundary,
12 the piezometric data for HC1-86. I note that between
13 those two points there is a contour and that contour
14 has an elevation as I read up at the top of 181.
15 Ideally it should not be going between these two
16 points, both of which are less than 181. It would be
17 my interpretation that that contour should bend in some
18 fashion and mirror the 181.5 contour.

19 Q. Can you just point out what you've
20 done? We can't really see it from this distance.

21 A. I should take a bolder pen and in
22 red I have deleted a portion of the contour, that
23 contour being 181 metres above sea level at the
24 southern property boundary between the wells, HC8-84
25 and HC1-86, both of which record a groundwater



1 elevation at the bedrock contact below 181. I have
2 moved that contour to the left in a fashion that mimics
3 the pattern at this point in the site to the contour
4 181.5.

5 Q. So in your Drawing 16, H-39, you
6 have made the change in the red marker?

7 A. Correct.

8 MR. McQUAID: Perhaps we had better mark
9 that as an exhibit, Mr. Chairman.

10 MR. LANCASTER: Six thirty-five.

11 --- EXHIBIT NO. B-635: Copy of Drawing 16 of Exhibit
12 No. H-39 with markings by
Mr. Petrie

13 MR. PETRIE: I am marking Drawing 16 of
14 Exhibit H-39 with an altered potentiometric contour of
15 the 181 elevation on the south property boundary as
16 Exhibit B-635. It does not make a dramatic difference
17 to the pattern of groundwater flow except I would
18 conclude that the pattern of flow is generally a little
19 more to the south portion of the site being a compass
20 bearing of east at that point as shown by Trow. My
21 statement on page 90 of the report, the bottom of the
22 first paragraph, as demonstrated by Trow, flow at the
23 bedrock contact is towards the south and southeast. I
24 am referring to the compass directions of this way and
25 this way being south and southeast (indicating).



1 I note in the second paragraph there
2 that I have interpreted the upper granular unit as
3 consisting of a -- consisting of two lenses beneath the
4 site. Reading on in that second paragraph:

5 "The rate of lateral groundwater flow
6 within this unit will be controlled for
7 the most part by the permeability of the
8 strata enveloping these lens."

9 In referring to that if we have a lens of permeable
10 strata embedded in, in this case a till of lesser
11 permeability, the flow within that lens will reflect
12 the rate and direction of flow within the lower till.

13 The bottom paragraph on page 90 refers
14 back to something which we raised in our critique of
15 the Trow report that in reviewing all the geologic data
16 there are, in some portions of the site, some strata
17 which may be interpreted as being lateral continuations
18 of the granular unit. Noting in that bottom paragraph
19 on page 90 I am referring to 0.3 metres of silt
20 interbedded with clay and minor pebbles encountered at
21 HC6-85. One may interpret that this represents a
22 geologic equivalent of the upper granular unit.
23 However, it is my opinion that such materials have a
24 similar hydraulic conductivity to that of the lower
25 till and that they do not represent a hydrogeologic



1 equivalent for the granular layers. This compares or
2 agrees with that which Mr. Sobanski indicated when a
3 similar question was put to him. His remark was to the
4 effect that he has interpreted the distribution of the
5 granular unit to show where he felt it was
6 hydrogeologically significant. I am making the same
7 remark here. Where we have permeable strata I am
8 reflecting that they may indeed be a proportion of one
9 or other of the granular units. Where we have strata
10 that do not appear to be till but are of low
11 permeability my reference, silt interbedded with clay
12 and minor pebbles, I do not consider that these
13 materials provide a pathway for lateral groundwater
14 flow. I further consider that these materials will
15 behave like the lower till, that is hydraulically like
16 the lower till.

17 I conclude at the bottom of page 90 it
18 is my opinion that the horizontal component of
19 groundwater flow in both granular units is to the south
20 and southeast at a low gradient, paralleling the
21 direction shown by Trow, that is Drawing 16 before the
22 Board, for the bedrock/overburden contact. I have only
23 addressed myself to the horizontal component of flow.
24 I will note that it is my opinion that the granular
25 strata in the lower granular bed which extends beneath



1 the site in a west and east fashion within the bedrock
2 valley and water within the lens of the lower -- of the
3 upper granular unit will in general flow in this
4 fashion, this fashion being to the south and southeast.

5 Q. All right. Having addressed the
6 geology, the groundwater flow system we have just been
7 discussing at page 91 you have then discussed the
8 results of the Trow exhibit insofar as contaminant
9 migration is concerned.

10 A. Correct. At this point we have
11 defined the hydrogeology of the site. We are now
12 looking at a valuation of the potential for contaminant
13 migration. We are noting in the first paragraph on
14 page 91 that the evaluation undertaken by Trow which is
15 the situation in which the hydraulic trap has failed
16 and no remedial measures are implemented to restore the
17 trap. In all my remarks addressing the contaminant
18 migration potential I am referring to the situation I
19 have just described, failure of the trap and no
20 remedial measures. When the hydraulic trap is
21 operating as designed there will be some contaminant
22 loss from the landfill by the mechanism of diffusion
23 and Trow indicate this diffusion halo will migrate a
24 distance of as much as three metres in the unweathered
25 upper till. They note that three metres was for



1 chlorides, and the volatile compounds, VOC's, that the
2 diffusion front would advance a shorter distance.

3 Q. Could you explain or indicate your
4 views with respect to the difference between those, the
5 diffusion fronts of those chlorides as opposed to the
6 volatile organic?

7 A. I am just noting there that the
8 chlorides will advance a greater distance and
9 essentially reach some sort of steady-state condition.
10 It is not expected to change with time, recognizing it
11 will take quite some time on a scale of tens of years
12 to reach that three-metre point for chloride. For the
13 VOC's, given that they are attenuated in some fashion
14 within the clay till strata, their distance of
15 diffusion will be less than that for chloride.

16 I note in the next paragraph that the
17 long-term failure of the hydraulic trap, contaminants
18 may migrate from the landfill downward through the
19 unweathered upper till, downward through the lower till
20 and laterally in either the granular units or the
21 bedrock. I don't indicate on page 91 that lateral
22 migration from the landfill could also occur. I wish
23 to correct this, the impression I have left here. We
24 could also expect in the failure of -- long-term
25 failure of the hydraulic trap that a component of



1 lateral migration through the weathered upper till may
2 also occur.

3 Q. So could you tell us where, what
4 sentence and where we should add that comment?

5 A. On page 91 following the second
6 paragraph we can insert -- I beg your pardon -- at the
7 end of the second paragraph, not starting a new
8 paragraph. Also for long-term failure of the hydraulic
9 trap contaminants may migrate laterally from the
10 landfill -- I haven't caught up with myself yet --
11 through the weathered upper till.

12 Q. All right, thank you.

13 A. I just repeat again that
14 Mr. Crutcher identified the engineering options related
15 to the landfill design engineer. Some of those options
16 one might review during the stage of excavation of the
17 landfill. In the event that fractured or seepage faces
18 are seen during the excavation, one might consider some
19 remedial works at that phase or secondly if groundwater
20 contamination were identified beyond the landfill
21 within the weathered zone, he further identified the
22 engineering options that would be available to
23 ameliorate that situation.

24 Q. Going over to page 92 we
25 concentrate on the downward migration through the



1 unweathered upper till in the event of the failure of
2 the trap and no remedial action?

3 A. Correct. To undertake this
4 evaluation we employed the Ogata-Banks solution which
5 was the same solution employed by Mr. Feenstra as he
6 reported to the Board earlier. In this evaluation we
7 have used, the hydraulic conductivity of 1.4×10^{-8} for
8 the unweathered upper till. We have used the hydraulic
9 gradient and the effect of porosity values taken from
10 Trow, specifically on Table 10, page 88 of Exhibit
11 H-39. We used for the failed system, i.e., the numbers
12 towards the top of the page, we use a vertical
13 hydraulic gradient of 0.85 and then an effective
14 porosity of 0.25. I stay with Trow's numbers at this
15 point because we are still evaluating Trow's landfill
16 design. You will note that the only number I have
17 changed is the vertical hydraulic conductivity that we
18 have developed.

19 The third paragraph on page 92 notes
20 that in order to determine the first arrival times of
21 conservative contaminants migrating downwards through
22 four metres of the unweathered upper till we use the
23 Ogata-Banks solution. The four metres of unweathered
24 upper till is the same vertical thickness of
25 unweathered upper till that Trow used or Mr. Feenstra



1 used in his evaluation of the transport times through
2 the upper till. I will develop this solution or the
3 curve, rather, the resulting curve which one can
4 compare to the curve provided by Trow on page 98 of
5 Exhibit H-39, that being Figure 9. If you just wish to
6 have that curve open as I go through this discussion.
7 Again that is page 98 of Exhibit H-39.

8 Q. Could you explain, first of all,
9 your results as we see them on page 93?

10 A. Ninety-three provides the Ogata-
11 Banks solution for contaminant transport, a non-
12 reactive constituent, in this case chloride or using
13 Mr. Feenstra's notation, a value of $R = 1.0$. We have
14 provided that. As we note the only value I have
15 changed is indicated at the bottom left-hand corner of
16 this figure. We note the data is from Trow from page
17 98, the figure you have before you except K_v the
18 vertical hydraulic conductivity is 1.4×10^{-8} cm/sec.
19 You do not see that value over here in the water
20 velocity. That water velocity is hydraulic
21 conductivity multiplied by the hydraulic gradient and
22 divided by the porosity. That value there is directly
23 equivalent to 0.015 metres per year or as you see
24 before you, 0.476×10^{-7} cm/sec. The only number I
25 have changed is the hydraulic conductivity, that



1 provided by Trow on Figure 9 at page 98. The point to
2 note is that the initial break-through time is in the
3 order of 80 years, recognizing the point 80 years where
4 this curve departs from the 0.0 relative concentration.
5 Taking a relative concentration, i.e., C/C_0 on the
6 vertical axis of 0.1 we note that that takes
7 approximately 125 years for that to occur. I am just
8 reading 0.1 from a relative concentration of 0.1 over
9 to the time scale at the bottom and I'm noting that
10 point is approximately 125 years.

11 DR. KINGHAM: Before you take that off,
12 please, are we to assume that for this diagram and
13 others like it that this is for the hydraulic trap not
14 in operation?

15 MR. PETRIE: That is correct. It is for
16 downward flow across four metres of till. The four
17 metres refers to distance for the condition where the
18 hydraulic trap has failed and no remediation has
19 occurred. The heading of the figure you have before
20 you being Figure C.2.5 is "Breakthrough Curve -
21 Unweathered Upper Till - Trow Design." What I have
22 taken from Trow are some other numbers but I am
23 referring specifically now to the thickness of the
24 till.

25 Recalling the stratigraphic sequence we



1 have at the site beneath the unweathered upper till we
2 still have the lower till. I have not undertaken an
3 independent evaluation of the lower till but it is my
4 opinion that the upper till provides the primary
5 attenuation or control in the event of the failed
6 landfill system. It has not been remediated for some
7 tens of years.

8 The second paragraph on page 94 repeats
9 some of the -- while we have page 98 of Trow you will
10 notice that for the vertical hydraulic conductivity
11 they have used, and reading the graph on page 98, we
12 notice it is in the order of about 25 years before the
13 curve labelled R = 1.0 unreactive constituents reach a
14 relative concentration of 0.1. I am contrasting 125
15 years for the vertical hydraulic conductivity that CRA
16 provides with a value of approximately 25 years from
17 page 98 of Trow.

18 Q. So we compare the initial
19 breakthrough that you have on page 93 of 80 years to
20 the 25 years on page 98 of Trow?

21 A. Correct.

22 Q. Then we go to the 0.1 entry. You
23 give us the figures 125 years?

24 A. Can I repeat your statement? I
25 may have misunderstood you. I am comparing a value of



1 125 years which occurs, I've seen on Figure C.2.5 to a
2 relative concentration of 0.1 and comparing that value
3 to approximately 25 years that I see reading page 98.
4 That is 98 of the Trow document, Exhibit H-39. I am
5 comparing 125 to approximately 25 in both cases for the
6 relative concentration of 0.1. The 80 years you
7 referred to was my indication from Figure C.2.5 were
8 from our computer simulation where that curve deviates
9 from 0.0 concentration. Taking that point from the
10 Trow report it looks like we are approximately 20
11 years. As I say, 20 years is my estimation from the
12 figure on page 98 where the curve $R = 1.0$ deviates
13 initially from the 0.00 concentration, i.e., comes off
14 the bottom of that graph.

15 The second paragraph on page 94
16 addresses the lower till that separates the upper till
17 from the first granular unit. Here, as I indicated, we
18 have not undertaken an independent evaluation. I am
19 taking Trow's numbers. Trow's numbers are provided on
20 page 100. We see the same curve, the same curve being
21 the relative concentration on the vertical axis, the
22 elapsed time in years along the bottom for vertical
23 migration across that portion of the lower till that
24 separates the upper till from the uppermost granular
25 unit. I note that for the relative concentration of



1 0.1 that we have approximately 25 years that elapse
2 before the breakthrough concentration reached 0.1.
3 That is breakthrough between the top of that lower till
4 to the first granular unit encountered. So, I am
5 simply taking that value of 25 years and adding it to
6 the 125 years which I developed from examination of
7 Figure C.2.5, 125 years being the breakthrough time at
8 0.1 relative concentration and note that they had up to
9 150 years. This is an approximate way of doing it but
10 it is reasonable for the values we have before us.

11 I note that the last part of the
12 paragraph on page 94, that being the second paragraph
13 this indicates that in the event of a failure of the
14 proposed landfill, I should note an unremediated
15 failure, approximately 150 years are required for
16 contaminants at one-tenth the concentration as that
17 found in the leachate, i.e., a relative concentration of
18 C/C_o of 0.1 for a leachate at that concentration to
19 migrate from the base of the landfill to the top of the
20 uppermost granular unit.

21 DR. KINGHAM: I'm sorry, I don't follow
22 you on that. I thought you had just told us that it
23 would take 125 years for the concentration between the
24 upper till and the lower till to reach one-tenth of the
25 initial value according to your Figure C.2.5; is that



1 correct?

2 MR. PETRIE: I believe you may have
3 misunderstood me. This is the time, 125 years I am
4 referring to for contamination leaving the landfill to
5 migrate across the upper till to reach the base of the
6 upper till.

7 DR. KINGHAM: Yes, I do understand that.
8 That means that at 125 years, if I've understood you
9 clearly, the concentration at the boundary between the
10 upper and lower till is 0.1 of the concentration in the
11 landfill. Then it takes a further 25 years for one-
12 tenth of that concentration to reach the upper granular
13 unit. Does that not mean the concentration at the
14 upper granular unit would be 1/100 of Co in the
15 landfill?

16 MR. PETRIE: I understood your question.
17 I made the limiting assumption being the 125 plus the
18 125 being -- recognizing I was being conservative. I
19 had not endeavoured to couple these equations as Mr.
20 Feenstra had done. The number I provided of 150 years
21 is conservative. A relative concentration of 0.01,
22 crossing first the upper till unit and then the lower
23 till unit would be in excess of the 150 years. So I
24 made a rather simplified assumption. I note on the
25 bottom paragraph of page 94 it must be recognized that



1 contaminants will reach the upper granular unit where
2 this unit is present in the event the landfill fails
3 and no remedial measures are implemented for this
4 period. Restoration of the hydraulic trap would
5 reverse the direction of groundwater flow and any
6 contaminants that had migrated into the underlying
7 tills would, in time, migrate back towards the
8 landfill. I am noting that if within the period of
9 something less than 125 years the hydraulic trap was
10 restored we would then have vertical flow, i.e., flow
11 upwards across this upper till such that any
12 contaminants that had migrated into the upper till
13 would then reverse their flow direction and migrate
14 back into the landfill. The driving force for that
15 being the hydraulic trap restorations.

16 Mr. Crutcher is just pointing out to me
17 that the question that you raised earlier, if after 125
18 years we have concentrations of 0.1 relative strength
19 at the base of the landfill -- I beg your pardon -- at
20 the base of the unweathered upper till, starting at
21 that relative concentration of 0.1 then an additional
22 25 years being the travel time across the lower till to
23 the first granular unit, the relative breakthrough time
24 would be 0.01 concentration. I was just pointing out
25 that I made some limiting assumptions here in order to



1 arrive at a more conservative estimate than that
2 indicated had I been more rigorous. I am noting that
3 it is my opinion that 125 years is a very long period
4 of time for a failed landfill system.

5 DR. KINGHAM: I had concluded from what
6 you said that it would be 150 years for the
7 concentration in the upper granular unit to reach
8 1/100. For a situation in a landfill in a fully
9 coupled model.

10 MR. PETRIE: Correct.

11 MR. McQUAID: Q. Mr. Petrie, does that
12 complete that section in discussing the contaminant
13 migration?

14 MR. PETRIE: A. Correct, it does. I
15 make one comment. We don't address lateral flow in the
16 granular unit at this point. I believe we discuss that
17 later on when we are reviewing the design, such a
18 landfill design that Mr. Crutcher will provide.

19 MR. McQUAID: Mr. Chairman, we are now
20 going into a new section and this would be a convenient
21 time to break. I would appreciate it.

22 DR. KINGHAM: If we are going to break
23 there is just one other point I would like to have
24 clarified before we leave this section and it has to
25 do with your reference, Mr. Petrie, to the diffusion



1 halo which you describe on page 91 in the first
2 paragraph.

3 MR. PETRIE: I see that.

4 DR. KINGHAM: What you have told us this
5 morning is that the diffusion halo would migrate a
6 distance of as much as three metres into the
7 unweathered upper till. We understood that to mean
8 that a steady state condition would be arrived at where
9 the diffusion, the entropy if you will, of the
10 contaminant is counter-balanced by the inflow of the
11 groundwater in the hydraulic trap and that distance is
12 three metres.

13 MR. PETRIE: Correct.

14 DR. KINGHAM: You have also told us this
15 morning that your value for the hydraulic conductivity
16 of that stratum is about one-sixth of the value assumed
17 by Trow being 1.4×10^{-8} versus 8.8×10^{-8} . Does that
18 mean then that the contaminant would diffuse a greater
19 distance or because of the counter current is less by
20 one-sixth or does it mean that the two effect counter-
21 balance one another leaving the diffusion halo still at
22 three metres? To be clear I am asking you whether that
23 means that the rate at which the chloride in this case
24 diffuses out is slowed by as much as the rate at which
25 the groundwater diffuses in so that for your less



1 porous medium you still have the same penetration of
2 the chloride. Do you understand the question?

3 MR. PETRIE: Yes. For the hydraulic
4 conductivity we have provided a factor of approximately
5 six lower, the rate of vertical groundwater flow being
6 inflow which, as you know is counter-current to the
7 direction of diffusion, is also less. So there is a
8 lower restricting force, if that is the correct
9 expression, on the diffusion front. It is my
10 expectation that the diffusion front will be in excess
11 of three metres for chloride for the condition that I
12 have provided being the hydraulic conductivity of the
13 unweathered upper till.

14 DR. KINGHAM: Thank you.

15 MR. LANCASTER: One forty-five.

16 --- Luncheon recess at 12:34 p.m.
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1 . --- Upon resuming at 1:53 p.m.

2 MR. LANCASTER: Be seated, please.

3 MR. MCQUAID: Thank you, Mr. Chairman.

4 Q. Mr. Crutcher, I would like to
5 begin to continue in B-618 at page 95, a section that
6 begins "Conceptual Landfill Design." There is a
7 description of some of the principal features of
8 hydrogeology to be considered in designing a landfill.
9 I wonder if you would just take us through those and
10 then indicate how they were incorporated into the
11 conceptual design for the site.

12 MR. CRUTCHER: A. We are in Part C of
13 this report which deals with our opinion and
14 recommendations on the site. Essentially this deals
15 with the items that we would address as being the
16 designers of the site, understanding how we have
17 presented the hydrogeology. If you refer to page 95 we
18 outline the key points to be dealt with.

19 First, we have a weathered upper till in
20 the order of four metres in thickness which we indicate
21 has a potential for lateral groundwater flow. Beneath
22 this weathered upper till we have an unweathered upper
23 till with a vertical hydraulic conductivity of
24 approximately 1.4×10^{-8} cm/sec. That overlies the
25 entire site to a depth of approximately four to eight



1 metres below ground. We also believe that is a
2 suitable base on which to landfill.

3 The mean vertical hydraulic gradients
4 are directed downwards at 0.2, the base elevation of
5 the upper till, which would indicate it would be
6 approximately 174 to 176 metres above sea level. Below
7 the upper till -- the lower till, we have less steep
8 gradients, typically downwards and we also note that
9 there are nearby domestic wells both in the overburden
10 and in the bedrock. We state, and I am now at the top
11 of page 96, the first full paragraph:

12 "CRA considers that a hydraulic trap
13 landfill design can be implemented at
14 this site."

15 To implement there are two main design features.
16 Essentially there is one main design feature. That
17 feature is to maintain the maximum leachate level in
18 the site 0.4 metres below the April, 1986 piezometric
19 elevations. That is the criterion that Trow utilizes.
20 We are in agreement with that criterion.

21 We would also want to maintain a maximum
22 thickness of the unweathered upper till underlying the
23 base of the landfill site. Those two are somewhat --
24 don't contradict each other but they are at ends with
25 each other. The deeper you excavate the more you are



1 providing a positive hydraulic trap but you are
2 reducing the thickness of the unweathered upper till.
3 We were very cognizant of that. So when you are
4 designing the site you have to design with that in
5 mind. In fact you are trying to optimize both as best
6 you can.

7 We undertook a complete evaluation of
8 the Trow design and we note when Mr. Hiraishi discussed
9 in chief dealing with the design, he indicated it was a
10 concept and required optimization. We undertook what
11 we refer to more as the optimization design and we went
12 a few steps further than Mr. Hiraishi in taking a look
13 at the site. I believe he testified he felt it was
14 feasible to construct a landfill site at this location
15 and he provided the concept plans for that. He didn't
16 qualify it saying they were concept plans. We took it
17 a step further than that and outlined it in a report
18 which I will be testifying to subsequently entitled
19 "Evaluation of Halton Regional Landfill Technical Study
20 Site D, Milton, Design and Operations Report." I don't
21 intend to get into any particular detail on the design.
22 I think it will be beneficial to just outline to the
23 Board the concept of that design since the subsequent
24 sections in this report detail some of our predictions
25 using the optimized design.



1 I have sketched on the drawing board
2 here the basis of what we are referring to as an
3 alternative design. We entitled it "CRA Concept on
4 Landfill Design Alternative." It is intended to be a
5 3-D pictorial of the base of the landfill to -- showing
6 the unweathered upper till. I was a little skeptical
7 in sketching it only on the basis of my ability of
8 sketching. I hope it is evident.

9 Essentially the basis of the redesign is
10 a contouring of the base of the landfill site, where
11 the leachate collection system would be installed. In
12 the Trow design essentially the base is relatively flat
13 with a shallow slope all in one direction. Our
14 recommendation is in fact that you would peak the base
15 in essentially the centre or the mid-point of the
16 landfill itself and have drainage in all directions
17 from that. We have specified a half a per cent grade
18 in all directions from that peak.

19 Q. So there is a crown or a centre
20 point in the cell?

21 A. That is correct.

22 Q. Could you indicate exactly where
23 that is?

24 A. I will circle it in pink and I
25 will call it the crown. So, we have drainage in all



1 directions. The leachate would drain along this
2 drainage path and be picked up with leachate collectors
3 at the base. Essentially what we are doing is creating
4 a swale in the base. This configuration would be a
5 series of these across the bottom of the site. So, it
6 is an undulating bottom of the site. At the low point
7 the leachate collector pipe would be installed, again
8 at a half of one per cent grade.

9 To assist in removal of leachate between
10 the collector pipe we recommend installing French
11 drains. Essentially that is a granular trench. I
12 should note that we are also recommending not to
13 excavate into the till but rather placing of the trench
14 and the actual leachate collector pipe at the base
15 level. So, in fact you would excavate and shape the
16 bottom of the landfill site, place a stone trench on
17 the base, not excavating into but placing it on the
18 base and likewise with the collector pipe.

19 Q. I'm not sure that I've got it
20 spatially in my mind yet. Those French drains, are
21 they running along the base of the triangles going down
22 from the crown?

23 A. That is correct. They are spaced
24 approximately every 20 metres.

25 Q. And their depth is what?



1 A. They are sitting on the base of
2 the landfill. They are not excavated in. The reason
3 for that is we are trying to address item No. 2 where
4 we are trying to maintain the maximum thickness of the
5 unweathered upper till. By excavating them in we are
6 reducing that thickness to some degree. By placing
7 them directly on the base we eliminate that as any
8 concern. I should say it's not really a concern but we
9 have maximized the thickness. By doing the design in
10 this configuration we believe we achieve both items 1
11 and 2. We have reviewed the complete site and in fact
12 have prepared drawings on the complete site and we can
13 maintain with confidence the 0.4-metre maximum leachate
14 level.

15 Q. Did you say 0.4?

16 A. Sorry, the 0.4-metre maximum
17 leachate level below the highest piezometric
18 elevations. We can maintain a thickness of the
19 unweathered upper till on average of approximately 4.5
20 metres and the minimum at all cells, the minimum at any
21 location we have determined as 3.2 metres. We believe
22 this is an improvement or an optimization of the Trow
23 design.

24 We have also, by the shaping of the base
25 of the landfill, improved or increased the slope. As



1 you recall, Mr. Hiraishi indicated the slope he had on
2 his tiles was approximately 0.25 per cent. We have
3 been able to increase that to 0.5 per cent.

4 Q. You have actually written on 0.5
5 per cent down the lines which represent the crown, the
6 triangular -- I am not sure what the correct geometric
7 term would be at the top but like a pyramid I guess, a
8 very narrow or thin one. Then you have 0.5 going down
9 all of those directions?

10 A. That is correct. We maintain that
11 slope in all directions.

12 I should note that this design is very
13 similar to the design which we used at the Keele Valley
14 landfill site in Toronto. The basis was they had a
15 half a per cent grade and the shaping of the base of
16 the landfill at Keele Valley, it was the configuration
17 of the top of the liner. As I indicated, there was a
18 1.2-metre clay liner placed in. This configuration was
19 in fact the design for the top of the liner or the
20 slopes on the liner. That system, as I have testified
21 earlier, is operating very well.

22 MR. MCQUAID: Mr. Chairman, I guess we
23 should mark that sketch.

24 MR. LANCASTER: Six thirty-six.

25 --- EXHIBIT NO. B-636: Sketch entitled "CRA Concept
of Landfill Design Alternative"



1 MR. CRUTCHER: From this alternative
2 design we then undertook an impact assessment which
3 Mr. Petrie will discuss.

4 MR. McQUAID: Q. All right. Now,
5 Mr. Petrie, would you just indicate where we pick up
6 the examination of impact as a result of this
7 conceptual design? I see the numbers at the bottom of
8 page 96 that Mr. Crutcher was referring to.

9 MR. PETRIE: A. That is correct. The
10 bottom of page 96 provides the numbers there, being the
11 thickness at the alternative design, the one that
12 Mr. Crutcher has outlined on Exhibit B-636 and will
13 speak to in more detail in the design evaluation
14 portion of this hearing. From that landfill design we
15 note that the minimum unweathered upper till thickness
16 is 3.2 metres. Just with reference to the drawing, I
17 would point out that that 3.2 metres would occur on the
18 corners where the slopes are contoured in those
19 directions. I also note in the last sentence on that
20 page that the till thicknesses range up to 6.6 metres
21 and average 4.5 metres in thickness.

22 We again undertook to evaluate the
23 contaminant travel time through such a system and for
24 this evaluation we employed a minimum thickness of 3.2
25 metres being a minimum design thickness. We used the



1 same value for dispersivity and molecular diffusion as
2 were used previously by Trow and we used a groundwater
3 velocity term that incorporates a hydraulic
4 conductivity of 1.4×10^{-8} and a vertical gradient of
5 0.85. I would point out again that this simulation is
6 performed under the assumption that the landfill has
7 failed and, further, that no remedial efforts were
8 undertaken. We are looking at a failed system, the
9 system in question being conceptualized on B-636. We
10 provide, as per Figure C.3.1 on page 98, the
11 breakthrough curve for this thickness of till. We
12 notice in the bottom left-hand corner the data from
13 Trow, Exhibit H-39, page 98 except $K_v = 1.4 \times 10^{-8}$. I
14 should indicate that where we have the distance 3.2 on
15 this figure that that is CRA's number that I just
16 mentioned.

17 The breakthrough time one notes is at
18 approximately 40 years where we have the first point of
19 departure from the curve being the first occurrence of
20 contamination exceeding the relative concentration of
21 0.0 after a time of approximately 40 years. I have in
22 the text 60 years. At 60 years we have simulated
23 contaminants in excess of 0.0 relative concentration
24 and further that a relative concentration of 0.1 is
25 reached at approximately 95 years. Again one can



1 indicate that from reference to relative concentration
2 being the vertical axis of 0.1 and scaling off the time
3 scale across the bottom of Figure C.3.1.

4 Again in the next paragraph on page 97 I
5 repeat what I have done earlier in reviewing the
6 computed simulation of breakthrough through the upper
7 till, namely, that I add to this value, this value
8 being the 95 years, the 25 years that is interpreted
9 from the Trow simulation for the lower till being the
10 flow across the lower till to the upper granular unit.
11 I note that Trow indicated a time of 25 years with the
12 contaminants starting at a concentration of one at the
13 top of the lower till, that they would take an
14 additional 25 years to migrate across the lower till to
15 the upper granular unit. Adding those numbers I come
16 to a total travel time of approximately 120 years to
17 breakthrough. I should note, as Dr. Kingham pointed
18 out this morning, ideally the breakthrough
19 concentration in the lower granular unit after 120
20 years would be 0.01 relative concentration.

21 DR. KINGHAM: I appreciate that
22 clarification but you do mean upper granular unit not
23 lower granular unit?

24 MR. PETRIE: I do.

25 DR. KINGHAM: So that second-last sign



1 you are saying to reach concentration of 1/100 of that
2 in the landfill to reach the upper granular unit; is
3 that correct?

4 MR. PETRIE: That is correct. There is
5 one limiting situation attached to the mathematics this
6 morning. It assumes during the 25 years of travel
7 across the lower till that the concentration at the
8 uppermost boundary of the lower till does not change
9 through that period of time. We are superimposing
10 breakthrough curves. I took a most conservative
11 approximation by just directly adding them. If you
12 take a more rigorous one arriving at the number of
13 1/100 of the relative concentration, I point out that
14 the more rigorous evaluation of that would arrive at
15 something slightly in excess of the number you proposed
16 and less than the number I have indicated. In other
17 words, were one to couple these two equations being the
18 Ogata-Banks solution for travel through the -- across
19 the unweathered upper till and across the lower till to
20 reach the upper granular unit, the time I have
21 indicated being 120 years is conservative. I note on
22 the last paragraph there that we are dealing with a
23 situation where the hydraulic trap fails for a period
24 of 120 years and no restorative measures are
25 implemented.



1 I would further like to point out that
2 this assumption does not address or this evaluation
3 does not address the upper granular unit. It is my
4 interpretation that the upper granular unit is a lens.
5 It does not provide a pathway for off-site or lateral
6 groundwater flow off-site.

7 I would also like to note with respect
8 to Exhibit B-636, the conceptual diagram that
9 Mr. Crutcher has just exhibited, that the thicknesses
10 range from 3.2 metres to 6.6 metres. Obviously if one
11 were to investigate, use a thicker upper till, one
12 would obviously have a longer travel time. So, we are
13 looking at a long-term, unremediated failure and,
14 secondly, we have taken the thinnest point, if that is
15 the correct way to describe it, being 3.2 metres
16 between the base of the ultimate design proposed by CRA
17 and 3.2 metres being the thinnest portion of the till
18 at that site. We have added, in not the most rigorous
19 method, to arrive at a value of 120 years for
20 contaminant travel in that situation to the upper
21 granular unit and arrive at a travel time for
22 breakthrough of 120 years.

23 I conclude on the top of page 99 that in
24 the event of failure of the hydraulic trap sufficient
25 lead time is provided by the extremely slow rate of



1 groundwater flow within the underlying unweathered
2 upper till such that remedial measures aimed at
3 restoring the hydraulic trap can be implemented.

4 MR. McQUAID: Q. Mr. Petrie, continuing
5 in the report there is a section then where you have
6 the CRA recommendations respecting monitoring. You
7 indicated that you felt that the Trow numbers were
8 excessive this morning in Part B. I wonder if you
9 would just go on and continue to indicate what CRA's
10 recommendations would be.

11 MR. PETRIE: A. Our critique this
12 morning with respect to the Trow monitoring program
13 indicated two points as I recall; the number of
14 monitoring points, being 76 was excessive and,
15 secondly, that they did not appear to address
16 monitoring of the leachate head within the landfill.
17 Mr. Sobanski did indicate he would be monitoring water
18 levels adjacent to the landfill. My concern is that it
19 would be prudent, given that the hydraulic trap is the
20 proposed design for this site, that one ought to be
21 monitoring water levels within the landfill. The first
22 section there under C.4.1 on page 100 addresses
23 hydraulic monitoring. We note that we recommend that
24 part of this program, the program being the monitoring
25 program, is focused to monitoring the leachate mound



1 within the landfill. Obviously those water levels or
2 liquid levels could be compared to the water level data
3 obtained from monitoring piezometers adjacent to or
4 outside the landfill cells. I recommend at the bottom
5 at each landfill cell, four piezometers be installed at
6 the base of the excavation midway between a pair of
7 collection pipes. Further, that these installations
8 should ideally consist of flexible tubing laid across
9 the floor of the excavation and up the side slope.
10 That would ensure that these installations are unlikely
11 to be damaged during landfilling. I note that were one
12 of the piezometers to become inoperable it could be
13 replaced by drilling through the landfill refuse and
14 installation a piezometer at the floor of the landfill.
15 Every effort should then be made to ensure that the
16 installation is not destroyed during continued
17 landfilling.

18 One additional point I would like to
19 make that is not in the text is that I have recommended
20 four piezometers for each cell. I would like to note
21 that the number of piezometers and the preferred
22 location of these piezometers be evaluated by the
23 landfill design engineer so that he, recognizing that a
24 hydraulic trap is the hydraulic prime control at this
25 site that he can advise where he would prefer those



1 piezometers to be located in order to evaluate the
2 integrity of the hydraulic trap.

3 Turning to page 101, the second
4 paragraph, I note that these installations for leachate
5 levels are only for liquid level monitoring. I don't
6 propose to sample these to provide a measure of
7 leachate quality. Thirdly -- I beg your pardon -- in
8 the next paragraph, adjacent to each cell, at least one
9 monitoring nest complete with piezometers set at the
10 top of the bedrock at the elevation of the upper and
11 lower granular unit should be monitored to determine
12 the lowest piezometric elevation in the strata.

13 I should also note, which I do not have
14 in that paragraph, that we ought to have a piezometer
15 in the upper till. For each piezometer nest I am
16 recommending four piezometer installations, one at the
17 bedrock contact ...

18 Q. I'm sorry, for each cell ...

19 A. Adjacent to each cell for each
20 piezometer nest there should be four piezometers at
21 that nest, the lowermost one completed at the bedrock
22 contact, one in each of the granular units and one in
23 the upper till. That is the unweathered upper till. I
24 believe that should be the weathered upper till. That
25 should be a correction there.



1 Q. So that is bedrock, upper granular
2 unit, lower granular unit and weathered upper till?

3 A. Correct, and I should note I have
4 used the words "elevation of the granular units." If
5 the granular unit was not encountered at the elevation
6 at which it is interpreted to exist a water well screen
7 would be installed at that elevation in any event.

8 The last paragraph on page 101 notes
9 that evaluation of this monitoring data should be
10 conducted on an ongoing basis to ensure that the
11 hydraulic trap is performing as designed.

12 Q. Right. Then turning to page 102
13 you discuss the water quality monitoring.

14 A. Yes. We note on page 102 that we
15 have two sections to this, the leachate
16 characterization and the groundwater quality
17 monitoring. For the leachate characterization I
18 suggest that samples for such would be collected from
19 the leachate collection system, i.e., the engineered
20 drains that are installed at the base of the waste.
21 This characterization is focused to identify target
22 parameters for the groundwater monitoring. Initial
23 characterization from each cell should include a
24 complete suite of organic compounds, including PCB's,
25 pesticides and VOC's along with general chemistry



1 parameters and metals. That complete, our initial
2 characterization for the most broad suite would be
3 undertaken to identify target parameters. I note that
4 annual characterizations thereafter should be focused
5 on a limited suite of constituents including the more
6 mobile and the more toxic species. Included within
7 this limited suite would be those parameters that are
8 targeted for groundwater monitoring. In other words,
9 if one identifies at some point in the future that some
10 contaminants in the leachate are occurring which were
11 not identified initially and would like to be in the
12 position of one, recognizing that there are some
13 changes in the leachate water quality and to undertake
14 consideration whether the suite of target parameters
15 for the groundwater monitoring program should be
16 expanded to address that eventuality or situation.

17 Page 102 at the bottom we are addressing
18 the groundwater quality monitoring. The first point to
19 notice is that it is recognized that for the hydraulic
20 trap in operation the need for comprehensive
21 groundwater monitoring is reduced. However, a more
22 intensive monitoring program must be implemented in the
23 event that a failure occurs in the hydraulic trap.
24 Following successful implementation of remedial
25 measures to restore the hydraulic trap, the frequency



1 of groundwater quality monitoring could then be
2 reduced.

3 A more intensive monitoring program
4 could encompass a number of things. One, more frequent
5 monitoring; two, monitoring at more of the available
6 installations, that is an and/or, and/or monitoring for
7 a more extensive suite of constituents, i.e., when the
8 trap is working the need for detailed groundwater
9 monitoring is less. One would like to have a program
10 of sufficient flexibility and we are concerned
11 regarding the effectiveness of the hydraulic trap
12 raised. That effectiveness would in part be indicated
13 by monitoring of the leachate levels within the
14 landfill, that the monitoring program is sufficiently
15 adaptable that it could be expanded to address that
16 concern.

17 I note on page 103, this is suggested
18 locations of groundwater quality monitoring wells. No.
19 1, three nests along First Line Road, that is the site
20 west property boundary. I noted earlier that each nest
21 would consist of four piezometers. Two, one nest along
22 each of the northwest and southeast property
23 boundaries.

24 Q. Could you just identify where you
25 are, generally where you are contemplating those?



1 A. I could make that with respect to
2 Drawing 16 which happens to be Exhibit B-635, three
3 nests along First Line Road. I am talking about that
4 portion of the Site D between the perimeter of the
5 landfill cells and the site property generally one,
6 two, three equidistant along that portion of the
7 boundary. One might focus the location of those wells
8 adjacent to the domestic wells and one may also focus
9 them with respect to defining in more detail at that
10 point the position and thickness of the granular
11 strata.

12 Q. Could you just -- I think we have
13 marked B-635 for purposes of the flow. Could you just
14 mark the nests in order as you go down here, just in
15 general locations?

16 A. Should I number them so we are
17 dealing with one, two, three?

18 Q. Yes. Use B-635. If you wanted to
19 use 1-1, 1-2, 1-3 then I guess 2-1 and so on as we see
20 them on page 103.

21 A. I have marked on Exhibit B-635
22 three red circles along First Line Road frontage, being
23 1-1, 1-2 and 1-3, the three nests referenced on page
24 103 and would repeat what I mentioned earlier, that
25 these locations would be optimized with respect to the



1 interpreted position of the upper granular unit and
2 with respect to the private wells located on the west
3 side of that road.

4 Secondly, point No. 2, that is on page
5 103, we have one nest on each of the northwest and
6 southeast property boundaries. Northwest, I am
7 referring to site north -- putting it essentially
8 midway along the site north property boundary. That
9 will be 2-1. I also mentioned along the southeast
10 property boundary essentially midway and that is 2-2.
11 To point No. 3 I have indicated two nests along the
12 northeast perimeter of the landfilled area. The
13 northeast perimeter being approximately the up and down
14 perimeter on the site. The current design by Trow is
15 focused approximately using the western two-thirds of
16 the site. That will be 3-1 and 3-2.

17 The next paragraph reads:

18 "For the alternative landfill design
19 proposed by CRA ..."

20 To which Mr. Crutcher will speak in another portion of
21 this hearing:

22 "... a second well nest at the southeast
23 property boundary is recommended."

24 It is my recollection that the landfill site of CRA
25 extends out beyond the area of HC4-85 in which case



1 another installation along the bottom property of the
2 site is recommended.

3 Q. All right, so that is between --
4 what is the -- between 2-2 and Highway 25?

5 A. Correct. I would note that for
6 the alternate design proposed by CRA that installation
7 3-2 would have to be relocated.

8 Considering four piezometers at each of
9 those locations I came up with a number of 24 being the
10 number of groundwater quality monitoring points. I
11 will note earlier that with respect to the hydraulic
12 monitoring that we would obtain water level data from
13 piezometer nests adjacent to the cells. Where
14 practical we would use these groundwater monitoring
15 installations to provide that control. In any event,
16 we would collect water levels or it is my
17 recommendation that water levels be obtained at
18 monitoring wells on a regular basis. That brings it to
19 a total of 28 installations. I believe I may have said
20 24 earlier.

21 Q. You said four piezometers at each
22 of six.

23 A. Each of seven. We have three
24 under item 1, there are two under item 2, that is one
25 each on two portions of the property boundary and we



1 have two under item 3. That is a total of seven nests,
2 seven times four equals 28.

3 Q. You did say 24 earlier.

4 A. I believe on page 71 this morning
5 when I was addressing the groundwater monitoring I
6 indicated that we identified a number of 24, yes, I
7 did. When I refer back to page 71, the first
8 paragraph, the last line in that, we mention a section
9 in Section C.4.2 provides CRA's recommended monitoring
10 program which consists of 24. That should be 28. It
11 should also be groundwater monitoring piezometers, not
12 points.

13 Page 71 which is Part B of our critique
14 of the Trow monitoring program, here I made reference
15 to the point I am just discussing in Part C, the second
16 paragraph. Ideally it is the first complete paragraph.
17 The last sentence reads:

18 "This provides CRA's recommended
19 monitoring program which consists of 28
20 (instead of 24) groundwater monitoring
21 piezometers (instead of points)."

22 In addition I would like to point out another item.
23 There are two pumping wells currently on site being the
24 PW-1 and PW-2. PW-1 located to the south and PW-2 to
25 the north, roughly on a line midway up and down the



1 property. It is my understanding that these wells will
2 not be demolished, if that is the word or sealed during
3 the landfilling procedure, operation. It is my
4 expectation they will be available for monitoring once
5 the landfill is in operation. I would recommend that
6 those two wells also be included within the monitoring
7 program.

8 Q. So at page 103 in that last
9 paragraph on the page you referred to where appropriate
10 existing monitors could be used, is that referring to
11 something different from the two pumping wells?

12 A. It was not referring explicitly to
13 the two pumping wells.

14 Q. But they could be included in that
15 sentence?

16 A. Yes. Turning to page 104 I note
17 at the top that at each nest we would have the four
18 piezometers set in the bedrock, the granular units and
19 the weathered till. I note on the second complete
20 paragraph there that in addition to the above on-site
21 wells four domestic wells along First Line Road should
22 be monitored on a continuing basis along with any of
23 the on-site domestic wells that will not be destroyed
24 by landfilling.

25 The next paragraph addresses the need to



1 establish background water quality prior to
2 landfilling. It is my expectation that that can be
3 done in conjunction with the initial development of the
4 site such that for the first year of monitoring at the
5 site one might undertake a more in-depth evaluation or
6 more frequent sampling in order to provide a data base
7 against which future groundwater quality changes, if
8 any, can be assessed.

9 From a review of the leachate
10 characterization when obviously leachate is available
11 to be sampled at the site and the additional background
12 data recommended above, a suite of indicator parameters
13 can be developed for an ongoing monitoring program.

14 I should point out again that the focus
15 of the monitoring program was initially to ensure that
16 the hydraulic trap was functioning as designed and to
17 develop background water quality data for the site and
18 secondly, in the event of some form of failure or
19 uncertainty regarding the effectiveness of the trap the
20 monitoring program can be stepped up to address
21 potential groundwater quality changes that may or may
22 not accrue from that.

23 Q. Right. Then turning to page 105,
24 the contingency section, please describe what CRA's
25 recommendations are in that respect.



1 A. Yes. We note initially that the
2 hydraulic trap provides for the primary protection of
3 groundwater quality at the site. Therefore the
4 monitoring program is designed to collect sufficient
5 water level data to ensure that the effectiveness of
6 the hydraulic trap can be evaluated. The first level
7 of contingency options at this site should therefore be
8 focused on remedying any excessive leachate mounding
9 within the landfill that may occur. I note that Trow
10 evaluated additional contingency options for the
11 situation in which an uncontrolled leachate buildup
12 occurs and that contaminants migrate from the landfill
13 cells. I am noting in addition, in the second
14 paragraph as shown by the evaluation of contaminant
15 migration for a failed hydraulic trap it will take a
16 period of in excess of 100 years in order for
17 contaminants migrating downward across the unweathered
18 till and the lower till to reach the upper granular
19 unit where present. During this time contingency
20 measures could be implemented to restore the hydraulic
21 trap. If, however, the contingency measures are not
22 effective, contaminated groundwater may egress from the
23 landfill by and we identify the two flowpaths; lateral
24 migration in the weathered upper till and downward
25 migration in the granular units and/or bedrock and



1 | thence lateral flow off-site.

2 I am indicating here that potentially
3 groundwater flow within the granular units may move
4 off-site. That is not my conclusion based on my
5 hydrogeologic evaluation of the site. However, in
6 order to provide a conservative review of contingency
7 options available and the potential for negative
8 impacts to occur within the groundwater I have assumed
9 here that the granular units may provide for off-site
10 flow. It is my indication to the Board that that is a
11 most conservative assumption. However, as I indicated
12 earlier, given that there are domestic wells adjacent
13 to the site that exploit groundwater from the
14 overburden materials it is most prudent to consider
15 this eventuality.

16 DR. KINGHAM: Mr. Petrie, had I
17 understood you earlier to say that it was your
18 assumption that migration would not occur in the upper
19 granular unit and now you are saying that assumption
20 applies to both units?

21 MR. PETRIE: I have been too general in
22 my statement. The upper granular unit does not provide
23 for a pathway laterally off-site, the lower granular
24 unit does.

25 We would also assume given that we have



1 a landfill at this site that in the event of a
2 necessity of contingency options, i.e., a failed
3 leachate collection system or failed hydraulic trap the
4 direction of flow in those units, the direction of flow
5 would be from the site to the domestic wells in
6 question.

7 The first line of contingency options
8 available in my opinion are leachate purge wells.
9 Having identified from the leachate monitoring,
10 leachate level monitoring that there is some
11 uncontrolled or non-designed leachate head buildup it
12 is my expectation that the landfill design engineer in
13 conjunction with the site operators would address
14 cleaning of the drainage system. I am focusing my
15 remarks with respect to leachate wells beyond cleaning
16 of the leachate collection system. Assuming that the
17 most obvious remedial options available to the site
18 operator do not prove effective then leachate purge
19 wells could be considered to control the leachate head.
20 I note on page 106 that purge wells could be drilled
21 directly into the landfilled materials and used to
22 control leachate levels. The number and spacing of
23 such leachate purge wells is dependent on the
24 hydraulics of the landfilled materials, the area over
25 which control is required, as well as the amount of



1 head reduction required. I note that leachate would be
2 pumped directly into the nearest operating leachate
3 collection system. This option could be implemented
4 readily and could be expected to provide the required
5 control and monitoring would be required to verify the
6 effectiveness of the purge well operation. One might
7 suspect if a purge well or wells is required to control
8 leachate level, additional monitors in the waste may be
9 required to demonstrate the effectiveness of that
10 purging operation. Those additional monitors would
11 just be looking at liquid levels in the landfill.
12 Again, one might expect that were this purging of
13 leachate to be undertaken that the monitoring program
14 may be stepped up for some period of time in order to
15 provide a demonstration that the pumping was effective.

16 Mr. Crutcher is pointing out that some
17 of the wells would already be in place, i.e., we are
18 proposing monitors within the leachate.

19 Purge wells would be a different well
20 designed specifically to address the leachate level and
21 pump the leachate levels. One might note that if
22 problems were encountered with the leachate levels
23 purge wells might be installed. The operation of these
24 purge wells may be contingent on continuing leachate
25 increases. To drill the well and operate it may not



1 necessarily be the same step. I am just intimating
2 that given some concern with rising leachate levels and
3 the failure of obvious remediation such as cleaning the
4 drainage system beneath the site, leachate purge wells
5 may be installed at that point in time. If the
6 leachate heads continue to build up then the operation
7 of those wells may be initiated at that time.

8 MR. McQUAID: Q. Page 107 over to the
9 top of page 108 you have summarized I think the earlier
10 comments that were made both in Part B and touched on
11 by Mr. Crutcher respecting control of that weathered
12 upper till. Is that correct?

13 MR. PETRIE: A. Correct. The note at
14 the top of page 107 is that Trow has proposed a
15 perimeter drain designed to intercept potentially
16 contaminated groundwater migrating within the weathered
17 upper till. CRA expects that such a system will
18 capture 100 per cent of the groundwater in this zone.
19 I make the additional note here in the second paragraph
20 that Trow concluded that within five years of a failure
21 of the hydraulic trap contaminant migrating in this
22 zone could reach the site boundary. The hydraulic
23 assumptions that led to these calculations were in my
24 opinion most conservative and I provided to the Board
25 as to the potential flow rates in that system.



1 I note here that based on that scenario
2 the five years of travel time, it could be concluded
3 that such perimeter drains should be installed at the
4 time the landfill cells are excavated. CRA does not
5 consider this appropriate for the following reasons.

6 Point No. 1, development of extensive
7 contaminant plumes within weathered clay horizons is
8 inconsistent with the experience gained at other
9 similarly-sited Ontario landfills.

10 Point No. 2, when I reviewed this last
11 night I could not reproduce the mathematics of those
12 numbers at all. I would like, because I cannot
13 reproduce those numbers, to refer the Board to the
14 numbers I provided earlier this morning. Those numbers
15 are provided in conjunction with the discussion that
16 was on page 87. At the top of page 87 I noted that,
17 this is with reference to the weathered upper till, for
18 a conservative hydraulic conductivity of 1×10^{-6} an
19 effective transport porosity of 0.02 and a hydraulic
20 gradient of 0.005, the average linear groundwater
21 velocity of 0.079 metres per year is calculated. With
22 a hundred metres of travel time to the site boundary we
23 are looking obviously at well in excess of 100 years
24 for such travel.

25 DR. KINGHAM: Are you now replacing the



1 0.063 metres per year at the end of paragraph 2 on 107
2 with 0.079 metres per year?

3 MR. PETRIE: As I indicated a few
4 minutes ago, I was not entirely sure what these numbers
5 are and how I arrived at this portion of the text.

6 DR. KINGHAM: Would it not be the factor
7 which you referred us to this morning being the
8 gradient 0.004 rather than the gradient of 0.005?

9 MR. PETRIE: The gradient of 0.005 and
10 we end up with the 0.079 metres per year, that is the
11 ambient condition. The 0.005 is the site prior to
12 landfilling, the site as it now stands. For a failed
13 hydraulic trap that lateral gradient could be expected
14 to increase, i.e., provide for a stronger driving
15 force. If one, for example, increased that gradient by
16 a factor of ten, i.e., to 0.05 then the groundwater
17 velocity in that unit would be 0.79 metres. Then it
18 may be more appropriate, point No. 2 on page 107, to
19 indicate ...

20 MR. McQUAID: Q. I wonder if I can ask
21 you just to look at another calculation you did for us
22 earlier at page 88 -- I'm sorry -- when you were
23 discussing page 88 of H-39, bearing in mind, as I
24 understand it, we are looking at the leachate
25 collection system in operation?



1 MR. PETRIE: A. That's right. That is
2 at the bottom ...

3 Q. Of page 88?

4 A. Of H-39, yes.

5 Q. You may recall that I asked you
6 before the luncheon recess what the figure would be
7 with the changed conductivity that would relate to the
8 weathered upper till.

9 A. Correct, I do.

10 Q. I note that you have in the second
11 sentence there referred to a groundwater velocity of 13
12 metres per year. That would appear, would it not, that
13 that should be 130 or is that right?

14 A. Thirteen metres per year is with
15 no collection system in operation.

16 Q. I see linear groundwater velocity
17 of 130 over in the right-hand column.

18 A. That is with the leachate
19 collection system in operation.

20 Q. I see, so we are -- yes, I see.

21 A. I believe my confusion stems from
22 a point which I did not address.

23 Q. I know I'm leading, I just wanted
24 to not leave us all here with different numbers because
25 I know this morning we had reference to 0.631 metres



1 per year earlier. The record will have to pick it up
2 later. I see it's the same figure in this section.

3 A. That value of 0.631 metres per
4 year I referenced this morning was the inward flow into
5 the collection system with the leachate collection
6 system in operation, the inward flow from the weathered
7 upper till. It may be appropriate to consider that for
8 a failed system that hydraulic gradient would be
9 reversed, i.e., instead of 0.04 inward it would be 0.04
10 outward in which case, for a failed landfill system,
11 the rate of lateral groundwater flow in the weathered
12 upper till would then be that 0.0631 (sic). If I can
13 repeat that. For a failed landfill system the
14 groundwater flow velocity in the weathered upper till
15 would be 0.63 metres per year. I cannot relate that
16 number directly to the numbers provided on Table 10 of
17 page 88 of Exhibit H-39 because the horizontal gradient
18 used at the top of that table being for the weathered
19 upper till with no collection system in operation,
20 0.004 does not, in my mind, address the effects of
21 leachate mounding. That value of 0.004 is consistent
22 with Trow's review of water level data at the site as
23 it is now, i.e., prior to landfilling. That was their
24 interpretation of the lateral gradient in the site at
25 present.



1 MR. HODGSON: I'm sorry, what is the
2 witness now telling us that the gradient should be in
3 the first line?

4 MR. PETRIE: Zero point zero four, ten
5 times greater for the failed system. In other words, I
6 am taking the same 0.04 that appears at the bottom of
7 the table, the bottom of the table being the leachate
8 collection system in operation. For the weathered
9 upper till that 0.04 is directed inward towards the
10 landfill because the hydraulic trap is working. I am
11 making a very liberal assumption that for the failed
12 system that gradient would be of the same magnitude but
13 directed outwards. I am noting that for a failed
14 system, using that gradient, being 0.04, the effective
15 porosity of 0.02 and the hydraulic conductivity of
16 1×10^{-6} , it is my opinion that the lateral groundwater
17 flow through that till unit would conservatively be
18 0.63 metres per year.

19 So, if I could go over point No. 2
20 again. Let me back up a little further. We are
21 addressing in this section the need to provide
22 engineering controls in the event that we have
23 contaminant migration in the weathered upper till. I
24 am noting in the second paragraph at page 107 that
25 based on Trow's figures, i.e., it could take five years



1 following failure for contaminants to reach the
2 boundary, one could conclude based on those numbers
3 that one should provide that control at the onset of
4 landfilling, i.e., when the landfill cells are
5 excavated. I am indicating to the Board that I do not
6 consider that an appropriate option for two reasons:
7 one, we don't get extensive contaminant plumes within
8 weathered clay horizons in Ontario and, secondly, this
9 is the point I wish to clarify, if under a failed
10 system the lateral hydraulic gradient is 0.04 outward
11 from the landfill and incorporating a hydraulic
12 conductivity of 1×10^{-6} and a transport porosity of
13 0.02, the resulting groundwater flow velocity is 0.63
14 metres per year. I am noting that for 100 metres of
15 travel to the site boundary the time for that travel to
16 occur is obviously in excess of 100 years. There is
17 sufficient lead time to monitor the weathered upper
18 till such that if contamination was identified remedial
19 measures can be implemented before off-site migration
20 becomes a concern.

21 MR. McQUAID: Q. All right. Does that
22 complete then your recommendations and comments on that
23 migration control in the weathered upper till?

24 MR. PETRIE: A. Have I clarified
25 everything in point No. 2 on page 107?



1 Q. I hope so.

2 A. Yes, it does in answer to your
3 first question.

4 Q. Then, turning over to granular
5 unit purge wells, page 108, could you just explain then
6 the contingency arrangements being recommended there?

7 A. Were contaminants potentially to
8 migrate to the granular units the pumping test
9 conducted by Trow on both the upper and the lower
10 granular units indicate that lateral migration within
11 these units can be controlled. I note that the
12 required pumping rate will approximately equal the
13 infiltration rates. Trow calculated a value of 2.8
14 gallons per minute. I have provided a different number
15 using the height of the lower hydraulic conductivity
16 and a similar gradient with Trow and note that that
17 infiltration rate is 0.5 gallons per minute. I
18 consider it appropriately conservative to stick with
19 the Trow's gallonage, pumping rate, although my
20 calculations show that that pumping rate will indeed be
21 less.

22 With respect to the upper granular unit,
23 I have noted that from my review of the hydraulics of
24 this unit as I interpreted it from the pumping test
25 results of the upper granular unit that we are dealing



1 with a lens under a large portion of the site. Pumping
2 of this unit at the rate suggested in Trow's 2.8
3 gallons per minute will, in my opinion, essentially
4 dewater that unit at some point in time such that we
5 would expect a lower pumping rate would be required in
6 order to avoid dewatering that unit.

7 The rate of groundwater inflow into a
8 lens within the lower till will be controlled by the
9 gradients and permeabilities of the lower till, not the
10 gradients and permeabilities of the granular unit. In
11 this case I am referring to the upper granular unit.

12 I also note, on page 109, that in Part B
13 of our critique we noticed that one can calculate the
14 effect of purge well operation at the higher rate
15 determined by Trow might have on adjacent groundwater
16 levels. It is my recollection we have calculated 0.7
17 -- I beg your pardon -- I shall find the appropriate
18 page. I am referring to page 68 where on the previous
19 page we note that the effects of a purge well operation
20 at Site D were examined by CRA using the Theis
21 Equation. Page 68 notes that the variables we have
22 calculated, a drawdown of 0.76 metres. That is based
23 on the assumption that the granular unit being either
24 the upper or lower granular unit -- I beg your pardon,
25 that mathematics was for the upper granular unit -- is



1 based on the assumption that the upper granular unit
2 extends to the wells in question. I would note from
3 the Trow report, based on their review of the geometry
4 of the existing wells, I am referring to Exhibit
5 H-39A, the last appendix which is Appendix 16. They
6 note on page 3 of that appendix under the entry marked
7 small "b" that the available drawdown in nearby
8 domestic wells is about 8.7 metres, i.e., 28.5 feet.

9 So, just noting, that calculated
10 interference is 0.76 metres and further, that
11 calculated interference is based on the assumption that
12 the upper granular unit has a uniform permeability or
13 hydraulic conductivity and it extends from the site to
14 the wells in question. Zero point seven six metres is
15 very small relative to the 8.7 metres of available
16 drawdown.

17 Q. Then on page 109, the last
18 sentence, could you just read that, your conclusion as
19 to the ability to construct purge wells in these
20 granular units?

21 A. "Purge wells can be constructed in
22 either the granular units and/or the
23 lower granular unit if (warranted)..."

24 MR. McQUAID: Mr. Chairman, I see we are
25 at 3:00 o'clock and I am just going to start the last



1 section of the report with Mr. Crutcher. I think it
2 would take a little while, sir, unless ...

3 MR. LANCASTER: We will take ten
4 minutes.

5 --- Recess

6 MR. LANCASTER: Please be seated.

7 MR. McQUAID: Q. Mr. Crutcher,
8 beginning at page 110, this section of B-618 relates
9 the principles in Part A to the discussion that has
10 been taking place in particularly Part C. I wonder if
11 you would just go through the headings of
12 "Predictability", "Acceptability", "Ability to
13 Monitor", "Contingency Plans" and just give us your
14 conclusions with respect to those four criteria.

15 MR. CRUTCHER: A. Yes. As we did in
16 Site F we are now testing our interpretation of the
17 site against the criteria for hydrogeologic
18 suitability. On page 110 we outline the key items that
19 we believe are the criteria for the acceptability being
20 the ability to predict and what you are predicting as
21 being acceptable. The ability to monitor the site and
22 the ability to institute feasible contingency plans if
23 your monitoring indicates the need. We test those in
24 the following section.

25 Dealing with predictability, firstly I



1 would like to indicate that the site is designed on the
2 basis of a hydraulic trap, essentially that hydraulic
3 trap allows for essentially no egress of contaminants
4 from the site. That basis is quite straightforward to
5 actually determine that the site is predictable and
6 acceptable. I would also like to note, I am talking
7 specifically about the hydraulic trap aspect, that the
8 monitoring for the hydraulic trap would be one of the
9 easiest monitoring to undertake because essentially it
10 is a water level monitor. The ability to monitor water
11 levels allows you, with obviously some confidence and
12 fairly limited expense, to be able to evaluate that the
13 trap is operating properly. So, in dealing with the
14 proposal as put forward on the hydraulic trap principle
15 we accept that it is predictable and acceptable.

16 The dissertation that we provide on
17 pages 110 up to 112 in fact deals under a failed
18 condition on the basis that there is some failure of
19 the hydraulic trap at the site. We note that in the
20 first line under "Predictability" in order to ensure
21 unacceptable groundwater quality impacts will not occur
22 in the event of an uncontrolled landfill failure. Then
23 we test our knowledge of the site and ability to
24 predict the site under that case.

25 Turning to page 112, the first full



1 paragraph, we go through the criteria. Firstly, the
2 first full line on that page, we say:

3 "This evaluation (that is
4 predictability) requires that those
5 parameters which govern the rate of
6 groundwater flow along the defined
7 contaminant pathways be defined."

8 We go on:

9 "Groundwater flow at the site is most
10 strongly controlled by the unweathered
11 upper till."

12 Again we are referring to this in a failure mode. This
13 unit, that being the unweathered upper till, limits the
14 rate of exfiltration from the landfill and provides for
15 slow groundwater movement downwards to the underlying
16 strata. Sufficient data are available to accurately
17 predict the rate and direction of groundwater flow in
18 this unit. We believe that we understand the
19 permeability of the unit, its attenuation
20 characteristics, its hydraulic gradients such that we
21 can predict with some confidence how that unit will
22 behave. We also have a very clear picture of the unit
23 itself, its thickness and its location.

24 The granular unit, the granular units we
25 are referring to are in the lower till, comprise a



1 pathway through which lateral off-site groundwater
2 movement may occur. Again, the hydraulic gradient and
3 direction of the flow in these units are imprecisely
4 defined. However, in fact we have taken quite a
5 conservative approach and under the conservative
6 approach we believe the site is both predictable and
7 acceptable. If you can meet the criterion of being
8 conservative then in fact when you get to reality you
9 are most certainly in an acceptable fashion. So, where
10 we have some uncertainty about the granular units we
11 have overcome that by being conservative in dealing
12 with them.

13 I go on to indicate essentially that --
14 it says:

15 "However, a reasonable value for the
16 hydraulic gradient is provided by Trow
17 for the failed landfill and the
18 direction of groundwater flow is assumed
19 to be towards the domestic wells along
20 First Line Road."

21 We are assuming that that is the case:

22 "This provides a reasonable and
23 conservative prediction of contaminant
24 arrival times at the site boundary."

25 I would like to emphasize this is all dealing with a



1 failed system.

2 Should groundwater contamination reach
3 levels that are potentially unacceptable the
4 contingency options are available and we discuss that
5 subsequently. We therefore believe that we have a good
6 hydrogeologic understanding of the site and it meets
7 the criteria of predictability and acceptability.

8 Firstly, in dealing with the proposal on
9 the hydraulic trap in operation, we do not have egress
10 of leachate from the site and if in fact we did have
11 failure of the hydraulic trap, firstly I would like to
12 indicate that we do not believe that we would have a
13 total failure of the system. We cannot conceive of how
14 that would happen. We can conceive of how we could
15 have a partial failure of the system. We have taken a
16 look at the aspects under a partial failure mode and we
17 have estimated again, again conservatively, that we
18 have 120 years before contaminants actually reach the
19 upper granular unit, that being at the 0.1 of their
20 initial concentration. Within that period of time in
21 my mind it is inconceivable that we would not know that
22 and we would implement one of the contingency items to
23 deal with it.

24 We haven't dealt in this particular
25 section on the unweathered -- pardon me -- the



1 weathered upper till. The reason for that is we
2 believe that that would be engineered around and the
3 decision of the need for that would be at the basis of
4 the detailed design. Monitoring to verify that
5 decision is very easily implemented to be considered a
6 non-issue. So to reiterate, we consider that the site
7 meets the criteria of being both predictable and
8 acceptable.

9 The next two areas that we discuss are
10 the monitoring and contingencies. We indicate that our
11 monitoring program is essential and it must be
12 implemented. To have a successful monitoring program
13 we have to firstly understand where the potential
14 contaminant pathways are. We have that understanding.
15 We must establish the background water quality against
16 which quality changes can be assessed and we must
17 determine suitable indicator parameters. The
18 contaminant pathways have been reliably delineated. We
19 understand the units which allow for lateral migration
20 as well as vertical migration. They are very readily
21 identifiable in the field.

22 We took a core of the overburden at the
23 site and it would be relatively easy to see that the
24 till units and the sand units, there is no question of
25 where those units are. We have modelled the site and



1 we have estimated arrival times which we can then
2 compare under again a failed system, our predictions.

3 We do not believe that the background
4 water quality has been adequately defined at this time.
5 We don't believe that is a limiting factor at this time
6 but it should be defined prior to the development of
7 the landfill site. That can be developed with the
8 installation of the monitoring wells and instituting a
9 monitoring program at that time to establish a stable
10 background water quality against which to judge any
11 changes.

12 We believe that there are some
13 uncertainties associated with the inorganic monitoring
14 due to some of the elevated levels presently found at
15 the site but in fact leachate indicator parameters we
16 believe can be readily developed.

17 The monitoring program which we have
18 presented within our report is designed to firstly
19 address water level monitoring to determine the
20 piezometric elevations in the strata underlying the
21 site. Leachate level monitoring which will allow for
22 assessment of the performance of the hydraulic trap.
23 As I indicated, that is one of the easiest monitorings
24 to undertake to interpret. So in fact with respect
25 specifically to the hydraulic trap that assessment is



1 rather straightforward.

2 We have monitoring within the granular
3 units and the bedrock around the perimeter of the site.
4 We also have monitoring in the weathered upper till
5 unit to verify in fact migration through the weathered
6 unit is not problematic. Primarily for peace of mind
7 of the residents in the area, groundwater quality
8 monitoring of the domestic water supply.

9 In dealing with contingencies there are
10 a number of contingencies that can be discussed and
11 have been discussed in our report and through Trow's
12 report. Trow identified that perimeter drains could be
13 installed in the unweathered upper till should the need
14 arise and we have identified there are other options
15 available, that a purge well system can be installed
16 into the granular units to control any off-site
17 migration. Again this is under a failed landfill
18 situation that the hydraulic trap is not operating. We
19 believe contingency plans can provide for effective
20 control.

21 We also note, I am referring to page
22 115 at the top, that we recommend that in fact if we
23 have a failure of our hydraulic trap which we cannot
24 remediate by the flushing or implementation of some
25 remedial action on the leachate collection system, that



1 leachate purge wells be considered. Again we believe
2 this is a relatively straightforward manner and easily
3 monitored to determine its success.

4 Another item which we have not discussed
5 in any detail is the fact of another option available
6 to the residents as a contingency should we have
7 catastrophic failure which I could not see at this site
8 but should we have, we could provide piped water to the
9 residents. In fact within our design and operations
10 report we evaluate the feasibility of that. I will be
11 testifying to that particular item at a future date.

12 We therefore conclude ...

13 MR. ESTRIN: Can I just rise to observe
14 that the witness is not saying he has been now retained
15 by the Region of Halton to evaluate, make that
16 commitment on behalf of the Region that we can supply
17 the water.

18 MR. CRUTCHER: That is correct, we have
19 not been retained. The royal "we" may be a little too
20 royal.

21 We conclude that that effective
22 contingency plan can be implemented. We may have
23 neglected to include during the monitoring section the
24 fact that we conclude that an effective monitoring plan
25 can be developed. Our overall conclusion on the site



1 is therefore presented at the bottom of page 115 and it
2 states:

3 "CRA concludes that Site D is
4 hydrogeologically suitable for
5 landfilling. The potential for
6 contaminant migration can be predicted,
7 the site can be monitored effectively.
8 In addition, effective contingency
9 measures can be implemented if
10 contamination is detected by monitoring
11 in the weathered upper till and/or the
12 granular units."

13 MR. McQUAID: Q. I would like to turn
14 now with you, Mr. Crutcher, and also with Mr. Petrie to
15 some of the hydrogeological inputs and comments that
16 were made during the presentation of the Milton case.
17 I think we can turn to what is Exhibit B-501. I
18 understand there is an overhead of that, that is the
19 page from M-442, if I have it correctly, page 27.

20 MR. CRUTCHER: A. That is correct.

21 Q. Using that, you may recall
22 Mr. Hodgson used this page during discussion of this
23 with the witness as a summary of the various
24 hydrogeological and other scenarios that had been
25 undertaken and examined.



1 DR. KINGHAM: Was that M-442?

2 MR. McQUAID: Yes, sir. What I am
3 suggesting, sir, is the basic report is M-442 and then
4 the exhibit which is really page 27 with certain
5 notations on it and the columns numbered is B-501.

6 DR. KINGHAM: How could we ever have
7 forgotten it?

8 MR. McQUAID: Q. I guess I would ask
9 you, Mr. Crutcher, first of all as I understand it you
10 are going to address column 2, the hydraulic
11 conductivity of the waste.

12 MR. CRUTCHER: A. That is correct.

13 Q. The assumptions that are being
14 made in the various cases we see being considered on
15 this table.

16 A. Dr. Rowe in the preparation of the
17 table provided essentially the input data to his model
18 and a number of the parameters and specifically the
19 hydraulic conductivity of waste which I am addressing
20 we believe are not based on realistic assumptions. The
21 item I am initially addressing is where he utilized a
22 permeability of the waste of 1×10^{-5} cm/sec.

23 Q. What cases should we be looking
24 at for that?

25 A. That refers to cases 2 to 5. In



1 this particular area, cases 2 to 5, he utilized the
2 waste permeability of 10^{-5} or 1×10^{-5} cm/sec. We have
3 not, in our experience, found such a permeability of
4 the waste. That permeability is -- I would call it
5 excessively low. The design permeability which is
6 typically used by the industry as a whole is 10^{-4}
7 cm/sec. I should also note that we have not ever
8 encountered the result of a 10^{-5} basis, meaning through
9 cross-examination I think we demonstrated quite
10 adequately that we would have leachate spurting out of
11 many of our landfill sites if in fact we had 10^{-5} . We
12 do not encounter that type of head within a landfill
13 site. Any testing that I have been involved in in
14 dealing with the permeability of the waste has never
15 encountered a permeability up to that range.

16 I should also note that at Keele Valley
17 landfill site we had the responsibility for the design
18 of the leachate collection system amongst other things.
19 The permeability of the waste which we utilized for
20 that, we conservatively used 10^{-4} . That site has been
21 monitored extensively since that time. In fact the
22 predictions that we made utilizing the permeability of
23 the waste and the configuration of the leachate
24 collection system in fact verified that that was an
25 appropriate value to utilize. Our submission to the



1 Board is that a permeability of 10^{-5} is unrealistic.

2 Q. There was some indication, I think
3 it was in Dr. Charlesworth's report in one or two of
4 the references that there had been some reference in
5 reports or other documents to 10^{-5} . One of the
6 references, as you may recall, Mr. Crutcher, was a
7 reference to the Fresh Kills landfill in -- I've
8 forgotten whether it was New York or New Jersey -- New
9 York I think it was. We filed as an exhibit the
10 hydrogeologic report, B-503.

11 A. That is correct.

12 Q. I want to ask you two very basic
13 questions. One, how the involvement that your firm has
14 with respect to those particular sites and, secondly,
15 whether with a review of the material, either you or
16 Mr. Petrie concluded that there is support for 10^{-5} in
17 those documents, those two documents, B-503 ...

18 A. Firstly dealing with our
19 involvement, we were retained in dealing with a
20 litigation matter on the landfill site so we are
21 familiar with the background on the site. I personally
22 was not responsible for that particular project.
23 However, I was aware that we had been working on the
24 site. When Dr. Charlesworth cited his reference of the
25 permeability of the waste being at the Fresh Kills



1 landfill site we obviously had an opportunity since we
2 had the documents available to us to review the basis
3 of that number. In fact on reviewing the documents
4 that we had we could not verify that number. In fact
5 we verified the permeability was considerably higher
6 than 10^{-5} .

7 Q. Right. Now, returning to B-501,
8 I'm not sure whether it is you or Mr. Petrie,
9 apparently other hydrogeological ...

10 A. There is one other item I would
11 like to address before Mr. Petrie deals with it and it
12 is dealing with total failure of the collection tiles.
13 On this particular basis I believe Dr. Rowe was
14 referring to -- these are cases 6 to 10. He has used
15 varying hydraulic conductivities of the waste. I would
16 like to note that we do not believe that a total
17 failure of the collection tiles is a conceivable basis.
18 We can accept in our own mind that some limited failure
19 of the collection tiles is understandable but a total
20 failure is, in our mind, not conceivable and it is an
21 unrealistic assumption. It certainly is very
22 conservative or pessimistically conservative, whatever
23 terminology you want to use. We have never encountered
24 such an occurrence. We have encountered occurrences
25 where we may have limited failure but not a total



1 failure. We put forward to the Board that this site
2 will be comprehensively monitored and in fact if there
3 was a failure occurring you would know that early on
4 in its site life and in fact we would remedy the
5 situation as the site is developed if there was a
6 problem with the design of the system.

7 Q. Right. So can you give us the
8 case numbers that contemplate total failure?

9 A. I am just noting under column 1 it
10 refers to:

11 "Comments: Total failure scenarios are
12 indicated under various modes, under 6,
13 7, 8, 9 and 10."

14 Q. All right. Mr. Petrie, I would
15 like you to -- I would like to ask you in view of the
16 discussion we have had over the past particularly
17 couple of days on Site D with respect to hydraulic
18 conductivities if you could indicate your views on the
19 input I guess that appears under column No. 4.

20 MR. PETRIE: A. Prior to that I would
21 just notice Mr. Crutcher has just indicated that for a
22 permeability of the waste being cases 2 through 5, the
23 permeability of the waste being 1×10^{-5} and less, in
24 addition cases 6 through 10 being a total failure of
25 the engineered system, that those cases represent as



1 Mr. Crutcher has just indicated, a most unlikely
2 situation. We do not believe them to be possible.

3 On those grounds, in reviewing the
4 modelling undertaken by Dr. Rowe we are left with three
5 cases which in our mind provide a plausible scenario
6 for site conditions, plausible with respect to column 1
7 and with respect to column 2. Those plausible cases
8 are case No. 1 and cases 11 and 12. I should note
9 initially that case No. 1 is where Dr. Rowe simulated
10 the site using Trow's numbers. However, his
11 mathematical modelling is slightly different from that
12 provided by Trow. It was his opinion that it provided
13 a more rigorous result. It is case No. 1, Trow's
14 numbers being the column No. 2, the hydraulic
15 conductivity of the waste of 10^{-4} which in CRA's
16 opinion is a most reasonable number for the hydraulic
17 conductivity of the waste in order to assess the
18 hydraulic performance of the landfill. For column No.
19 4 we are addressing the hydraulic conductivity of the
20 upper till. We note here that Trow have recorded a
21 value of 8×10^{-8} for the hydraulic conductivity of the
22 upper till. Utilizing those numbers and just moving
23 the exhibit further to the right, in the furthest right
24 column being an unnumbered column which is indicated as
25 "Time to Reach Boundary (In Years)" we have an



1 indication of 70 years. A little subscript, a
2 postscript beside 70 is a D and that information is
3 available from overhead 49 of Exhibit M-444.

4 Q. M-444, three 4's?

5 A. Three 4's, that being the joint
6 Dr. Charlesworth/Dr. Rowe witness statement. That is,
7 we have just taken the figures from overhead 49 and
8 transposed them to the right end. Taking the case
9 which is Dr. Rowe's rendition of Trow's hydraulic
10 numbers, one number in that case which is not directly
11 from Trow is the average piezometric head in the waste.
12 We note in here it is 182.5. I gather during
13 discussion that Dr. Rowe corrected that number to 185
14 metres. That is my recollection on the notes I have
15 before me. That is not specifically Trow's number. I
16 believe it was Dr. Rowe's estimate or his
17 interpretation of his understanding of Trow's
18 evaluation of the failed landfill system. So we are
19 noting in column 1 that Trow's heading "No Leachate
20 Collection", that being Trow's description, 10^{-4} for
21 the waste, 8×10^{-8} for the upper till and the
22 piezometric head in the waste provided by Dr. Rowe of
23 185. The results indicated on the far right being 70
24 years for travel time to reach the site boundary within
25 the upper granular unit.



1 As I indicated earlier these assumptions
2 are all predicated on -- these results are all
3 predicted on the assumption that the upper granular
4 unit is continuous to the site boundary. It is my
5 interpretation based on the hydraulic characterization
6 of that unit developed from pumping tests that it is
7 not continuous. So we have two conservative or two
8 considerations here; one a failed landfill and two,
9 that the granular unit does extend from beneath the
10 site westward to beyond the property boundary. I have
11 put before the Board from page 30 of Exhibit M-442
12 being Dr. Rowe's review of the examination of potential
13 impacts on groundwater quality for Site D. The
14 reference is page 30. This provides graphically a
15 comparison of the results for his case 1. Case 1 as
16 indicated has the dashed line on this figure, his case
17 1 using two-dimensional, layered soil analysis. That
18 is his descriptive term for his mathematical or
19 computational effort. We note here that the solid
20 black line is THCL's or Trow's curve and I assume he
21 just took that graphically from the figure he
22 references there being Figure 19. We note that we have
23 a specific concentration on the vertical axis and the
24 time in years across the bottom. It is my recollection
25 that Trow in reviewing their results provided an



1 indication that 60 years was the potential arrival time
2 in the upper granular unit at the site boundary and
3 Dr. Rowe, when comparing these graphs, noted that his
4 arrival time is longer. He also noted that his
5 contaminant peak was slightly in excess of that
6 developed by Trow.

7 I draw the Board's attention to the
8 summations of Dr. Charlesworth regarding the
9 hydrostratigraphic conceptualization of the site. His
10 opinion was Trow had not been particularly
11 conservative. I note from that, that being the figure
12 before the Board, page 30 from M-442 and in reviewing
13 the results provided by Dr. Rowe and again Dr. Rowe
14 made these comments in the report and in cross-
15 examination that his mathematical computation which he
16 felt was more rigorous provides for a longer arrival
17 time under the failure mode at the site boundary. He
18 also noted higher concentration in his peak
19 concentration in his simulation relative to that
20 developed by Trow.

21 Again I just want to point to the time
22 scale. We are looking at peak concentrations at a time
23 of 100 years after unremediated failure for Trow's
24 curve and a peak concentration in the order of 150
25 years for Trow's -- for Dr. Rowe's simulation.



1 DR. KINGHAM: I think you are trying to
2 tell us how travel time slows from Dr. Rowe's review of
3 Trow's ...

4 MR. PETRIE: Could I ask that you repeat
5 that? Yes, using the same -- can I start that again?

6 Trow and Dr. Rowe for the simulation
7 before you have used the same input. The mathematical
8 manipulation is different between the two cases. I am
9 not commenting on the fact of what the difference is.
10 I am noting as Dr. Rowe indeed noted that given the two
11 methods of analysis Trow's provides for an earlier
12 arrival time and in that sense could be construed to be
13 a conservative estimate of arrival time. He also
14 noted, he being Dr. Rowe, that his simulations provide
15 for a higher peak concentration. I am pointing out to
16 the Board that that peak concentration on this graph
17 appears to be in the order of 150 years, relative to
18 the slightly lower peak concentration developed by Trow
19 in my estimation from this curve which would occur at a
20 point 100 years, that is 100 years after failure is
21 initiated and not remediated, again assuming the
22 continuity of the upper granular unit.

23 There are two other cases which I drew
24 the Board's attention to.

25 MS CRONK: Can I ask the witness what



1 was the number of the last figure?

2 MR. PETRIE: It was an overhead from
3 page 30 of Exhibit M-442.

4 MS CRONK: Thank you.

5 MR. PETRIE: Referring back to the cases
6 on Exhibit B-501, just repeating what was said earlier,
7 cases 2 to 5 in our minds are an implausible option
8 with regard to the waste permeability.

9 Addressing my next case, case 11. In
10 case 12 it provides for a limited failure of the
11 collection tile. We recognize the possibility of some
12 degree of failure on some of the collection tiles at
13 the site. For both these cases Dr. Rowe has used a
14 hydraulic conductivity of the waste up to 10^{-4} . Where
15 these cases differ from that provide by Trow in case 1
16 is under column 4 being the hydraulic conductivity of
17 the upper till. For case No. 12, being the bottom case
18 on this page, we have a value of 8×10^{-7} cm/sec. In
19 my mind that is an implausibly high hydraulic
20 conductivity for a till which contains, averaging 20
21 per cent clay and 40 per cent silt. For a till that
22 Hvorslev tests develop by Trow yield a mean value of
23 8×10^{-8} , that is the same till for which the
24 laboratory hydraulic conductivity tests yield a mean
25 value of 1.4×10^{-8} . We therefore have or Dr. Rowe



1 has therefore employed a value with a hydraulic
2 conductivity of the upper till one order of magnitude
3 in excess of that developed by Trow. It is my opinion
4 that the Trow number, the Trow number being 8×10^{-8}
5 cm/sec, is conservative. I cannot agree with the
6 hydraulic conductivity of the upper till of 8×10^{-7}
7 cm/sec. It is my opinion therefore that the resulting
8 travel times developed by Dr. Rowe for his case 12 do
9 not represent a reasonable option for this site.

10 Focusing then on case 11, again we note
11 under column 1, case 11 addresses limited failure of
12 the collection tiles. Dr. Rowe is looking at two-way
13 flow with a failure length of 60 metres. He is looking
14 at a waste permeability of 10^{-4} , he is looking at a
15 hydraulic conductivity of the upper till of 4×10^{-7} .
16 Again I would like to point out the comments I just
17 made earlier. That number is five times higher than
18 the number for Trow for this unit, that number being 8
19 $\times 10^{-8}$, a factor of five times higher than the value
20 used by Trow.

21 Again I would point out that Dr. Rowe
22 used a piezometric head in the waste of 183.6 which is
23 lower than the average piezometric head in the waste
24 for case 1. Although it says 182.5, I am recalling
25 that Dr. Rowe corrected that during his evidence, that



1 that value should be 185. Just comparing the 185 from
2 case 1, that being from column 3, the head in the
3 waste, that the 183.6, that being the head in the waste
4 for case 11, I am drawing the Board's attention to, as
5 I understand Trow's design, they were incorporating a
6 base for landfilling at 179 metres. We are therefore
7 looking at an average head buildup over that portion of
8 the site for which the collection system has failed of
9 4.6 metres.

10 For the head buildup of 4.6 metres and
11 the hydraulic conductivity of 4×10^{-7} being a factor
12 of five times in excess of the value developed by Trow,
13 we have the resulting arrival time which is indicated
14 on the right of Exhibit B-501, the unnumbered column on
15 the right being 36 years. That is the arrival time at
16 the site boundary, 36 years after the head builds up to
17 this level, this level being an average level of 183.6.
18 No remediation was effective that could reduce that
19 head and the upper granular unit is continuous west
20 beyond the site boundary. An arrival time of 36 years.

21 In my mind, of the cases developed by
22 Dr. Rowe, case 1 presents, again of the cases developed
23 by Dr. Rowe, case 1 provides the most reasonable
24 result. To my mind that is still conservative. It is
25 conservative because I would have employed a lower



1 value for the hydraulic conductivity of the till and.
2 I'm also recognizing that it is based on a continuous
3 upper granular unit which I do not agree with. Case
4 No. 11 provides a somewhat less reasonable case but not
5 implausible, although it is based on the hydraulic
6 conductivity of the till that is five times greater
7 than that provided by Trow and in excess of 50 times --
8 that is not correct -- a factor of 28.5 times higher
9 than the hydraulic conductivity that I believe is
10 applicable for this unit.

11 MR. McQUAID: Q. I think the
12 mathematics may have been explained but if the Trow
13 number which is five times were used or your number,
14 28.5, what does that do to the time to reach the
15 boundary that we see over in the last column?

16 MR. PETRIE: A. The last column being
17 the unnumbered column, the arrival times would be
18 longer.

19 Q. By that same factor or some other
20 factor?

21 A. No, by some other factor. That
22 question was posed to Dr. Rowe which Mr. McQuaid put to
23 him that were the hydraulic conductivity of the upper
24 till 1.4×10^{-8} cm/sec and Dr. Rowe did not believe
25 that it were but he accepted that for the purposes of



1 the question, were that the case he provided his
2 estimates for time of transport to the boundary. This
3 is a poor copy of Exhibit B-505. This was prepared by
4 Dr. Rowe in response to a question from Mr. McQuaid and
5 we note the assumptions at the top. Assuming -- point
6 No. 1 on the figure Exhibit B-505 is entitled "Crude
7 Estimate of Time for Transport to the Boundary",
8 assuming that K, the permeability of the upper till is
9 1.4×10^{-8} cm/sec. Dr. Rowe did not agree with that
10 assumption but proceeded and that; two, the head drop
11 across upper and lower till remains unchanged, i.e.,
12 the driving force of the hydraulic gradient does not
13 change; three that the head drop or hydraulic gradient
14 along the upper granular unit remains unchanged. That
15 is assumption No. 3. Assumption No. 4, that the lower
16 till has a hydraulic conductivity of 2×10^{-6} cm/sec,
17 that is the value provided by Rowe. That gives him,
18 him being Dr. Rowe, an equivalent K of 2.4×10^{-5} . I
19 have a little trouble reading that number. That number
20 I believe is not significant with respect to the
21 comments I am going to make. He notes the thickness of
22 the units there again, the assumptions that he takes
23 from Trow. Four metres of thickness for the upper till
24 and three metres of thickness for the lower till and we
25 have for the cases he considered his time to move to



1. boundary based on equivalent K for upper and lower
2. till.

3. Taking case No. 11 which I believe is
4. your question, Mr. McQuaid, for a limited failure of
5. the system, incorporating a hydraulic conductivity for
6. the waste of 1×10^{-4} , leaving the average piezometric
7. head in the waste as you read it and just reducing the
8. value in column 4 by that factor I intimated, being
9. 28.5, i.e., the entry in column 4 would be 1.4×10^{-8} ,
10. we would have an arrival time at the site boundary of
11. 793 years for case No. 11.

12. Case No. 1 which was Dr. Rowe's
13. modelling of Trow's conceptualization at the site using
14. Trow's numbers, he arrived at an arrival time of 330
15. years. Again I am indicating to the Board that in the
16. cases that I considered the most plausible of cases 1
17. to 12, those cases being case 1 of Trow's case and case
18. 11, Dr. Rowe's, that again Trow have provided the most
19. conservative estimate of time to move to site boundary
20. for the hydraulic conductivity of the upper till of 1.4
21. $\times 10^{-8}$ cm/sec.

22. I would like to turn to some of the
23. cases, being between 2 and 10, for which a portion of
24. those entries we consider inappropriate. The worst
25. case developed by Dr. Rowe is case 8. My recollection



1 is Mr. Hodgson provided considerable cross-examination
2 on this case and he indicated we should number the
3 columns as indicated across the top, case 8 requires
4 total failure of the collection tiles across the domain
5 of the site. Only the perimeter tiles being in
6 operation. Mr. Crutcher has indicated that as being
7 implausible. Here we have in column 2, in case 8 we
8 have a hydraulic conductivity of 1×10^{-4} . That is a
9 reasonable number. We have an average piezometric head
10 in the waste being 194. Given a landfill base of 179,
11 that represents a 15-metre mound within the landfill.
12 That in our mind is a very large mound, a very large
13 mound. Case No. 8 also incorporates a hydraulic
14 conductivity of the upper till of 4×10^{-7} , a factor of
15 five times in excess of the number developed by Trow
16 and 28.5 times in excess of the number that CRA got.
17 The boundary condition just addresses at what level
18 the groundwater in the granular unit at the site
19 boundary is constrained for the purposes of this model.
20 We note that the arrival time under those conditions is
21 six years, the arrival time to reach the site boundary.
22 That is, as Dr. Rowe intimated, was his worst case. We
23 believe it is an implausible case recognizing it
24 requires total failure of the site and hydraulic
25 conductivity five times in excess of Trow's.



1 We note that for cases 2 to 5 where I
2 don't think we need to focus in cases 2 to 5 for the
3 meaning of L, it's just whether he is addressing one-
4 way flow or two-way flow. The point remains that in
5 cases 2 to 5 the collection system is working and we
6 have a hydraulic conductivity of the waste of 1×10^{-5}
7 or less. The average piezometric head in the landfill,
8 recognizing a base elevation of the system at 179 is a
9 3.7-metre head and Dr. Rowe has incorporated a
10 hydraulic conductivity of the upper till of 8×10^{-7} , a
11 factor of ten in excess of Trow for cases 3 through 5.
12 He has incorporated a slightly lower value, five times
13 in excess of Trow, for case No. 2.

14 Q. Can you comment on -- I think you
15 have -- on the five times. Similarly the ten times is
16 not a number that you would accept, that is the $8 \times$
17 10^{-7} ?

18 A. Correct, I would not. We have the
19 results for those simulations of 2 through 5. Just
20 looking at the far right-hand column we have arrival
21 times at the boundary varying from 46 to 32 years for
22 those various systems, various situations modelled.
23 Again our concern with those cases is one, the high
24 hydraulic conductivity of the till we believe is
25 inappropriate and the low hydraulic conductivity of the



1 waste which we cannot support.

2 I would like to point out again that
3 when we come to the conclusions in Dr. Rowe's report
4 that it was these cases, being 2 to 5, that led him to
5 conclude that even with the leachate collection system
6 operating as designed he could foresee contaminant
7 migration problems. I put it to you that these cases
8 are not plausible with respect to the permeability of
9 the waste or the permeability of -- or the hydraulic
10 conductivity and they do not represent to me a
11 realization of the site as designed.

12 MR. McQUAID: Mr. Chairman, one of the
13 things when I'm leading the witness I am not supposed
14 to wear him out. I have to give him a little bit of
15 energy for cross-examination. I am going into one area
16 that will take a while and some summation in the
17 morning. I would estimate that I would not be very
18 long in the morning, maybe to the morning break. I was
19 going to ask the Board's indulgence if we could break a
20 little early today so I won't wear Mr. Petrie out.

21 MR. LANCASTER: We will adjourn until
22 9:30.

23 MR. ESTRIN: Mr. Chairman, I think this
24 is clear I have a potential problem starting Monday but
25 on the assumption I am not cross-examining on Monday



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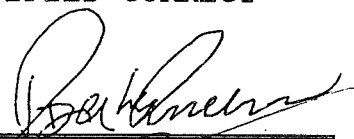
Crutcher, Petrie,
ex (McQuaid)

1 then we are prepared to proceed. I don't think that is
2 an issue.

3 MR. LANCASTER: Right now you know
4 that better. Nine-thirty.

5
6 --- Adjournment at 4:15 p.m.

7
8 CERTIFIED CORRECT

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10 
11 P. D. McQueen

12 (page 26650 follows)
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