

CONSOLIDATED HEARINGS BOARD

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

— and —

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

— and —

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

— and —

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

— and —

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

— and —

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

— and —

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

— and —

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

— and —

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

— and —

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

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

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

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

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

— and —

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

— and —

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

— and —

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

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HELD AT: Oakville, Ontario

DATE: March 21, 1988

OFFICIAL REPORTERS

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I N D E X

WITNESSES:

ANTHONY J. CRUTCHER (Resumed)
JOHN M. PETRIE (Resumed)
Examination by Mr. McQuaid (Cont'd) 26156

E X H I B I T S

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BEFORE: H. H. Lancaster, Q.C. - Chairman

Dr. D.J. Kingham - Member



Nethercut & Co. Ltd.

Toronto, Ontario

Hearing conducted at The Oakville
Granary Commercial Centre, 105 Robinson
Street, Oakville, Ontario, on
Monday, March 21, 1988

VOLUME 109

APPEARANCES:

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



Nethercut & Co. Ltd.

Toronto, Ontario

APPEARANCES (Cont'd):

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C. Stevenson
P. Hancock

for Framgard Holdings,
Fosseri Investments
Limited, Seriphos
Investments Limited and
Topic Investments

J.H. Olah

for the Halton Region
Conservation Authority

* * * * *

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Per: P. D. McQueen



1 --- Upon Commencing at 9:37:

2 MR. LANCASTER: Please be seated.

3 MR. HODGSON: Yes, Mr. Chairman, I just
4 wanted to file with the Board a copy of a test result
5 that was obtained by Gartner Lee. Gartner Lee detected
6 elevated levels of toluene in HC15-1. It is also as
7 reported in H-625 and discussed in H-625. It was
8 considered appropriate to retest that borehole to
9 confirm or disconfirm that result. The result of the
10 test has been received. I have given copies to all my
11 friends. I think I would indicate for the record there
12 has been a test result. That could be 625A and we
13 could attach it to Exhibit H-625.

14 The other thing, Mr. Chairman, when
15 Mr. Feenstra was in the witness box,
16 Mr. Feenstra made use of some information that was
17 reported in a draft paper authored by D'Astous, Ruland,
18 Bruce, Cherry & Gilham entitled "Fracture Effects in
19 the Shallow Groundwater Zone in Weathered Sarnia Area
20 Clay". Mr. Feenstra was unable to provide copies of
21 that paper to everyone. The draft was circulated and
22 returned to Mr. Feenstra.

23 Mr. Feenstra gave an undertaking to this
24 Board that he would file this paper when it became
25



available in final form. It is now available and I have copies for the Board.

MR. McQUAID: Could I have a look at it first?

MR. LANCASTER: Would that take the next number.

MR. HODGSON: We didn't give it a reserved number. H-88 is still sitting there. It is sitting like a gap in the teeth in the exhibit list if you want to use up the number. I don't think it matters, Mr. Chairman.

MR. LANCASTER: We could use H-88 if there is no objection.

---EXHIBIT H-88 Paper entitled "Fracture Effects in the Shallow Groundwater Zone in Weathered Sarnia Area Clay."

MS. CRONK: I am just inquiring from my friend Mr. Hodgson what the status of this paper was. I wonder if he could confirm that?

MR. HODGSON: It has been submitted to the Canadian Geotechnical Journal.

MS. CRONK: It has not been accepted then at this stage by that journal?

MR. HODGSON: No.

MS. CRONK: Thank you.

DR. KINGHAM: I have a question as well on H-625A. You say that that related to a high reading



in H-625, is that what you are referring to. Do you
have a reference to that, a page reference? I note on
page 116 that there is a reference to HC15-1, toluene,
but it shows trace and -- it just shows trace.

MR. HODGSON: The textual reference is
at page 22 of Exhibit H-625. The third paragraph from
the bottom.

DR. KINGHAM: And the tabular reference?

MR. HODGSON: 118 I am told by my
friends.

DR. KINGHAM: I would just like to make
a note of that on my copy. It is reference page 22.

MR. HODGSON: Reference page 22, and 118
and probably this result should be attached to page 118
since it refers to that information.

I should say I have been asked by
Mr. Estrin to clarify for the Board, with reference to
Exhibit H-625A that the well was redeveloped and
retested. A complete organic scan was performed. The
only thing that was found was again an elevated level
of toluene. The test results indicate that everything
on that page was tested for and only one thing was
found.

MR. LANCASTER: Thank you, Mr. Hodgson.

ANTHONY J. CRUTCHER (Resumed)

JOHN M. PETRIE (Resumed)



EXAMINATION IN CHIEF BY MR. McQUAID (Cont'd):

1 MR. McQUAID: Mr. Chairman, for your
2 benefit, Dr. Kingham and my friends, I propose this
3 morning to go through the witness statement which is
4 B-615 and to ask Mr. Petrie and Mr. Crutcher to pick up
5 on some of the comments that were made with respect to
6 items relating to Site F.

7 Q. I think we can start by just
8 glossing over paragraph 1. That just really is a
9 summary of the evidence you have given, Mr. Crutcher,
10 is that correct?

11 MR. CRUTCHER: A. That is correct.

12 Q. I would like to direct your
13 attention to paragraph No. 2 and in that paragraph
14 there is a summary of reference to previous studies
15 addressing landfill suitability at Site F and in
16 particularly, reference to earlier reports.

17 The text indicates some differentiation
18 between those earlier reports and the application and
19 the one currently before the Board and I wonder if you
20 could just explain what is being summarized at
21 paragraph 2.

22 A. Part of our review of the Site F
23 proposal we undertook a review of all the previous
24 studies that were available. Some of these studies,

25



1 those noted being Cherry & Lush evaluation essentially
2 of the Morrison Beatty hydrogeologic evaluation of the
3 site. Keros Cartwright. We are talking about a
4 landfill site that is actually different than what is
5 proposed now. I wanted to bring that to the Board's
6 report. If I may refer to Exhibit M-130.

7
8 Q. One-o-three.

9 A. That is correct. M-103. The
10 proposal put forward by NSP was essentially landfilling
11 in the central portion of the now site F. The bottom
12 of the landfilled area, I would estimate, would be 30
13 to 50 metres further south than the southern boundary
14 of the Bayview landfill site at the present time.

15 Q. Are we talking about in the upper
16 portion of what appears to be an L?

17 A. That is correct. The proposal was
18 for the landfilling of a little over 20 hectares of
19 land having a capacity of 1.6 million tonnes.

20 Q. Give me that again. 1.6 million
21 tonnes and the area again?

22 A. A little over 20 hectares. The
23 actually figure I have is 20.6 hectares. If you
24 compare those numbers to what is now proposed as
25 presented by Exhibit B-619, the proposal for Site F is
50 hectares landfilling, landfilling on approximately



1 50 hectares with a volume of 3.8 million tonnes.

2
3 There are some significant differences
4 in the proposal. I don't intend to go through the
5 details of that, but the most notable is that the
6 comments provided by Cherry & Lush were commenting on a
7 significant buffer zone south of the landfill. The
8 buffer zone at that time was approximately 300 to 500
9 metres in size and the proposal now before the Board is
10 essentially reduced down to as low as 50 metres.

11 Q. So your main points, looking at
12 them then, are the smaller area and the difference in
13 the buffer size?

14 A. Obviously the researchers did not
15 have the availability of the more detailed reports that
16 are now prepared by Trow and by Hewetson. In addition,
17 when they were doing their comments on the site they
18 were commenting on the proposal on its own merits.
19 They were not comparing it to another site which is in
20 fact much of what we are doing at this hearing.

21 Q. Right then in paragraph 3, I think
22 we have to defer that one until we have discussed
23 Site D then come back to that one later.

24 Paragraph 4, I think you commented on
25 this on Wednesday and Thursday, Wednesday or Thursday.
Is there anything further to be added to that,



1 Mr. Crutcher?

2 A. What I was trying to do in
3 paragraph 4 was to outline that we did not feel it was
4 appropriate to evaluate the landfill site on a regional
5 scale, which is essentially how Dr. Charlesworth did
6 for Site F from a hydrogeologic perspective. The site
7 has to be evaluated on a local basis and the impacts
8 must be evaluated on a local basis. Therefore, we did
9 not consider that was an appropriate procedure that Dr.
10 Charlesworth referred to.

11 I did talk to some degree earlier on
12 that matter.

13 Q. Then, I guess at this point there
14 is a series of paragraphs, five through nine that begin
15 with comments of Mr. Petrie and the theme, as I read
16 through those paragraphs, Mr. Petrie, if you could
17 confirm is comments with respect to Dr. Rowe's
18 modeling?

19 MR. PETRIE: A. That is correct.

20 MS. CRONK: Excuse me, Mr. Chairman. I
21 am sorry to interrupt my friend Mr. McQuaid but before
22 he goes further with respect to the four paragraphs
23 following in the witness statement, I would like to
24 review the submissions I made to you last week with
25 respect to Mr. Petrie's qualifications to speak to



1 these issues. You will recall, sir, that I raised the
2 matter in a broader sense last week when initially
3 Mr. Petrie was invited to give evidence with respect to
4 modeling and we had some clarification at Mr. McQuaid's
5 request provided by Mr. Petrie and Mr. Crutcher.

6 You may recall, sir, that Mr. Crutcher
7 has confirmed, dealing with his qualifications for the
8 moment, that his modeling expertise was restricted to
9 work undertaken by him in concert with his master's
10 thesis of 10 years ago at the University of Waterloo.
11 With respect to Mr. Petrie he provided, at
12 Mr. McQuaid's invitation, a long explanation of what
13 his role had been with respect to those parts of the
14 Site F report prepared by Conestoga-Rovers dealing with
15 modeling and he made it quite clear that he did not
16 consider himself and I am quoting from the transcript,
17 from the answers that were given, that he did not
18 consider himself qualified to speak to the field of or
19 the mathematics of groundwater modelling and then he
20 went on to explain his role as a hydrogeologist
21 in advising those in the firm who typically did the
22 modeling work and went on to explain why he thought the
23 input of a hydrogeologist was relevant in the
24 circumstances.

25 In combination those two facts, in my



1 submission, make it quite clear that neither
2 Mr. Petrie nor Mr. Crutcher are qualified in a legal
3 sense before you to speak to the type of modeling work
4 that Dr. Rowe undertook.
5

6 Now, the evidence has been given thus
7 far with respect to modeling goes to the modeling that
8 their firm undertook and I did not repeat my objections
9 again. We won't get back into that, but now we are
10 moving into an area where if we look at the witness
11 statements their evidence is going to be elicited that
12 specifically speaks to the appropriateness of or the
13 lack thereof of the modeling undertaken by Dr. Rowe and
14 the question of calibration of Dr. Rowe's model.

15 Looking at paragraph 7 of the witness
16 statement we were referring a moment ago to paragraph
17 6. In paragraph 8 he speaks to, again, the modeling
18 undertaken by Dr. Rowe and elicits an opinion with
19 respect to its suitability for contaminant mass,
20 prediction really through available fractures.

21 I can go through those paragraphs in
22 detail but looking again over at paragraph 9 on page 3,
23 but in my submission, sir, as a factual matter, there
24 are really two distinct points here. As a factual
25 matter these witnesses do not have the qualifications
to give opinion evidence on the modeling that was done



1 Dr. Rowe. That has been confirmed in the questions put
2 to them as to their expertise.

3 Secondly in the legal sense they have
4 not been qualified and have not been accepted, in my
5 submission, by the Board for the purpose of giving that
6 type of evidence. I think what we heard over the
7 balance of the three days last week and something about
8 the candor of the witnesses, Mr. Crutcher and
9 Mr. Petrie in admitting their qualifications,
10 Mr. Crutcher's case, distant time makes it quite clear
11 that these opinions should not be sought from these
12 witnesses and it would not be proper to do so in the
13 circumstances.

14 I raise it now before we get into it.

15 MR. McQUAID: Yes, Mr...

16 MR. ESTRIN: May I just say that I
17 support that.

18 MR. McQUAID: Mr. Chairman, I think that
19 the Board will have to sort out, in my submission, in
20 your final considerations, the weight that might be
21 established to any of the evidence that you have heard
22 whether it is from the Trow people, Dr. Rowe,
23 Dr. Charlesworth. I am not beginning by referring to
24 section 15 of the Statutory Powers Procedure Act but I
25 do say that we have heard evidence from all, many



1 witnesses and there are shadings of expertise, reliance
2 on other experts and so on that you will have to deal
3 with both in submission and in your decision-making
4 deliberations.

5 More importantly you will recall that
6 Dr. Rowe was put forward with Dr. Charlesworth a
7 hydrogeologist. Dr. Rowe needed the input and the
8 assistance of a hydrogeologist in order to do his
9 modeling. Mr. Petrie is being put forward in this
10 particular context to comment on tool as it has been
11 referred to, or the mathematical or computer model as a
12 hydrogeologist.

13 What did the results, the input that has
14 been put in by Dr. Charlesworth or even assumed by Dr.
15 Rowe indicate what do the output in terms of
16 calibration to pumping wells tests, in particular
17 referring to GL-24 and the reference by Dr. Rowe in
18 using GL-24, does this indicate to you or what can you
19 take from this as a hydrogeologist the use of
20 Dr. Rowe's model. I have no hesitation in saying I am
21 asking Mr. Petrie to confine his remarks to the
22 results, looking at it from a hydrogeologist's point of
23 view, looking at the data that we have here, the
24 pumping well tests and other data, how does it seem to
25 you as a hydrogeologist just as presumably



1 Dr. Rowe was using Dr. Charlesworth.

2 So, I am looking at it from that
3 particular focus. The fact that Dr. Charlesworth,
4 as I will be making a submission, did not seem to many
5 specific comments on Dr. Rowe's use of it or
6 calibration, doesn't mean that Mr. Petrie, that
7 I can't ask Mr. Petrie to do so. This is evidence that
8 Dr. Charlesworth could have gone into in more detail. I
9 am asking Mr. Petrie to do so. That is really my basic
10 submission that we are looking at it from the focus of
11 a hydrogeologist.

12 Then as I say, as factual and a legal
13 matter, first of all I should say as a factual matter
14 it is perfectly appropriate and as a legal matter it is
15 perfectly appropriate. The point is again not one of
16 getting into the tool, but rather how the tool is used
17 or how the tool is viewed as a hydrogeologist and the
18 end result. That is the basic thrust of it.

19 Secondly, I say to the Board, we have
20 heard evidence from many witnesses who have to rely on
21 other data, other disciplines in order to give their
22 opinions and I don't see this as being any different.
23 Ultimately I would say you would have to sort out my
24 friends' submissions in argument and determine what
25 weight you would ascribe to this if you feel they were



1 out of their areas of expertise. I think you should
2 still have the evidence and then consider what weight
3 should be given to it in the final analysis. I think
4 it would be effectively an error in my respect,
5 Mr. Chairman, not to accept the evidence at this point
6 on the basis of a sacredness of qualifications or
7 sacredness of the area of modeling and you somehow you
8 have to have a specific type of computer analyst or
9 something of that nature, a mathematician in order to
10 get into the hydrogeological effects of these models. I
11 think that would be an error, in my submission.

12 Based on the two main points I would ask
13 that we would be allowed to continue presentation of
14 this evidence.

15 MS. CRONK: May I respond to the
16 submissions, sir? There are two matters. First of
17 all, Mr. McQuaid indicated to you and asserted
18 questions goes -- it is a matter of weight and from
19 time to time of course in this lengthy hearing we have
20 referred to whether something should be admitted with
21 the recognition that at the end of the day the Board
22 will be in the exclusive position of determining what
23 weight should be attached to the evidence.

24 This is not a matter, in my submission,
25 that goes to weight at all. It goes directly to



1 admissibility. I say that, sir, because the case law,
2 the tradition of our tribunals and courts quite clearly
3 distinguishes between matters of weight and matters of
4 pure admissibility as a matter of evidence. I needn't
5 remind this Board that the rules with respect to
6 qualifying experts make it abundantly clear that an
7 expert, that the giving of opinion evidence is an
8 exception to the hearsay rule and that when you seek to
9 qualify someone as an expert to give opinion evidence
10 and to rely on exception of the hearsay rule you are
11 permitted to do it only to the extent of the
12 individual's acknowledged and proven expertise. It
13 goes to admission, not to weight when you are talking
14 about comparing the opinions of experts. In the end
15 that may be a credibility determination but their
16 ability in the first instance to express opinions is a
17 matter of admission not weight. I can refer the Board
18 to authorities in that respect if need be. Mr.
19 Chairman, the difficulty that arises here and I
20 recognize from time to time there is a blending of the
21 evidence you hear, but the problem that arises in this
22 situation is that the matter was raised initially when
23 the witnesses were first qualified before you, because
24 of the contents of the witness statement and because it
25 was made clear in the witness statement that is before



1 you that it was more than, in my submission,
2 hydrogeology parameters or input data upon which these
3 witnesses were going to be asked to opine.

4 If you look, sir, for example, Dr.
5 Kingham if you look at paragraph 6 in the witness
6 statement and if you look at paragraph 7 it is quite
7 clear in my submission that what is going to be sought
8 as a confirming opinion is that these witnesses wrote
9 that, Mr. Petrie presumably, those opinions do not go
10 merely to hydrogeological input, but into the model, it
11 is an opinion as to the appropriateness of using a type
12 of model for a particular purpose. That is paragraph
13 6. Paragraph 7 goes to calibration of the model.
14 Those are matters, sir, that the witness is not
15 experienced in in computer modeling by their own
16 admission. Opinions cannot be sought.

17 Mr. McQuaid suggested to you at the end,
18 implicitly at the end of the day it will all wash out
19 because at that point you can determine what weight to
20 attach to those opinions, it may be in error, he says,
21 not to receive the opinions. I put it to you in the
22 reverse, sir, that it would be in error to receive
23 them. There is a very clear boundary drawn on the
24 limits to which opinion evidence can be sought. This
25 is one of those.



These witnesses have not been qualified before you in a legal sense or a factual sense in the way that Dr. Rowe was. They admit they don't have these qualifications. I have no objection whatsoever to Mr. Petrie speaking to the relevant hydrogeology implications and the relevant hydrogeology input to modeling. That is why I didn't renew my objection last time when the witness was invited to get into that and did get into it. Now we are moving into something quite different. We are asking one expert to comment on the work of another in an area beyond the speaker's expertise. I put it to you, sir, that it would be a clear error if that evidence were to be termed admissible. There is a basic distinction between weight and admission and if it will be of assistance to the Board I will provide authorities to you in that regard but I am very concerned that these opinions not be sought from these witnesses in the way they have been qualified. They do not have a Rowe Charlesworth team here in the way it was provided by Mr. Estrin. We do not have that synergy of expertise. What we have here, parallel expertise is, both admitting they don't have the expertise to speak to the calibration and use of computer modeling beyond the hydrogeology aspect. There is a danger, sir, in going too far.



1 DR. KINGHAM: We have considered this
2 matter at great length last week when the question was
3 first raised. We recognized that it would be something
4 that is likely to be difficult in this kind of hearing
5 now and in the future. In fact we tried to find some
6 reasonable analogy by which we might understand what we
7 think is happening here and our analogy might not be
8 correct, but it seemed to be useful to us. It gave us
9 a kind of framework against which we might consider
10 both admissibility and weight.

11 The analogy was to a record player and
12 somebody with a set of records who appreciates music
13 but doesn't exactly know how to turn on the record
14 player and turn up the volume. The model could be
15 considered to be the tool or the instrument. The
16 hydrological input could very well be the record and
17 the sound that comes out the other end is the output.
18 We could imagine that these witnesses are telling us
19 that they are not particularly expert at putting the
20 record on and turning up the volume but
21 Mr. Schmidtke was the one who does that, as in the case
22 of Trow hydrogeology consultants and others, various
23 people can put the input into the machine.

24 We felt that to the extent that these
25 witnesses or any other got inside the record player and



1 started messing around with the resistors and
2 capacitors and wires that they were indeed not
3 qualified to get in and play with the internal workings
4 of the computer program and they had used the services
5 of a third party identified in there, in the documents
6 to run the model, and we decided that what we would be
7 watching for very carefully was the extent to which
8 they did anything other than put on the record and
9 listen to the music and pass judgment as to the quality
10 of the output dependent upon the input.

11 With that model in mind we decided that
12 we would be very careful as we listened to their
13 evidence last week and evidently we will have to do
14 the same thing this week to be sure that the matter is
15 one of the nature of the input and their expertise and
16 that input and their appreciation of the output for
17 that model as opposed to any extent to which they have
18 changed the model or changed its inner workings and
19 which they have professed themselves not to be
20 competent to do.

21 So it was with that understanding in
22 mind that we listened to their evidence last week and
23 we intended to listen to it this week. It was thus
24 that we have accepted their evidence on hydrologic
25 input and the output in mind.



1 MS. CRONK: Sir, I appreciate the
2 helpfulness, Dr. Kingham, in understanding the analogy
3 that the Board has been considering. Perhaps my
4 submissions could be reexpressed this way. There is a
5 distinction to be drawn between giving opinion evidence
6 as to the appropriate hydrogeology inputs and that is a
7 subject on which you have received submissions in the
8 face of no further objections last week.

9 To use your analogy it is always
10 dangerous for a lawyer to try and understand another
11 expert's analogy. The distinction as between receiving
12 opinion evidence as to whether a record player is
13 appropriate or a compact disc. If opinion evidence is
14 sought as to the very basis upon which those results
15 were obtained and that opinion is sought from a person
16 who can make no judgment as to the adequacy of the
17 instrument that produced the results, then, sir, that
18 is not admissible evidence unless the witness is
19 qualified to do so.

20 I agree with you that if these witnesses
21 were to be invited to speak to you about how the
22 model's workings in particular were to be appropriately
23 done that would be clearly improper and you would hear
24 from me again. That is not what you have been told is
25 the nature of the opinion evidence that is going to be



1 sought. Expressions of opinion as to the
2 appropriateness of this model or a particular model
3 calibrated this way or that goes to the very nature of
4 the tool or the instrumentation that produces the
5 sound. In my submission you look at the witness
6 statement, that is what they are being asked to comment
7 on. That goes to the very heart of it and in my
8 submission I can only review it. I do not regard this
9 evidence as admissible. I would ask that you consider
10 that. There is a distinction to be made between
11 pushing buttons and making judgments as to the adequacy
12 of the equipment in the first instance and that is what
13 these witnesses are being asked to opine on.

14 Just finally, as I said there are
15 numerous authorities but I don't intend to burden the
16 Board with them this morning, but the classic authority
17 on the subject makes it clear that the usefulness of
18 receiving opinion evidence is limited to the limits of
19 the expert's own knowledge and before the court will
20 receive admission, will receive his testimony on
21 matters of substance it must be demonstrated that the
22 witness possesses sufficient background and expertise
23 in the area so as to be able to appreciably assist the
24 Board in making its judgment on the matter at issue. I
25 refer, sir, to Sopinka and Lederman the Law of



1 Evidence, civil cases at page 310. The chapter is
2 quite lengthy but it is more than a semantic
3 difference, there is a distinction. I understand the
4 difficulty which faces the Board in trying to
5 distinguish in matters of this kind, but it seems to me
6 that this is one where there is a clear distinction to
7 be drawn and that the language of the witness statement
8 must be examined before the decision can be made.

9 DR. KINGHAM: Our judgment of
10 admissibility would be based on the extent to which we
11 are satisfied that witnesses are staying within their
12 areas of expertise. We have yet to hear any suggestion
13 that they will in fact be altering the model. If
14 their concerns expressed about the model relate to its
15 adequacy from a hydrogeological perspective, from their
16 understanding of hydrogeology it would appear they are
17 within their area of expertise as qualified by us.

18 MR. McQUAID: May I continue?

19 Q. Now, Mr. Petrie, you indicated to
20 me that in discussing these paragraphs, 5, 6, 7, 8,
21 that it might be appropriate to start with paragraph 7
22 and the reference particularly there to the Gartner Lee
23 well No. 24. Could you explain the significance of
24 that as you understand it as a hydrogeologist in terms
25 of the end results of Dr. Rowe's use of the material?



1 MR. PETRIE: A. Certainly.

2 Dr. Rowe's computer model was calibrated, if that is
3 the correct word, to hydrogeologic data provided from
4 Gartner Lee well No. 24 located in the proximity of the
5 Burlington landfill site. My comments with respect to
6 item No. 7 here focused on the appropriateness of using
7 that well for a calibration point. Specifically does
8 that well provide an adequate representation of the
9 hydrogeologic system at this site at this point.

10 Q. Can I stop you at this point.

11 Would it be of assistance to the Board to have the
12 joint witness statement of Dr. Rowe and Dr.
13 Charlesworth before it?

14 A. Not specifically. I will address
15 as I walk through this. That is Exhibit...

16 Q. M-444. Can you refer us to a page
17 or part of the text that demonstrates the significance
18 of well No. 24 in Dr. Rowe's material?

19 A. Yes. Turning to Exhibit M-444,
20 overhead 23 provides some measure of that significance.
21 We will see on that figure...

22 Q. Just stopping for a moment, again
23 to give the Board some background, do I have it
24 correctly, if we just back up to pages 19, 20, 21 and
25 22, Dr. Rowe has summarized there the steps that have



1 been taken leading to the overheads or the pages, page
2 23 being an example of what is about to be addressed.
3 Is that correct?

4 A. In a general way, yes. The
5 remarks I wish to make with respect to this figure is
6 just noting that in general the graph exhibited on page
7 23 of M-444 on the vertical axis we have concentration
8 in the rock fractures and on the horizontal axis
9 distant from the landfill. I wish to draw the Board's
10 attention to an entry in the upper left-hand corner
11 within the domain of that graph being 25 metres
12 from landfill. It is my understanding from reading
13 Dr. Rowe's work that he is referring there to a
14 borehole called Gartner Lee No. 24.

15 My concern is that Dr. Rowe, having run
16 his contaminant modeling and undertaken analysis of
17 various parameters, various hydrogeologic input
18 parameters and then focused on the chemistry recorded
19 at GL-24 on which to confirm the results of his
20 modeling. My concern is does that borehole or does the
21 data generated from that borehole provide good
22 representation of the groundwater quality downgradient
23 from the Burlington landfill?

24 I wish to initially focus on the
25 geologic log for that well or the geologic records



1 provided by that well GL-24. I have just Xeroxed for
2 the overhead from Exhibit H-83, being the plume
3 delineation report, the well records obtained for this
4 installation and the page number there is 48 at the
5 top.
6

7 Q. H-83 is the Gartner Lee Plume
8 Delineation Report?

9 A. That is correct. I would just
10 read to the Board the description that you see before
11 you for the weathered shale noting it extends from a
12 depth 1.2 metres below ground to 18.3 metres below
13 ground.

14 Just reading that description you see
15 before you:

16 "Weathered shale: red, brown weathered
17 shale with few random very thin
18 grey, green silt lenses below 1.5 metres
19 plus or minus up to 4 millimetres
20 thick. Becoming less weathered below
21 plus or minus 4 metres also with grey,
22 green thin hard bands at random
23 intervals, particularly below plus or
24 minus 8 to plus or minus 9 metres.
25 Generally fractured and wet below plus
or minus 8 metres."



Referring just to the middle portion of that figure where we have a column headed Monitor Details and Number we just note the position of the well screens relative to the elevation, the column on the far left.

In my reading of that which I have just read to you being a stratigraphic description I see no comment highlighting where a fracture horizon may be, if indeed there are any fractures encountered within this portion of the rock. It is noted that it was generally fractured and wet below eight metres but I could not indicate to the Board where I might expect to find more or less fracturing within that vertical profile.

In reviewing page H-83 and the other Gartner Lee work undertaken at this site, I note that one, the boreholes were drilled using the tri-cone method. The tri-cone method provides small chips of rock, it is like a large dentist's drill to put it in simple terms. I see no opinion expressed in this stratigraphic description as to where fractures may or may not be based upon the description of these rock chips. Indeed I would find this a little difficult to do;

I note that for the Trow's drilling on



1 the proposed Site F their drilling was undertaken with
2 a coring method such that a cylinder of rock can be
3 retrieved. That cylinder of rock can be expected in
4 the field and opinions provided regarding location or
5 measurements made of fractures with respect to
6 elevation and frequency of fractures. In my reading of
7 this borehole log I can see no preferred location of
8 fractures, no description of fractures and it is my
9 opinion that one cannot conclude from the chemistry
10 data that results from sampling from those three
11 installations, that they provide the most
12 representative measure of groundwater quality
13 immediately downgradient from the site.

14 I might also note that the hydraulic
15 conductivities in general downgradient from the
16 Burlington site as reported by Gartner Lee are in the
17 order of 10^{-6} . I say in general; whereas, some of the
18 numbers at Site F from Trow's pumping test data,
19 indicate hydraulic conductivity is in the order of
20 10^{-4} . By being this significant, Dr. Rowe, I believe
21 it is implicit in his arguments that having calibrated
22 his computer model to the chemistry that is provided
23 for this installation then extrapolates this opinion to
24 give his recommendations concerning potential
25 groundwater contamination that may occur at the



1 Burlington landfill.

2 I am indicating to the Board that I see
3 differences in hydraulic conductivity between the
4 Burlington site and the proposed Site F such that one
5 cannot conclusively extrapolate results obtained at
6 this installation, for example, in the Burlington site
7 to the proposed Site F.

8 Q. I think you did comment on that in
9 your evidence last week. Can you be more specific,
10 just to remind us, what are the differences you are
11 seeing that lead you to make that comment,

12 A. The pumping test conducted by Trow
13 at proposed Site F provide measures of the hydraulic
14 conductivity in the order of 10^{-4} centimetres per
15 second. This is in excess of the values generated from
16 different types of tests conducted by Gartner Lee at
17 the Burlington site. I say different pumping tests, as
18 I understand it, have not been conducted by Gartner Lee
19 on the Burlington site.

20 I will indicate to the Board that I am
21 comparing values generated from different test
22 procedures, but backing up a little, it is my opinion
23 that the data provided by the pumping tests give a
24 better measure of interconnections of fractures within
25 the rock and provide a more representative bulk value



1 for the hydraulic conductivity.

2 I will stress the word bulk. We
3 recognize this site is highly heterogeneous and the use
4 of any one number to provide a measure of the hydraulic
5 conductivity has to be questioned.

6 Continuing on with respect to No. 7 of
7 the witness statement being Exhibit B-615 it has not
8 been demonstrated that this or indeed any other of the
9 Gartner Lee wells located downgradient from the
10 Burlington landfill are screened in the most active
11 fracture zones underlying the site. Therefore, I raise
12 the question. The results generated by Dr. Rowe are
13 calibrated to this well. I cannot conclude that the
14 well data, that the groundwater quality data provided
15 at this installation reflect the chemistry located
16 downgradient from the site. I reference that with
17 respect to our Site F report being Exhibit B-617 when I
18 was addressing the groundwater quality data at the
19 site.

20 If I could refer the Board to page 73 of
21 Exhibit B-617.

22 DR. KINGHAM: Excuse me. Can I have that
23 number again?

24 MR. PETRIE: It is B-617, page 73.
25 The entry on the right of No. 2:



"The position of the observation wells screens with respect to the more transmissive fractures is unknown."

Just to repeat, I cannot conclude that the chemistry data available for this or indeed any of the other installations provide me with a measure of groundwater quality in the fractures that may emanate from the landfill at this site.

With respect to the same point I would like to refer the Board to Exhibit H-625. That is the Gartner Lee monitoring report which the Board received last week, being Halton Regional Landfill-Burlington 1987 Monitoring Report. Just to focus on the first conclusion, presumably that is at page 1. Reading the first conclusion:

"The previously reported occurrence of attenuated and diluted leachate in groundwater 25 metres south of the landfill."

Just stopping there, this is the installation GL-24 the log of which you see before you being 25 metres south of the landfill.

The previously reported occurrences here confirmed, based on the 1987 volatile organic results.

"Trace concentrations of leachate may



also be present in groundwaters 100 metres south of the landfill."

I focus on that point 100 metres south. In the previous reports, the occurrence of contamination at this point has not been indicated. Between the previous report that this report would now have -- we have done two things. Gartner Lee have done two things. One, confirmed the contamination at 25 metres south and secondly indicated trace occurrences may be present 100 metres south. Again this bring me back to the appropriateness of interpreting the results provided by Dr. Rowe given that his conclusions were weighted heavily by the groundwater contaminant levels that he had available to him for the installation being 25 metres south of the landfill.

Q. In paragraph 7 at the end in the last sentence you raise the question respecting the validity of the results generated by Dr. Rowe's model. Can you be more specific as to the question of the validity?

A. That reference is the hydrogeologic validity of using well 24 to provide calibrations for his model. The contaminant levels in the last year as reported by Gartner Lee have changed. Trace contaminant levels are possibly indicated 100



1 metres downgradient. I cannot extrapolate Dr. Rowe's
2 data to indicate what he might consider to be the
3 appropriate parameters he may have modeled to produce
4 the contaminant levels 100 metres downgradient.

5 Q. Those are your comments with
6 respect to paragraph 7?

7 A. Correct.

8 Q. What would be the most sensible
9 order then to continue your views as a hydrogeologist
10 with respect to the outcome or the input of these
11 models?

12 A. Focused on No. 5. I am not doing
13 them in numerical order. As indicated by
14 Dr. Charlesworth the volume of water pumped by Trow for
15 installation PW-1 at the site. It is my recollection
16 he used a number equivalent to 0.1 millimetres of
17 infiltration.

18 Q. You said Dr. Charlesworth?

19 A. That is correct.

20 Dr. Charlesworth in cross-examination indicated to the
21 Board that it was his opinion that the volume of water
22 pumped from PW-1 was consistent with 0.1 millimetre
23 volume of water. I agree with that point. I note that
24 it is my opinion that volume is significant with
25 respect to total infiltration as determined by Dr. Rowe



1 of one millimetre per year. In essence one is pumping
2 out one-tenth of the volume of water available from
3 infiltration in a 24-hour pumping test.

4 It is my conclusion that the results of
5 the pumping tests indicate to me that infiltration at
6 this site is significant, at least with respect to the
7 value of one millimetre per year. I cannot agree that
8 an infiltration of one millimetre per year provides a
9 measure of infiltration into the rock at this site.

10 Picking up on that point and returning
11 to Exhibit M-444, to page 20, page 20 of M-444 and I am
12 just focusing on the third heading on the left being
13 recharge. We note we had three numbers for the
14 recharge.

15 DR. KINGHAM: Are you in one of the tabs
16 at M-444?

17 MR. PETRIE: I am in the overheads. It
18 is behind Tab 2. The heading on that page says
19 Summary of Parameters Considered. The third entry on
20 that page says recharge focusing on the points there we
21 have three entries under recharge. 14 millimetres per
22 annum, one millimetre per annum, 2.5 millimetres per
23 annum. Looking above where we had the entry lateral
24 flows, we see that the 0.7 metres per annum being the
25 Darcy velocity there is based on Trow's original model.



1
2 Coming down to the entry under recharge where we have
3 the 14 millimetres per annum moving across to the right
4 we see that as equivalent to 0.7 metres per annum being
5 the Darcy velocity.

6 Looking again for the one millimetre per
7 annum and noting above that is based on expected
8 conditions. So one millimetre per annum is the
9 expected condition as reported by Dr. Rowe and we note
10 that the worst case condition looking at the lateral
11 flows again, gives a Darcy velocity of 0.125 metres per
12 annum. Looking under the entry under recharge that is
13 equivalent to 2.5 millimetres per annum infiltration.

14 Last week when I was reporting to the
15 Board on our sensitivity analysis that we had
16 undertaken on Trow's models we were able to demonstrate
17 that for a variety or a specific variety of
18 hydrogeologic parameters being the hydraulic
19 conductivity of the layers in question, we were able to
20 use the Trow model and provide a similar fit of the
21 water level data, yet provide more than in excess of 10
22 times variation in the amount of infiltration going
23 into the site.

24 Based on the parameters one may choose
25 to enter, we had an infiltration ranging from one to 31
millimetres per annum. I am just referring back to



1 Exhibit B-617 to find those exact numbers. Those exact
2 numbers are found on the table on page 123.

3 We have an entry under the column at the
4 far right being infiltration and in discussing this
5 last week I drew the Board's attention to cases 1, 2, 4
6 and 6 being isotropic cases which gave a similar fit
7 with respect to calibrated water levels and the field
8 data. The infiltration results from those four cases
9 ranging from 1.1 for the lowest to 31 -- I beg your
10 pardon -- ranging from 1.9 to the lowest of the cases I
11 considered having a reasonable fit being case No. 2, to
12 31.1, the infiltration for case No. 4.

13 My conclusion from that is that the
14 FLONET model does not provide a measure of infiltration
15 into this site and therefore I question the validity of
16 basing some contaminant modeling on an infiltration
17 that is consistent with the numbers provided by Trow.

18 MR. McQUAID: Q. Is that your opinion
19 then, your comments with respect to paragraph 5,
20 Mr. Petrie?

21 MR. PETRIE: A. Correct. Picking up on
22 paragraph 6, the block of rock modelled by Dr. Rowe
23 with a single value for hydraulic conductivity, he did
24 run some variations on that but within any one
25 simulation he used a single value for the hydraulic



1 conductivity.

2
3 Further the block of rock he modelled,
4 his dimensions were, as I recall, 1250 metres long
5 being the approximate length of the landfill site on
6 shale and 25 metres deep. My concern, as I have
7 indicated, my conclusions as I indicated to the Board
8 last week with respect to the available hydraulic
9 conductivity data showed that the reported values range
10 over about eight orders of magnitude.

11 It is my conclusion ...

12 Q. Could you give us that range again
13 just so we have those numbers?

14 A. I am referring to Exhibit B-617
15 and I noted that the reported values ranged over eight
16 orders of magnitude. That is the reported values for
17 hydraulic conductivity and I am referencing that on
18 page 97. I concluded that on page 110 that the
19 hydraulic conductivity data range over more than five
20 orders of magnitude reading the first entry under
21 discussion on page 110 and, secondly, there is no clear
22 pattern to the distribution of hydraulic conductivity
23 values.

24 Reading on:

25 "This range reflects the variable degree
of fracturing within the bedrock and



1 demonstrates the degree of complexity of
2 the hydrogeology at this site."

3 My concern is the applicability of using a single
4 number for the hydraulic conductivity at this site.

5 That implies that it is a homogeneous system in which
6 the degree of interconnection between the fractures is
7 generally uniform across the block of rock in question.

8 My concern is: (1) it is an extremely
9 heterogeneous system;

10 (2) that the degree of
11 interconnection between fractures is unknown, i.e., if
12 one encounters fractures one does not know they are
13 connected, the fractures, to any other fracture system.

14 (3) were we to have such a homogeneous
15 system I would expect a more uniform distribution of
16 the hydraulic conductivity, that is in space vertically
17 and horizontally, a more uniform pattern to the
18 hydraulic head data, the water level data, and a more
19 uniform pattern of groundwater quality data and I am
20 really focusing on chlorides. I am not addressing
21 contaminants when I mention that statement.

22 Three things; more uniform hydraulic
23 conductivity, more uniform distribution of water level
24 data and a more uniform pattern of chlorides.

25 Given that I do not see those patterns



1 it is my conclusion that to use a single value for the
2 hydraulic conductivity of this rock mass is
3 inconsistent with the available data.

4 Q. We had an exhibit, as I recall,
5 Mr. Petrie. We have commented on B-519 which is a
6 schematic used by Trow and it seems to me we had an
7 exhibit also which compared the Trow schematic, --
8 which is the correct terminology, the
9 hydrostratigraphy. Yes, the Trow hydrostratigraphy we
10 see on the left?

11 A. On Exhibit B-515, we have on the
12 right-hand an interpreted hydrostratigraphic column as
13 we interpret from the data provided from Geocon being a
14 single value for the hydraulic conductivity for that
15 rock mass. We just contrast the hydrostratigraphic
16 sequence, this being the sequence on the left as taken
17 directly from Trow in which the pathways, the hydro-
18 stratigraphic units can be delineated.

19 It is my contention that this rock mass
20 has a significant degree of heterogeneity. You cannot
21 define those pathways within that rock mass which
22 provides a more rapid groundwater flow and it is my
23 opinion that were one to try and model the system and I
24 have serious doubts of the ease with which one can
25 model this system, that one should be focusing it in



1 order to model a more rapid groundwater flow, such that
2 that is the pathway by which contaminants will migrate
3 off-site.

4 By way of contrast, as we undertook in
5 our assessment of infiltration at the site to provide a
6 schematic like this, this being a uniform value of
7 hydraulic conductivity for the site. That was
8 undertaken in order to provide for us, or for the
9 Board, a conservative estimate of what infiltration and
10 hence groundwater flow through the system may be. We
11 do not propose that that is the hydrostratigraphy at
12 the site.

13 We are in a position of having to try
14 and come up with an estimate of infiltration and hence
15 flux through the site. We reduced it to its most
16 simple terms in which we took the conservative value of
17 hydraulic conductivity in order to arrive at an
18 estimate of the infiltration.

19 We do not suppose that that is the
20 hydrogeology at the site nor that that sequence could
21 provide an indication to the Board where we would feel
22 that the preferred contaminant pathways are.

23 Q. Mr. Petrie, I am going to ask you
24 while we have B-515 up and I don't know whether it is a
25 question of doing art work or just making comments, but



1
2 could you in the middle portion on the right-hand side
3 where there is a white section, take a red marker, and
4 indicate to us by either drawing or comment what your
5 conclusions are with the hydrostratigraphy? That is,
6 could you just write on, I suppose, the comments that
7 you are making, you used the words "highly" or
8 "extremely heterogeneous" as I understand it. Could
9 you just do it in the middle and just put CRA just
10 where that black clip is?

11 A. I will right CRA up here. In
12 simple terms, I will put Site F here. I have entered
13 onto Exhibit B-515 under the heading marked CRA (Site
14 F) the word "heterogeneous" being a one word synopsis
15 of the hydrostratigraphy at Site F.

16 By that we reference the non-uniform
17 water levels, the non-uniform gradients, non-uniform
18 chloride distributions, non-uniform hydraulic
19 conductivities.

20 Q. Should we turn then to paragraph 8
21 then of the witness statement?

22 A. Yes. This refers to a statement
23 in the -- Dr. Rowe's and Dr. Charlesworth's witness
24 statement in paragraph 14 of the text. It is located
25 on page 12 of the text which is not behind any tabs.
Just reading this paragraph:



1 "With respect to Mr. Feenstra's response
2 to Mr. Tidball's question found at
3 volume 46, page 10402, that we don't
4 know precisely which fractures carry the
5 bulk of the groundwater, Dr. Rowe would
6 agree but point out that if it is only a
7 few fractures carrying the contaminant
8 then there is unlikely to be any
9 significant impact. The only way there
10 can be a substantial impact is if there
11 is a large volume of contaminant moving
12 through the shale over a large area.
13 Given the hydraulic characteristics of
14 the site as commented by Dr.
15 Charlesworth, Dr. Rowe is of the opinion
16 that contaminant would have to move over
17 a wide front of the order of 100 or more
18 metres and through a thickness of the
19 order of tens of metres to have a
20 significant impact downgradient of the
21 landfill. The monitoring data which is
22 available would suggest that this is not
23 the case."

24 Q. Just for the record, you have
25 really just read into the record paragraph 14?



1 A. Correct, I have. My concern is
2 found at the end of the first sentence in which Dr.
3 Rowe would agree that if there are only a few fractures
4 carrying the contaminant there is unlikely to be any
5 significant impact. Dr. Rowe when undertaking his
6 modeling developed a number for the contaminant mass at
7 the site. I have no question of that contaminant mass.

8 I wish to draw the Board's attention to
9 how that was handled. In characterizing the hydraulic
10 properties of his fracture or the fracture system, he
11 defined -- he, shall I say,-- pushed all the
12 contaminant mass through the available fractures. He
13 had a fixed mass and a number of fractures which he
14 defined. All the contaminants were free to distribute
15 themselves equally between the fractures open to that
16 mass.

17 I wish to question his statement:
18 "if only a few fractures are carrying contaminant." If
19 only a few fractures are carrying the contaminant all
20 the available contaminant mass must pass through these
21 few fractures. I then question if then there is
22 unlikely to be any significant impact. It is my
23 contention that if all the contaminant mass were
24 passing through one fracture, for example, then the
25 extent of that fracture is probably pronounced.



1 The contaminant concentrations within
2 that fracture are likely to be high. The contaminant
3 velocities within that fracture are likely to be high.
4 One could expect that if only one fracture, for example
5 was in the fractured rock system beneath the landfill
6 and further that fracture extended off-site, then the
7 concentrations and the groundwater velocities within
8 that fracture would be high.

9 I would then suggest to the Board that
10 such a concentration and velocity would be significant
11 with respect to ...

12 The second portion of that paragraph
13 addresses that, given the hydraulic characteristics of
14 the site Dr. Rowe and Dr. Charlesworth would expect
15 contaminant to move over a wide front in the order of
16 100 metres or more. If one did have a uniform hydro-
17 stratigraphy or fracture stratigraphy as indicated by
18 Exhibit B-515, then indeed one might expect the more
19 widespread contaminant front.

20 It is my contention, however, that the
21 fractures at the site have not been delineated with
22 respect to space. The velocities within those
23 fractures are unknown such that the contaminants might
24 move in a rather discrete flowpath and not lead to the
25 generation of a wide front in the order of hundreds of



1 metres, I beg your pardon, in the order of a hundred
2 more metres or in a thickness in the order of 10
3 metres. One does not need to have a wide front in
4 order to get a significant impact.

5 Q. Turning then to paragraph 9 of the
6 witness statement?

7 A. In this section I focus my remarks
8 to the attenuation mechanisms that are available to
9 slow contaminant migration at Site F. Dr. Rowe has
10 focused his modeling, not exclusively, but using the
11 mechanism of matrix diffusion by which he can account
12 for the contaminant distribution that he sees. Were we
13 to have an extension plume at Site F such that we could
14 locate it at more than two or three wells with some
15 significant history of pattern of that contaminant
16 migration, then one would be in a very good position to
17 take the shape of that plume with time and space in
18 order to calibrate a computer model and in order to
19 refine or to quantify those parameters which may effect
20 that pattern of contaminant migration.

21 That is how contaminant migration
22 modeling is often done, where extensive plumes or
23 existing plumes are available for calibration.

24 At this site, this site being Burlington
25 landfill, there is one well that when Dr. Rowe



1 undertook his modeling provided trace levels of
2 contamination being Gartner Lee 24. Dr. Rowe, has
3 assumed, as I understand it, that that point provides
4 the front for a contaminant plume. Therefore, all the
5 contamination exiting the site from day one to day
6 present has to be incorporated between Gartner Lee 24
7 and closer to the landfill.

8 On those grounds he had to review the
9 mechanisms available to him as he understands the
10 hydrogeology in order to arrive at an explanation for
11 the very little amount of transport at the site. He
12 did that in part by focusing on matrix diffusion.

13 It is my contention that in order to
14 quantify the effects of matrix diffusion one must, in
15 part, have a good measure of the geometry of the
16 fracture system. Their spacing as it relates to
17 spacing, as identified in the field, the opening of
18 the fractures which is a very difficult parameter to
19 get a handle on and the flux or groundwater velocity
20 through those fractures. Not a flux through a homo-
21 geneous system.

22 I will point out in the paper I
23 referenced the other day being one by Dr. Cherry and
24 some co-authors at the site in Oakville, Exhibit B-16,
25 Appendix C or 3, that he reports groundwater velocities



1 in a single isolated fracture at this site in the order
2 of 20 metres per day. He does point out, and I will
3 refer you to the text, page 13 being the last page of
4 that paper, the first sentence of the last paragraph,
5 page 13:

6 "Preliminary work at the Clarkson site
7 yielded a hydraulic aperture of 160
8 micrometres, a hydraulic gradient of
9 0.01 and a groundwater velocity of 20
10 metres per day."

11 Somewhere in this paragraph he indicates there is a
12 large amount of uncertainty attached to that number and
13 they undertake additional studies to confirm it. Just
14 moving down to the last statement on that page, reading
15 the last sentence:

16 "If our preliminary finding of large
17 groundwater velocities in the Dundas
18 shale at the Clarkson site is correct,
19 then it is reasonable to expect that
20 groundwater contamination could quickly
21 become widespread should any contaminant
22 enter the fracture zone."

23 Where we have high groundwater velocities and it is my
24 contention that 20 metres per day is a high groundwater
25 velocity, that the process of matrix diffusion may not



1 be pronounced relating it, as I recall, to Dr Rowe's
2 analogy of airplane passengers getting on or off a
3 conveyor belt where the conveyor belt is moving
4 extremely fast, it is difficult to get off that
5 conveyor belt.

6 While Dr. Rowe did not put numbers on
7 his conveyor belt and I did not expect that he would,
8 it is my contention that 20 metres per day is a fast
9 conveyor belt and the effects of matrix diffusion may
10 not be pronounced. Given that the effects of this
11 process, I am referring back to the witness statement
12 paragraph No.9:

13 "Given that the effects of this process
14 have not been quantified at Site F it
15 would be conservative to ignore this
16 process for contaminant transport
17 modeling."

18 To repeat, were one to have a plume for which one had
19 historical groundwater quality data, could map the
20 majority of that plume, then one is in a position to
21 have evaluated the potential of attenuating mechanisms
22 to quantify those mechanisms in some fashion in order
23 to reproduce that plume.

24 However, in a fractured rock environment
25 which is highly heterogeneous, I do not believe you



1 could take a value from one well, being GL-24, assume
2 that contaminants have not migrated beyond that point
3 and further assume that matrix diffusion is the
4 mechanism which controls that contaminant migration and
5 model the system.

6 Q. Continuing down to paragraph 11,
7 Mr. Petrie, this, I think, is addressing a comment of
8 Dr. Charlesworth's particularly with respect to the
9 migration of leachate?

10 A. Yes. Upward gradients have been
11 identified downgradient of Site F at boreholes HC10 and
12 HC11 and HC12. These boreholes are in the general area
13 of Aldershot. The upward gradients are measured between
14 the bedrock and the overburden. It is my contention
15 that for a degree of lateral flow leaving Site F and
16 moving beneath the Aldershot area, you cannot conclude
17 that it, I am reading the last sentence now:

18 "I (cannot) conclude that it cannot be
19 reasonably demonstrated that leachate
20 infiltrating into the shale will go to
21 depth and not come to the surface
22 between the site and the lake. The
23 presence of those upward gradients under
24 Aldershot, indicates to me that
25 potentially off-site flow from Site F



1
2 may have the capacity to reach that area
3 and potentially come to the surface in
4 that area."

5 DR. KINGHAM: Just for the record what
6 you have just said is not what is written in the last
7 sentence. "You will conclude that it cannot be
8 reasonably demonstrated" I think you said "You cannot
9 conclude that it cannot be demonstrated."

10 MR. PETRIE: You are correct. I will
11 take the sentence as read from the text.

12 MR. McQUAID: Q. Then would you
13 continue on paragraph 12 of the witness statement?

14 MR. PETRIE: A. I am referring here to
15 paragraph 65 of the joint Dr. Rowe, Dr. Charlesworth
16 witness statement. That is behind the text in the
17 front portion of this document. I find that on page 38
18 I shall just read the paragraph:

19 "From the standpoint of modeling
20 contaminant migration, Drs. Rowe and
21 Charlesworth will indicate that the
22 proposed Site D is at least as complex
23 as Site F and there is uncertainty
24 regarding the value of relevant
25 parameters at both sites. In both cases
modeling using reasonable combinations



1 of parameters will provide an indication
2 of the potential for contamination of
3 the groundwater. At Site F there is the
4 unique advantage of having the
5 documented performance of two existing
6 landfills which can be used to calibrate
7 the choice of parameters."

8 Just picking up at the last sentence I mentioned that
9 earlier, when I focused on the appropriateness of GL-24
10 to provide that calibration.

11 With respect to the first portion of
12 that paragraph, I would refer the Board to Exhibit
13 B-515. When this exhibit in some form was put to
14 Dr. Charlesworth his, not initial consideration, his
15 second consideration as I recall it, was that at Site D
16 the contaminant flowpaths were clearly defined such
17 that were one to arrive at an average value for the
18 hydraulic conductivity as he had done for Site F. If
19 one was to take that same approach and apply it to Site
20 D he felt it would not be appropriate. Specifically,
21 as I recall, because contaminant flowpaths were clearly
22 defined. Therefore, comparing the hydrostratigraphy at
23 Site D where it is my contention that contaminant
24 flowpaths are clearly defined with the
25 hydrostratigraphy as Dr. Charlesworth has provided for



1 Site F.

2 Reviewing that figure and recognizing
3 that we cannot, that I cannot define the flowpaths.
4 within Site F, it is my contention that Site D is
5 nowhere near as complex as Site F. I do recognize that
6 there is always a measure of uncertainty regarding the
7 value of relevant parameters at both sites, but I would
8 point out to the Board that the uncertainty is much
9 smaller when focusing on, for example, the hydraulic
10 conductivity for any one of these units,
11 hydrostratigraphic units at Site D that is, relative to
12 the range of values that has been provided for the
13 hydraulic conductivity of Site F recognizing that the
14 reported values range over about eight orders of
15 magnitude; whereas within each of these
16 hydrostratigraphic units the range of hydraulic
17 conductivity values is much smaller.

18 Q. We will be going into that in more
19 detail as we go into that report a little later this
20 morning.

21 A. We do indeed.

22 Q. All right. Mr. Crutcher, can I
23 just ask you to address your attention to, I think it
24 is paragraph 10 of the witness statement which focuses
25 on Site F, and could you explain to the Board the



1 purpose of that particular observation as we see it in
2 paragraph 10 of Exhibit B-615?

3 MR. CRUTCHER: A. Yes. In paragraph
4 10 we are referencing a comment made in paragraph 16 of
5 the joint witness statement of Rowe and Charlesworth.
6 If I may refer to that paragraph in Exhibit M-444, they
7 go to say:

8 "Dr. Charlesworth will comment with
9 respect to Dr. Kingham's question to
10 Mr. Feenstra with respect to the
11 potential for migration of leachate at
12 Site F in the weathered shale. He will
13 indicate that to the extent that any
14 leachate at the site may migrate through
15 the weathered shale it can be caught
16 by..."

17 And this is the area I am specifically addressing:

18 "...relatively straightforward
19 engineering devices such as toe
20 drains..."

21 I believe it was misspelled in the exhibit. It should
22 be "toe":

23 "...toe drains that have been installed
24 at both the Bayview and Burlington Park
25 landfill sites."



1 I addressed this, somewhat, in my evidence last week
2 and I wish to reiterate we do not consider that
3 relatively straightforward engineering devices can be
4 constructed along the southern slope of Site F. There
5 is a till mantle. That mantle is of variable
6 thickness. To install a toe drain into the weathered
7 shale, one first must excavate through that mantle.
8 The thickness does vary considerably. I believe last
9 week I discussed it being in the order of six to 10
10 metres.

11 I should clarify when I was referring to
12 six to 10 metres I was referring to the depth of
13 excavation. The actual till varies more in the order
14 of four to six metres that I have used in my normal
15 rationalization of the site of approximately six
16 metres. Therefore, we are dealing with a very
17 significant excavation just to get the collection
18 device at the top of the rock.

19 I also note that in fact the drain,
20 while it may be intersecting the top of the rock, will,
21 in our submission, only have a local effect on the flow
22 since much of the contamination will be passing beneath
23 that. We reference in our paragraph 10 of our witness
24 statement, that being Exhibit B-615, that the active
25 migration zone we are considering in this particular



1 case, is approximately 15 metres.

2 We have some difficulty in establishing
3 that depth and in fact evaluating our infiltration. We
4 give a range from 15 metres to 30 metres.

5 Q. Can you by reference to maybe the
6 tear sheet there just indicate to us what these depths
7 and excavations and where the toe drain would be and
8 that active migration zone then would be?

9 DR. KINGHAM: Do we not already have
10 that on an exhibit with coloured arrows, green and blue
11 and red? I recall we marked an exhibit up at some
12 point, an overhead?

13 MR. McQUAID: I guess...

14 DR. KINGHAM: That was the one where the
15 upper weathered shale ...

16 MR. McQUAID: We are assuming that ...

17 MR. CRUTCHER: We were using the Trow's
18 stratigraphy at that point.

19 MR. McQUAID: Q. You are concentrating
20 here at the point where the toe drains would be
21 constructed; is that right, Mr. Crutcher?

22 MR. CRUTCHER: A. That is correct.

23 Q. We will focus on that,
24 Dr. Kingham.

25 A. What I have sketched is along the



1 southern boundary of Site F. In this particular
2 location the refuse is actually placed on a till
3 mantle. That till mantle is approximately four to six
4 metres in thickness. It thickens as you proceed
5 further south and since we have a variable edge that is
6 why we have a variable thickness. If in fact we
7 constructed a toe drain, in the true sense of the word,
8 a toe drain would be constructed at the toe of the
9 refuse. In fact the witness statement is talking about
10 into the rock itself. So, in fact we have to excavate
11 if we take this range, saying six metres, at least six
12 metres to get to the till. One to two metres into the
13 rock itself. So, we are dealing with something in the
14 order of eight metres of excavation. That is a very
15 significant excavation to be able to get a properly
16 engineered system into that depth.

17 I am noting that that is far from
18 straightforward for that actual construction and any
19 effect that would have on the overall flow regime would
20 be local to that drain. We would have flow passing
21 that system further from the landfill, from the
22 landfill which is further to the north.

23 Q. You have put on a sort of a dashed
24 line and is that arrow to indicate a local effect?

25 A. Yes.



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Q. For that dashed line?

A. I have labelled it "Local
Influence Area".

Q. Then a larger continuous line with
an arrow below that and could you just describe what
that indicates?

A. Groundwater flow. I have labelled
it "Groundwater Flow Direction". I should also like to
note that we were the principal designers of the
perimeter drain or toe drain collection system along
the Bayview landfill site. Our system was designed
such that we would install a toe drain as deep as we
thought was practically possible. We had a somewhat
similar situation except we did not have the till. We
installed that at a depth of approximately three
metres.

Our rationale was, that we were trying
to collect the seepage that was coming at the true toe
of the slope, and any shallow groundwater that may be
encountered. We were very concerned about that the
system would not address the deeper groundwater flow
system. In fact that is why we recommended a
downgradient attenuation zone for the site.

Q. You make a comment continuing in
paragraph 10 of the witness statement, that such



1 streams will require pumping and may have to be set at
2 a significant depth in order to control contaminant
3 migration? I am sorry, that should be marked as an
4 exhibit.

5 MR. LANCASTER: B-628.

6 ---EXHIBIT NO. B-628: Flow Direction Sketch by
7 Mr. Crutcher

8 MR. CRUTCHER: By excavating the drain
9 to such a depth we lost our ability to use gravity
10 drainage as is the proposal within the drainage system
11 within the landfill itself. In fact we were required
12 to install manholes and pumping chambers to institute
13 this and I also note that we are at a fairly
14 significant depth which is not a straightforward task.

15 MR. McQUAID: Q. Could you be more
16 specific, what do you mean by straightforward? What
17 are the problems that are presented?

18 MR. CRUTCHER: A. It is primarily
19 dealing with the depth of excavation. I have drawn a
20 straight vertical cut showing how I would put the drain
21 in but in fact there really isn't equipment available
22 to do that, so in fact we would have to bench down the
23 excavation, create a much larger, I can't do it on this
24 particular case, but a much larger excavation to be
25 able to do that --the pipe in place. This will involve



1 significant earthworks program for the actual
2 installation. Then we will be only dealing with the top
3 of the rock. To penetrate much deeper beyond that we
4 are beyond the realms of practicality.

5 MR. McQUAID: Mr. Chairman, I am just
6 going to -- I have one other paragraph that relates at
7 this point to Site F. That is paragraph 14.
8 Mr. Crutcher was going to comment on that. I believe
9 that would take about 10 to 15 minutes. So, we could
10 leave that until after the break if that were
11 convenient, or we could continue?

12 MR. LANCASTER: Perhaps we should break
13 now. It is after eleven.

14 ---Recess

15 MR. LANCASTER: Please be seated.

16 MR. McQUAID: Q. Mr. Crutcher, just
17 continuing now in the witness statement B-615, I direct
18 your attention to paragraph 14 which addresses the
19 suitability of using the weathered shale at Site F for
20 liner material.

21 MR. CRUTCHER: A. Yes.

22 Q. You make reference to the Morrison
23 Beatty Limited Phase 2 hydrogeologic investigation,
24 Appendix D. Mr. Chairman, Dr. Kingham, that has been
25 marked as Exhibit N-473, N-473 in these proceedings.



1 I might say that Exhibit N-473 is an
2 appendix to the Phase 2 Morrison Beatty report which we
3 had marked earlier in the proceedings, Mr. Chairman, as
4 Exhibit 186 but we only put the front or basic summary
5 portion of the text in. This is an appendix to that
6 document.

7 Now, Mr. Crutcher, if you would just
8 summarize for us the import of N-473 and then indicate
9 to us your views whether you agree with or disagree
10 with the conclusions that are noted therein.

11 A. The reason why we were discussing
12 about the liner material as outlined in our point
13 number 14 is that in our document on the hydrogeology
14 of Site F we talk about an alternative design, that
15 including a liner. We include the use of a clay liner.
16 We did consider the possibility of using shale and that
17 is why we are addressing this point here. There is
18 very little information on dealing with shale and shale
19 as liners.

20 Our review of the shale sites, the only
21 two sites that we came across that were actively on
22 shale had clay liners on them so we could not use that
23 information to assist us on what would be the
24 permeability of a shale liner.

25 We noted that Morrison Beatty through



1 their work earlier on in the process, had submitted a
2 sample to Golder's which is documented in Appendix B of
3 their report, now Exhibit N-473, where they provided
4 some samples of the shale and essentially ask Golder to
5 determine the permeability. I understand the purpose
6 of that was in fact to see what a remoulded sample of
7 the shale would provide as a permeability for a liner
8 or low permeable base for the site. If you refer to
9 the second page of their letter.

10 Q. This is of the Golder letter?

11 A. Of the Golder letter, the third
12 complete paragraph that starts: "In summary.." I will
13 just read that paragraph:

14 "In summary it has been shown that the
15 laboratory permeability for weathered
16 Queenston shale compacted to the maximum
17 dry density as established in a standard
18 (Proctor) compaction test has a co-
19 efficient of permeability in the order
20 of 10^{-7} centimetres per second."

21 Q. Would you just indicate for the
22 record that is the end of the quote you are referring
23 to?

24 A. That is correct. You will refer
25 to the next page and you will see they did three tests.



1 They have a range of permeabilities 7×10^{-8} , 1×10^{-7}
2 and 3×10^{-8} . That permeability is considerably higher
3 than what we were considering, that being 1×10^{-8}
4 which we achieve using a clay liner. They also go on
5 to state and again I am quoting in the middle of that
6 paragraph now:

7 "However, it should be noted that due to
8 variation in grain size distribution and
9 the possible inclusion of shale
10 fragments within a fill area, the actual
11 permeability in the field could be
12 greater. Only a large scale field test
13 would determine the actual permeability
14 of this type of material."

15 Q. Again end of quote?

16 A. End of quote. What that
17 indicated to us was in fact their estimate of 10^{-7}
18 permeability using shale may be somewhat low due to
19 field conditions. They note shale fragments would
20 cause some concern to them. I also note that the shale
21 has some limestone inclusions which are harder than the
22 shale itself and those fragments, if encountered in the
23 liner material, would also create some difficulty in
24 maintaining that or achieving the permeability.

25 Q. Having pointed that out, what is



1 your specific conclusion with respect to the use of
2 this weathered shale and its suitability for a liner?

3 A. We specifically conclude from this
4 work that shale would not be suitable as a liner
5 material for Site F.

6 Q. Now, I would like to turn to the
7 Site D hydrogeologic report which we have marked as
8 Exhibit B-618 in the proceedings. I direct your
9 attention, Mr. Crutcher, first of all to the
10 introduction at pages 1 and 2. I think as we look
11 through here we see a summary confirming that the three
12 parts are identical in this report in terms of the
13 points directed and issues as they were in the B-617?

14 A. That is correct. The report is
15 set up in exactly the same format as the Site F report.

16 Q. Can I ask you very briefly to
17 confirm that part A which is the definition of
18 hydrogeologic suitability for landfilling where certain
19 general principles were discussed in B-217, that is
20 effectively the same section as in the other report?

21 A. Yes, it is an identical section.
22 In fact I made one correction to the Site F part of the
23 report I would like to make the same correction and it
24 is found on page 9. It is dealing with the
25 permeability and hydraulic conductivity of the clay



liners. It reads, the fourth line down from the top:
"Clay liners are typically designed to a
hydraulic conductivity of 5×10^{-8}
centimetres per second."

That should "designed to a hydraulic conductivity of
 10^{-8} centimetres per second." It was not intended to
have the five times. As I said earlier that would
imply that the range of permeability is 1.0 to 9.9 x
 10^{-8} .

The balance of the complete section is
identical to that found in Site F. It provides
essentially the generic basis of determining
hydrogeologic suitability. We critique the Trow
reports in section B, do an independent assessment of
the site, section C, and then we test the site for
hydrogeologic suitability using the criteria as
outlined in part A as the latter part of section --
part C.

Q. If I turn to section B I guess you
recall the order we went in. This is addressing the
critique of the Trow report on Site D. If I understand
it correctly, that hydrogeologic critique was
undertaken by Mr. Petrie?

A. That is correct.

Q. Mr. Petrie, could I ask you then



1 to turn to section B, page 14 and the first pages,
2 pages 14 and 15, as I understand it, constitute a
3 summary of the critique that you will be discussing in
4 this part; is that correct?

5 MR. PETRIE: A. If I can just catch up
6 with you, sir. Pages 14 and 15, just provide a quick
7 overview of those portions of the Trow report that we
8 looked at and we just note on page 15 that CRA agrees
9 with Trow that the site is hydrogeologically suitable
10 for landfilling.

11 However, design modifications are
12 recommended by CRA to ensure that the hydraulic trap
13 landfill designed by Trow is effective.

14 Q. Page 16 there is a section B.2.0.
15 continuing as I understand it over to page 31. In this
16 portion of the report, 16 through page 31 you are
17 looking at the geology as found at Site D?

18 A. That is correct.

19 Q. Could you just go through this
20 portion on geology then and highlight for us the items
21 of agreement and, if any, disagreements?

22 A. In reviewing the geologic data for
23 the site, I am referring to the first part of page 16,
24 we note there were some discrepancies between the
25 descriptive data interpretations provided by Trow in



1
2 Exhibit H-39 and the drawings that were attached or
3 appended to that report. We note the last sentence of
4 the first paragraph on page 16 that we conclude that
5 these inconsistencies do not effect the overall
6 conclusions regarding the geology. However, in order
7 to satisfy ourselves that we understood the geology
8 thoroughly, we noted first Trow's geologic sequence at
9 the site.

10 I am putting before the Board, page 18
11 from Exhibit B-618. This figure B.2.1. It is taken
12 from the Trow report as noted at the bottom and this is
13 Trow, 1986, Exhibit H-39, Figure 1, page 13. We just
14 note this is the stratigraphic sequence at the site as
15 defined by Trow.

16 I will indicate for the Board how such a
17 sequence was delineated. A number of boreholes were
18 bored in the vicinity of the site, 29, but not all
19 those were drilled by Trow but that information was
20 available to Trow. I beg your pardon, I think the
21 Comcor data was not available to Trow. I believe one
22 should subtract the three Comcor holes. 26 borehole
23 records were available to Trow. They drilled to
24 various depths in the stratigraphic sequence. They
25 took physical samples during the drilling and those
soils were logged by a geologist on-site.



1
2 Based on that description of the
3 materials they encountered they came up with some
4 general descriptions. I take no issue with them.
5 Upper till, a thin bed of silt, lower till sequence
6 extending from eight to approximately 24 metres below
7 the ground. Within that comes two granular units, one
8 of them being the upper granular unit between 11 and 12
9 metres below ground, and the second one being a lower
10 granular unit being 14 to 16 metres below ground.

11 Weathered shale, the bedrock was
12 encountered approximately 24 metres below ground. I
13 just wish to point out at this time that one can
14 provide from a description of the materials at Site D
15 the general delineation of the stratigraphy at Site D
16 and as I will show the Board this is related directly
17 to the hydrostratigraphy at Site D.

18 I wish to contrast that with Site F
19 where having undertaken a drilling procedure and
20 identified the fractures a second initiative had to be
21 taken in order to characterize the hydraulics of these
22 fractures. As I conclude from the Trow information one
23 could not take the fracture patterns identified from
24 drilling and directly infer the hydrogeologic
25 characterizations on the site. At Site D one can do
that.



Turning to page 17, the last paragraph of page 17 of Exhibit B-618, CRA examined the depth and thicknesses for each of the stratigraphic horizons encountered on the borehole logs. The borehole logs are found as Appendix 2 of Exhibit H-39A. We also note that additional borehole log information is provided in the Geocon documents being Exhibit M-438.

We, ourselves, prepared two cross-sections. The alignment of those cross-sections are shown thus as Figure B.2.2 from page 19. We have Site D outlined on this figure. We have a legend at the bottom left-hand corner that indicates who drilled the various boreholes or which companies drilled the various boreholes. We have indicated two cross-sections A-A extending approximately parallel to compass direction north and section B-B.

This alignment was chosen specifically as Trow have indicated in their work that there was a bedrock valley across the site approximately parallel to B-B. We aligned our section B-B to follow roughly along the length of that valley. We aligned cross-section A-A as approximately at right angles to it in order to provide on two cross-sections a reasonable geologic representation of the site.

The first of these cross-sections is



1 provided on page 20 being cross-section A-A. The
2 second on page 21 being cross-section B-B. Starting on
3 A-A which is Figure B.2.3a, page 20 you see before you
4 the stratigraphic information as provided by the
5 indicated borehole logs.

6 These logs, as I mentioned before, are
7 contained in Appendix 2 of Exhibit H-39A. We have just
8 provided the stratigraphic descriptions as we read them
9 there. There are some simplifications, obviously we
10 only have one or two words beside each vertical
11 increment delineated. That essentially is summarized
12 from the Trow data. We have identified the bedrock
13 valley by the dip in the bottom of the bedrock sequence
14 in the middle of the site.

15 We have identified the upper till
16 sequence with the thick dashed line extrapolated across
17 the site defining approximately the base of that
18 system. Within that upper till we have identified what
19 we believe from these records to be the base of the
20 weathered upper till. The base of the weathered upper
21 till was not always clearly delineated on the geologic
22 boring records. There is some interpretation is
23 required to identify that horizon.

24 DR. KINGHAM: You would confirm for us
25 that this is a 30 to 1 vertical exaggeration scale?



1 MR. PETRIE: Yes I can, noting that the
2 horizontal scale is 1 to 6000 in metres and the
3 vertical scale is 1 to 200.

4 DR. KINGHAM: So all of the features are
5 much less pronounced.

6 MR. PETRIE: A true scale, this would be
7 condensed in the vertical plane, correct. This scale
8 was chosen more for consideration of being able to
9 indicate the data and fit it on a sized piece of paper
10 that can be incorporated within the document.

11 One point of note that the till strata,
12 I am reading the legend, and I see an omission. We
13 have an indication being the third entry down in the
14 legend where it says "indicates glacial till" and we
15 have a vertical borehole record. Beside that it should
16 appear the cross-hatched lines such as you can see on
17 numerous borehole records.

18 So, we have provided the location of the
19 position where till has been interpreted to occur.

20 MR. McQUAID: Q. Could you just on
21 that overhead mark, I guess, the diagonal lines that
22 should be on the cross-section?

23 MR. PETRIE: A. I note it was omitted
24 on the second cross-section as well. I have marked on
25 Figure B.2.3a two short diagonal red lines on the



1 legend adjacent to the point where it indicates glacial
2 till.

3 Q. The same entry should be made on
4 page 21?

5 A. That is correct. I have marked on
6 Figure B.2.3b being page 21 of Exhibit B-618 again two
7 red diagonal lines and the legend indicating the
8 position of glacial till strata. This is for the
9 cross-section B-B which extends approximately along the
10 length of the bedrock valley, the geologic strata that
11 were encountered during the drilling.

12 Q. Could you just point out anything
13 else of particular significance to us on that figure?

14 A. We note that the upper till
15 thickness appears to increase as you move towards the
16 right-hand end of this section, being the east, which
17 if we locate it in space, B' on the right-hand edge of
18 that cross-section, we note which is the east or
19 southeast corner of the site that the upper till
20 appears thickened.

21 I also might note as we go back to
22 section A-A' that as one moves farther to the north
23 that the upper till appears to thin.

24 Referring back to cross-section A-A',
25 the right-hand figure being the north on cross-section



1 A-A' the upper till appears to be thinner. You will
2 note that we have located a property boundary for you.
3 The thinning of the till appears to occur at or beyond
4 the property boundary.

5 The following portions of the text
6 starting at page 22, for example, addressed the
7 geologic data for the upper till. We note in that
8 first paragraph, halfway down we have a heading there,
9 the thickness of the upper till, the second paragraph,
10 the first one under B.2.2 upper till unit, the
11 thickness of the upper till unit as interpreted by CRA
12 was observed to be between 4.45 metres at CC-OW-1, that
13 is the Comcor hole located north of the site and 12.2
14 metres located at the south edge of the site.

15 The average thickness using all the
16 information from all the boreholes was 7.74 metres. I
17 note here with respect to the 1984 series of boreholes,
18 the 1984 boreholes were drilled using less frequent
19 sampling. One sample which is generally 18 inches long
20 for five feet of drilling. One can be a little suspect
21 on where between any two samples the geologic contact
22 may be encountered. If one was to ignore the 1984
23 series of data just because one recognizes there may be
24 a measure of uncertainty attached to locating just
25 where the stratigraphic horizon might be, we note in



1 the second to last sentence that the average thickness
2 of the upper till is 8.1 metres, which in my mind is
3 similar enough to 7.74 metres which indicates to me
4 that one ought not to dismiss the sampling record
5 available from the 1984 series of boreholes.

6 I also note that these values, being
7 7.74 and 8.1 referring to the thickness of the upper
8 till is consistent with the value of eight metres which
9 is shown on Trow's schematic cross-section which I
10 provided as Figure B.2.1. The first figure I showed as
11 an overhead.

12 In order to assess the lithology of this
13 till, CRA reviewed all the grain sized data provided by
14 Trow and for those samples which CRA believed were
15 encountered within the upper till, we have provided the
16 complete grain size data. This is shown on page 24
17 which reads "Table B.2.1 summary of grain size
18 distribution upper till unit." We reference Appendix 3
19 of Exhibit H-39A as the source for this material.

20 The point to note in this table is with
21 respect to the geometric mean percentages of the clay
22 strata and the silt strata. You will note we have a
23 geometric mean for the clay of 20.6 per cent and for
24 the silt as 42 per cent.

25 We conclude from that that there is an



1 excess, using the mean numbers of 60 per cent fine
2 grain material, fine grain being silt and clay. This
3 in my mind indicates a very fine till material. You
4 will also note there is a degree of uniformity with
5 respect to the clay per cents and also the silt per
6 cents, recognizing that till tends to be an admixture
7 of materials picked up and deposited by the till sheet
8 or ice sheet. The variation in those numbers is not
9 pronounced relative to a lot of till sheets.

10 We note, picking up on page 23, that
11 silt and sand seams of less than 10 centimetres in
12 thickness were occasionally encountered within the
13 upper till. We also note that the uppermost portion of
14 this upper till, there were indications on the borehole
15 records of weathering and fracturing. The depth of
16 penetration of this weathering or frequency of
17 fracturing is not described in equal detail on all
18 borehole logs.

19 Hence, as I indicated earlier, the depth
20 of weathering we provided on the cross-sections was our
21 interpretation but in general it agrees with the
22 schematic depth or the depth of weathering shown on
23 Trow's schematic as being four metres. That schematic
24 being Figure B.2.1, page 18 of our report where zero to
25 four metres is described essentially as the weathered



1 portions of the upper till.

2 We note, over on the top of page 25,
3 that the thickness of the described weathered zone
4 varies between 1.5 metres and 9.5 metres. An average
5 thickness of 4.02 metres. With reference to the 9.5
6 metres at borehole CC-OW-3, right the way through the
7 log there was some indication of the person who
8 recorded the description of these materials that there
9 may be weathering and fracturing.

10 This was the only borehole log, based on
11 our review that indicated that the whole of the upper
12 till may be weathered and fractured. My suspicions are
13 that that description is inconsistent with other
14 descriptions of materials on-site and that this may not
15 be a true indication of the nature of weathering at
16 this one borehole.

17 I find it surprising that at one
18 borehole only the full thickness of the till is
19 described as weathered and fractured. The remaining 28
20 have a differential between the upper portion being
21 weathered and fractured and the lower portion of the
22 till being massive.

23 I note in this first complete paragraph
24 of page 25 a summary of just that remark. That at CC-
25 OW-3 the borehole log contains evidence of weathering



1 and fracturing to approximately 9.5 metres. Elsewhere
2 on Site D the appearance of weathering and fracturing
3 is limited to the upper four metres or so.

4 We then turned our attention to the
5 lower till unit which is discussed on page 26. We note
6 that the lower till overlies the bedrock and is in turn
7 underlain by the upper till. The unit was encountered
8 in all the boreholes and the thickness of this unit
9 ranges from 7.8 metres at HC3-85 to 29 metres at CC-OW-
10 2. We notice that the texture in the second paragraph,
11 as discussed by Trow, I reference the Trow document
12 there, the texture of the lower till unit is typically
13 sandy silt with varying amounts of clay and gravel.

14 The following table being on page 27
15 being Table B.2.2 provides our summary of the grain
16 size data as we found it in Appendix 3 of Exhibit H-
17 39A. Again we have geometric mean at the bottom for
18 each of the grain size materials encountered and we
19 note that the mean for the clay is 8.4 per cent and the
20 geometric mean for the silt is 45.6 per cent.

21 Q. Is there any significance in
22 adding those two figures together as you did for the
23 upper till unit?

24 A. One could and note that it is in
25 excess of 50 per cent for fine grain material.



1 However, the lower percentage of clay in referencing
2 the 8.4 relative to the 20.6 we obtained for the upper
3 till, indicates in my mind that there may be a lower
4 permeability for the lower till.
5

6 Turning to page 28 we note the granular
7 horizons are present within the lower till and discuss
8 them in the following few pages. Within the middle
9 paragraph there we note from inspection of the borehole
10 logs these materials, these materials refers to the
11 granular units are seen to vary in texture from
12 laminated silt and clays to sand and gravel. Quite a
13 textural variety. I also note that Trow had grouped
14 the strata into an upper and lower granular unit. We
15 note that Trow has shown the upper granular unit
16 generally occurs above an elevation of 172 metres above
17 sea level and that the lower granular unit at or below
18 an elevation of 170 metres above sea level.

19 Q. Now, you are going on to discuss
20 that division or characterization by Trow further on?

21 A. Correct.

22 Q. Would you just summarize though
23 for us at this point what your conclusions were?

24 A. Are you referring to my comments
25 on page 30, or should I just go through ...

Q. Perhaps you should just go through



1 and indicate what, if any, difference as you go?

2
3 A. We note at the very bottom of page
4 28 where CRA have identified granular sandy strata, we
5 have the borehole location and the thickness. We also
6 note that the borehole logs provided by Geocon and we
7 reference Exhibit M-438 show an upper granular unit at
8 CC-OW-2 and MB(1N) OW-4. Using my calculator I come up
9 with an average thickness of the above occurrences of
10 0.83 metres and we note approximates the thickness
11 identified by Trow on their schematic geologic
12 sequence, an approximate thickness of one metre as
13 shown on Figure B.2.1. That one metre occurring
14 between 11 and 12 metres below ground.

15 Two samples from the upper granular unit
16 were submitted for grain size analysis as reported by
17 Trow in the appendix in Appendix 3 of Exhibit H-39A.
18 We just have the percentage of various grain size for
19 these materials and we note that for those two samples
20 the percentage silt ranges from seven to 21.5 and the
21 clay per cent ranges from zero to four per cent.

22 We note that this demonstrates that the
23 texture of the upper granular unit is variable. We
24 note that Trow reported that this unit consists of
25 sands and gravels. I reference a page on the Trow
report where that is indicated. We are just noting



1 here that there is perhaps more textural variation in
2 the upper granular unit than is indicated by the use of
3 the words sands and gravels as indicated by Trow.

4 We note in the next paragraph, being the
5 last one on page 29 that the interpreted distribution
6 of the upper granular unit, Trow have shown that on
7 their drawing 8 of Exhibit H-18 of Exhibit H-39. We
8 are going to come back to this point in part C where we
9 provide our interpretation of this site hydrogeology.

10 I just make the note at this point that the
11 distribution shown there is not consistent with the
12 borehole log data nor the geological cross-sections
13 provided by Trow. I will be coming back to this in
14 part C. This point was discussed before with the
15 Board, both by Trow and the consultants to Milton. We
16 note the same apparent inconsistencies.

17 Page 30 provides summation of the
18 geology for the lower granular unit. We note that the
19 lower granular unit was interpreted by Trow as a
20 relatively laterally extensive layer of silt and fine
21 sand which occurs at and below an approximate elevation
22 of 170 metres. That is metres above sea level. Refer
23 the note that the average thickness of the lower
24 granular unit as encountered in 14 boreholes is
25 approximately 1.68. I just refer again to the



1 thickness provided by Trow on the schematic geologic
2 sequence, Figure B.2.1 where they have provided a
3 thickness of 2 metres for the lower granular unit on
4 this schematic section.

5 In my mind 1.68 metres is approximately
6 two. That is with respect to the thickness of the
7 materials reported.

8 Provided at the bottom of page 30 and 31
9 our summary of the review, of our critique of Trow's
10 geology of this site. I note at the very beginning at
11 the bottom of page 30 that CRA is in general agreement
12 with the site geology as defined by Trow and page 31
13 summarizes our concerns or identified disparities.
14 Point No. 1 on page 31:

15 "The upper granular unit is shown to
16 consist of silty sand and gravel; not
17 sand and gravel."

18 The grain size data indicate to me there is finer
19 materials in the upper granular unit than one would
20 infer from the description of the upper granular unit
21 being sand and gravel as provided by Trow.

22 The second point I note:

23 "The interpreted distribution of the
24 upper granular unit (Trow drawing 18,
25 Exhibit H-39) is inconsistent with the



1 available borehole log data and
2 geological cross-sections."

3 I note that again in part C of our report, which
4 provides summation of the geology of the site,
5 addresses these two issues again.

6 Q. So that completes your critique or
7 examination of the geology and your description of the
8 strata as you analyzed it and at page 32 we see a
9 discussion on groundwater.

10 There, as I understand it, you are
11 analyzing the various pumping results as reported by
12 Trow?

13 A. We looked at initially the
14 groundwater and then the hydrostratigraphic
15 conceptualization of the site, yes.

16 Starting with groundwater, we note, as
17 has been noted before, that there are wells adjacent to
18 the site, being domestic wells, which contain sources
19 of water from the overburden or the bedrock. Trow have
20 completed an inventory of these wells and indicate that
21 12 residences obtain water from source aquifers within
22 the overburden and the source for an additional 14
23 wells is not defined.

24 The remaining 43 domestic wells are
25 completed in bedrock. I do not, in this portion here,



1 elaborate on the exact number 12. There has been quite
2 a bit of discussion is it one well more or less, is
3 this well overburden, or is this well not completed in
4 the overburden. I note in the next paragraph Trow
5 considers it probable that the overburden water sources
6 are laterally equivalent to or continuous with the
7 upper or lower granular units identified beneath the
8 site.

9
10 I note in the last paragraph we agree
11 with this interpretation and point out that the quality
12 of the drillers' logs leaves some room for uncertainty
13 but Trow's assumption is the conservative approach. In
14 short we recognize there are domestic wells adjacent to
15 the site that draw water from the overburden materials.

16 Page 33 introduces the schematic
17 hydrostratigraphic sequence for Site D as delineated by
18 Trow. I am referring now to Figure B.3.1 which is taken
19 from page 34 of our report being Exhibit B-618. We
20 note again the same sequence of strata being the upper
21 till, a lower till in which the granular units are
22 encountered on the site underlain by weathered till.
23 The difference between this figure and the one I put
24 before the Board a few minutes ago is the values for
25 the hydraulic conductivity as assigned by Trow for each
of these units. We note that the weathered till being



1 from zero to four metres below ground has a hydraulic
2 conductivity of 1×10^{-5} centimetres per second has
3 been assigned. For the unweathered till four to eight
4 metres below ground we have a value of 8×10^{-8} . To
5 the right we note the lower till being from eight to 24
6 metres below ground we have a K value of 2×10^{-6}
7 centimetres per second. We have an upper granular unit
8 of 8×10^{-3} and a lower granular unit of 3×10^{-4}
9 centimetres per second.

10 We can also note that the bedrock
11 underlying the site has K of 1×10^{-5} centimetres per
12 second. I was just reading the reported values as
13 indicated on Figure B.3.1. We note that the
14 hydrostratigraphic units coincide with the
15 stratigraphic units which contrasts to Site D, I beg
16 your pardon, which contrasts to Site F where that
17 coincidence was not noted.

18 We note the permeability contrast
19 between the till units which have low permeabilities
20 and between the granular units which have a higher
21 permeability. In the last paragraph on page 33 the
22 hydraulic conductivity values assigned to the low
23 permeable units by Trow were determined from slug tests
24 while those for the granular units were determined from
25 pumping tests.



1 You will also note that for the
2 weathered upper till the hydraulic conductivity of
3 1×10^{-5} was assumed by Trow and was not determined
4 from field data generated at the site. That assumption
5 was based on the consideration for the concern
6 regarding fracturing and weathering.

7 I note at the top of page 35 that a thin
8 bed of silt was identified in the hydrostratigraphic
9 sequence. It was also delineated in the geologic
10 sequence. I did not address it there in my discussions
11 this morning. Trow does not assign a hydraulic
12 conductivity to this stratum.

13 CRA estimates the hydraulic conductivity
14 in the order of 10^{-5} may be appropriate for this
15 material. Given the thickness of this material
16 averaging 17 centimetres or 0.17 metres and the
17 estimated low hydraulic conductivity, the 10^{-5} I just
18 indicated, CRA does not consider the stratum as
19 hydrogeologically significant.

20 The next three pages being 35 through to
21 the top of 38 address the weathered upper till. This
22 is the zero to four metres depth as provided on Trow's
23 schematic, the stratigraphic sequence. I note that
24 Trow assigned the value of 1×10^{-5} for these
25 materials. I am referring to the second paragraph



1 under the heading weathered upper till, page 35,
2 Exhibit B-618. I also note that Trow states that this
3 assumption is conservative. I agree that this value is
4 indeed conservative, i.e., it provides a higher value
5 for hydraulic conductivity than one might reasonably
6 determine from field testing.

7 The next paragraph being the bottom of
8 35 and over to 36 indicates that recent research
9 referenced by Trow, and I am referring to Maurice Desau
10 at the University of Waterloo, indicates that the
11 presence of fractures in weathered tills in Ontario
12 does not appear to substantially increase the bulk
13 hydraulic conductivity of these materials.

14 I further note that the weathering of
15 chlorite to smectite (a swelling clay) was believed by
16 Dr. Quigley and his colleague to account for this
17 phenomenon by effectively sealing the fractures. There
18 may be fractures in the clay, however, part of the
19 alteration process that generates the fractures also
20 contributes to an altering of clay chemistry, such that
21 swelling clays can effectively seal fractures.

22 We note that smectite was not identified
23 by Trow in the clays analyzed for the site, however,
24 they did identify vermiculite which is a swelling clay
25 in one sample analyzed from the weathered zone at



1 HC2-85 and I reference the page in the Trow document
2 where that information can be found. I note that the
3 presence of swelling clays in a weathered till suggests
4 that a bulk hydraulic conductivity of 1×10^{-5} is
5 conservative.

6 I would like to point out to the Board
7 that hydrogeologists are not in complete agreement
8 regarding the hydraulic characterization of fractured
9 till. The information I have provided to you is the
10 best I have at my disposal, however, additional
11 investigations are currently ongoing regarding this
12 matter.

13 Mr. Crutcher will address this
14 uncertainty with regard to the engineering options
15 available to us on this site.

16 The second paragraph on page 36
17 references the tritium data obtained by Trow. Trow
18 installed a number of piezometers within the upper till
19 in order that they could sample for tritium. That
20 tritium data, as I understood it, they specifically
21 wanted to get a measure of how far post-1952 water had
22 migrated into the till in order that they could get
23 some estimate of the hydraulic conductivity of those
24 same strata.

25 I am reading the second sentence, the



1 middle paragraph, page 36:

2 "The results presented by Trow show that
3 pre-1952 ...".

4 I am thinking about that, do I mean post? I believe
5 that should be post, can I make that correction for the
6 record, please, Mr. McQuaid. The second sentence,
7 second paragraph, page 36, should read:

8 "The results presented by Trow (p.61,
9 Exhibit H-39) show that post-1952 water
10 has migrated to a depth of 5.4 metres
11 below ground surface."

12 I further note that when Trow used that data to
13 calculate the hydraulic conductivity they arrived at a
14 value of 3×10^{-7} centimetres per second for the
15 weathered upper till and I contrast with the assumed
16 value that they provide a 1×10^{-5} .

17 I note the last paragraph on page 36
18 that the Board has heard some discussion previously
19 concerning the value for the vertical hydraulic
20 gradient employed in the above calculation. The above
21 calculation referencing that calculation that provided
22 Trow with a value of 3×10^{-7} centimetres per second.

23 I note in the second sentence that when
24 we reviewed that calculation which was provided by
25 Trow's H-181 we note that if mid screen elevations are



1 used as being the point at which the water level data
2 are representative then a lower downward vertical
3 gradient can be calculated. I calculated the value at
4 0.22 being the vertical hydraulic gradient from the
5 data provided by Trow.

6 I note that using that value of 0.22 and
7 completing the mathematics as Trow had undertaken it,
8 one could have calculated a hydraulic conductivity of
9 5.2×10^{-7} . I note that I do not consider this to be
10 significantly different from the value of 3×10^{-7}
11 calculated by Trow. I should further note again that
12 the assigned value of Trow being 1×10^{-5} is
13 conservative with respect to these calculations based
14 on the tritium occurrences.

15 In order to assess the rate of
16 groundwater flow through a unit the value for effective
17 porosity is required to be input to that calculation.
18 The first paragraph on page 37 addresses the effective
19 porosity for the weathered till. I note that Trow
20 assigned an effective porosity of 0.001 for this unit.

21 Evidence provided by Mr. Feenstra showed
22 that for a field experiment recently conducted at
23 Sarnia an apparent porosity of 0.02 was determined. I
24 note that Mr. Feenstra concluded that the assumed
25 effective porosity, that being the value of 0.001 which



1 was assigned by Trow, is quite conservative.

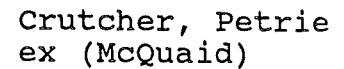
2 I further note that by assuming a low
3 value for effective porosity, I beg your pardon, an
4 expected porosity of higher than 0.001 has the effect
5 of reducing the groundwater velocity. The higher the
6 porosity the smaller velocity. There is an inverse
7 relationship there. The lower the velocity the longer
8 the travel time or the groundwater velocity within that
9 unit. Groundwater travel time to the site boundary.

10 I note that CRA agrees that the assigned
11 effective porosity of 0.01 is conservative.

12 Q. You make a comment in the next
13 paragraph that the effective porosity for the
14 unweathered upper till could be 0.25 but then you
15 concluded that in order to be conservative Trow has
16 assigned the values of 1×10^{-5} and 0.001 respectively
17 to the hydraulic conductivity and porosity and you
18 agree with those?

19 A. Can I just correct an impression
20 you may have left with respect to the second to last
21 paragraph on page 37:

22 "As discussed by Trow the rate of
23 tritium advance indicates that the
24 weathered and unweathered portions of
25 the upper till have a similar effective





1 may be part of the upper till being the data point for
2 HCl-85-3 which has a calculated hydraulic conductivity
3 of 7.9×10^{-6} , a geometric mean of 2.4×10^{-7} results.
4 If one were to include that additional sampling point
5 it would lead to a higher geometric mean for the upper
6 till. However, I note that in the next paragraph
7 addressing grain size again, recognizing that was in
8 excess of 20 per cent clay, that geometric mean of 20
9 per cent clay and in excess of 40 per cent silt in
10 these materials, it is my contention that the hydraulic
11 conductivity of such material is unlikely to exceed $1 \times$
12 10^{-7} centimetres per second.

13 I will not, however, draw a straight
14 line conclusion between per cent clay and hydraulic
15 conductivity. I am just noting that in my
16 interpretation, given those clay and silt per cents.

17 In the last paragraph on page 38 I note
18 the single well response tests are not the most
19 important method for determining hydraulic conductivity
20 in low permeable materials specifically when it relates
21 to the long time for water level changes to occur. I
22 note further that laboratory determinations of the
23 vertical hydraulic conductivity would have aided in
24 assessing the hydraulics of this unit.

25
Q. We will be discussing that



1 further?

2 A. Correct. We come again to that in
3 part C of our report.

4 Q. Now, the next few pages you are
5 addressing your consideration of the lower till, the
6 upper granular unit and the lower granular unit?

7 A. That is correct.

8 MR. McQUAID: Mr. Chairman, I notice we
9 are at 12:30. I am in your hands as to whether you
10 would like us to complete this section and then break
11 for lunch, or ...

12 MR. LANCASTER: How much time would you
13 need?

14 MR. McQUAID: I would expect about 10
15 minutes, would that be correct?

16 MR. PETRIE: Yes.

17 MR. LANCASTER: That's fine, we will
18 continue.

19 MR. PETRIE: Picking up on page 39 for
20 the lower till, referring back to Trow's schematic
21 hydrostratigraphic sequence, the lower till encompasses
22 the vertical interval of eight to 24 metres below
23 ground, but does include within that domain the
24 granular units encountered at the site.

25 We note from the grain size data,



1 looking up on the second paragraph there, that the
2 lower till has a lower clay content than the upper till
3 and I am comparing 8.4 per cent to 20.6 per cent. It
4 is my expectation, therefore, that the hydraulic
5 conductivity of the lower till would be somewhat
6 greater than that of the upper till.

7
8 I note in the next sentence that Trow
9 generated a value of 2×10^{-6} centimetres per second
10 from an analysis of slug test data and I note again
11 that this value is higher than the value determined
12 using the same procedures for the upper till.

13 Again I note that laboratory values of
14 hydraulic conductivity may have provided a better
15 measure for the permeability of these materials, being
16 the lower till.

17 Page 40 to 43 addresses the upper
18 granular unit. I note in the first paragraph that this
19 unit is discontinuous in its distribution beneath the
20 site and referencing back to the geologic descriptions
21 generally consists of silty sands and gravels. We come
22 again in part C of our document to our interpretation
23 of the distribution of this unit. Here I am critiquing
24 Trow and note as they have that this unit is not
25 continuous beneath the domain of the site.

Trow undertook two slug tests within



1 this unit and I have reported the values there as I
2 find them in Appendix 12 of Exhibit H-39A with HC2-85,
3 I will just locate these for the Board. At HC2-85 we
4 have a value of 1.1×10^{-6} and HC2-86 4×10^{-5} . HC2-85
5 lies up here. Here being in the sort of top right
6 corner of the site as defined and HC2-86 being in the
7 middle of the southwest quadrant of the site as
8 defined.
9

10 I would like to point out what I haven't
11 shown on this figure being Figure B.2.2 is the location
12 of the pumping wells for which pumping tests were
13 conducted. HC2-85 is very close to one of the pumping
14 wells.

15 I note in the third paragraph on that
16 page that the values of the hydraulic conductivity and
17 I am referencing 1.1×10^{-6} and 4×10^{-5} are lower than
18 expected for sands and gravelly sands and as indicated
19 by the grain size data and referencing the data for
20 HC4-85 which had four per cent clay and that these
21 materials may contain a significant amount of fine
22 grained material.

23 I should notice that the assigned
24 hydraulic conductivity for this unit being 8×10^{-3}
25 centimetres per second is consistent with what I would
call clean sands. Sands without a lot of fine grain



1 material. I would expect very little silt and
2 essentially no clay in the sand to give me a value of
3 8×10^{-3} . I am noting here that at two portions of
4 the site for which slug tests data is available we have
5 lower values which may indicate this material may
6 contain some finer lithologies and not just sand and
7 gravel.

8 DR. KINGHAM: Excuse me, can you just
9 clarify that. Your sentence in fact says "As indicated
10 by the grain size data... four per cent clay "...these
11 materials may contain a significant amount of fine
12 grain material." Are you saying a four per cent clay
13 is a significant amount of fine grain material to be
14 found in sand and gravel?

15 MR. PETRIE: For a granular unit that
16 has an assigned hydraulic conductivity of 8×10^{-3} ,
17 yes.

18 My point to note here is that there is
19 some lithologic variation in this unit and that the one
20 unit being 8×10^{-3} and a description of sands and
21 gravel as provided by Trow may not be complete. I note
22 at the bottom of page 40, again I am referring to
23 Trow's drawing 18 from Exhibit H-39, that drawing in
24 which the extent of the upper granular unit was
25 defined.



1 This paragraph is just addressing the
2 possible geologic continuity of the granular strata
3 noting that the geographic continuity of the strata
4 where they may be very thin, i.e., 30 centimetres or
5 very low permeable being silts and clays, that they
6 cannot be considered as hydrogeologically significant
7 with respect to the granular strata.

8 The next couple of pages addresses the
9 pumping test which was undertaken on PW-2. The pumping
10 test was of 49 hours duration. I might be a little
11 long again, Mr. McQuaid, this is a point of some
12 detail.

13 MR. McQUAID: All right, Mr. Chairman,
14 then I think if that were the case rather than keep the
15 Board and also getting into the lower granular unit it
16 would be better to break.

17 MR. LANCASTER: We will return at two
18 o'clock.

19 ---Luncheon Adjournment at 1:40 p.m.
20
21
22
23
24
25



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

2 MR. LANCASTER: Please be seated.

3 MR. McQUAID: Q. Mr. Petrie, when we
4 broke for lunch we were at page 41 of your report on D
5 and in particular on page 41 where there is the first
6 full paragraph about the middle of the page there is
7 reference to a pumping test on PW-2. You indicated
8 there were a couple of pages of discussion on that.
9 This is addressing the upper granular unit and your
10 review of the Trow conclusions in that?

11 MR. PETRIE: A. That is correct.

12 Q. Can you tell us what you observed
13 looking at pumping test data, what conclusions you
14 reached?

15 A. Firstly the pumping tests on well
16 PW-2 which was screened in the upper granular unit at
17 PW-2 and located adjacent to HC2-85, generally being in
18 the northern portion of the site. A pumping test of 49
19 hours duration was conducted on this well.

20 The purpose of this test, as I
21 understand it, was to characterize the hydraulics of
22 the upper granular unit. One being to get a measure of
23 the transmissivity and hence hydraulic conductivity and
24 secondly to make some conclusions regarding the lateral
25 continuity of this unit.



1 I note again in the first complete
2 paragraph on page 41, that the tabulated data for this
3 test was not provided so my interpretations on this
4 test are taken from the graphs of which there are three
5 types, the time drawdown, the time recovery and
6 distance drawdown graphs provided by Trow in Appendix
7 10 of Exhibit H-39A.

8 I note that initially, the second
9 complete paragraph on page 41, that CRA agrees with
10 Trow that these test results, specifically the pumping
11 test data generated during the pumping of PW-2,
12 indicate that the upper granular unit is discontinuous
13 eastwards from the pumping well. That is consistent
14 with Trow's interpretation as in drawing 18 in which
15 they show the distribution of the upper granular unit.

16 DR. KINGHAM: Have you got an exhibit
17 that shows the locations of the pumping wells?

18 MR. PETRIE: I don't have one here.

19 DR. KINGHAM: Maybe we can find it in
20 H-39.

21 MR. PETRIE: Could you also provide for
22 me, please, Mr. Ramsay, drawing 18 from that report?

23 DR. KINGHAM: We have the data.

24 MR. PETRIE: My apologies for not
25 bringing that today.



1 I am exhibiting before the Board drawing
2 5 from the Site D report of Trow Hydrology Consultants,
3 that being Exhibit H-39 and indicating the location of
4 PW-2 which is in the northern one-third quadrant of the
5 site adjacent to the east property boundary as defined
6 on drawing 5. I note that that well is very close to
7 HC2-85. Referring back to the text on page 41 the test
8 results provided by Trow, from those results they
9 conclude that the upper granular unit is discontinuous
10 eastwards from the pumping well. I am indicating
11 eastwards from the pumping well. Trow on drawing 18
12 which I understand Mr. Ramsay has just gone to get,
13 indicate that the upper granular unit is discontinuous
14 and lacking in a general line through there.

15 I will refer to that again when that
16 drawing is available to me.

17 MR. McQUAID: Q. Mr. Tidball has loaned
18 us his.

19 MR. PETRIE: A. I have put before the
20 Board drawing 18 from Exhibit H-39. It locates PW-2 in
21 the eastern boundary of the northern one-third of the
22 site. There is a heavy black line that runs generally
23 east-west and north-south down the mid portion of the
24 site and then east to west along the central southern
25 portion of the site. I note on the legend that that is



1 the interpretive extent of the upper granular unit.

2 A portion of the line, I am referring to
3 that which sort of encompasses PW-2, the position of
4 that line, as I understand it, was inferred by Trow
5 based on their review of the pumping test data at PW-2.
6 I am indicating to the Board that I am in general
7 agreement with the position of that line in the area
8 eastwards from PW-2. I make that statement with
9 respect to the second complete paragraph on page 41
10 where CRA indicates with Trow that these test results
11 indicate that the upper granular unit is discontinuous
12 eastwards from the pumping well.

13 Q. You just read the word "agrees as
14 indicates." It should read "as you have indicated CRA
15 agrees with Trow." Correct?

16 A. Yes. I note on the last paragraph
17 on page 41 of Exhibit B-618 the transmissivity result
18 calculated by Trow and the hydraulic conductivity,
19 specifically 8.2×10^{-3} , also calculated by Trow. I
20 note on the top of page 42 that given the grain size
21 variations encountered it is probable that the
22 hydraulic conductivity, that this hydraulic
23 conductivity is representative of the more permeable
24 portions of this unit.

25 I refer to that which I mentioned



1 earlier this morning where the grain size data for the
2 two samples for which data is available for the
3 granular unit they show as much as four per cent clay
4 being four per cent very fine grain material in one of
5 the samples. In consideration of that grain size data
6 and the hydraulic conductivity, specifically $8.2 \times$
7 10^{-3} , it is my interpretation that it is probable that
8 this hydraulic conductivity is representative of the
9 more permeable portions of the unit.

10 I note again, therefore, that the
11 hydraulic conductivity as calculated by Trow was
12 therefore considered by CRA as conservative.

13 Of interest in assessing the hydraulics
14 of this unit is the response of the pumping well
15 following the termination of the test. The termination
16 the test being after 49 hours, the pump is turned off
17 and some additional water level data were recorded.
18 This is generally described as the recovery phase of a
19 pumping test in which it is sometimes -- the water
20 levels are sometimes measured at the end of pumping to
21 demonstrate if the pumping well returns to its static
22 or original water level.

23 The first overhead I am putting before
24 the Board I have taken directly from Exhibit H-39A,
25 Appendix 10. These are the graphs from the pumping



1 test as provided by Trow. On the vertical scale we
2 have drawdown. There is a log scale on the vertical
3 axis and also a log scale on the horizontal axis. On
4 the vertical scale we have 0.1 metres to 1.0 metres
5 representing drawdown or change in water level from the
6 initial water level at the onset of pumping. The
7 horizontal axis being time and minutes. Those times
8 are referenced across the top. As I read it, the last
9 number out there looks like 1000 minutes. Also, of
10 note, as I have written on the side "end of test". As
11 I read that graph closely it looks like it is nearly
12 at, it is written on about 2500 minutes after pumping
13 started. It is my understanding that this test went
14 for 49 hours which is about 3000 minutes.

15 So, the end of the test interval is
16 about where we had this thick black line and maybe that
17 indeed is where the end of test is rather meant to be
18 rather than just on the line on which it is typed. The
19 point of concern from this graph, for example referring
20 to the well being OW-2, OW-2 in the legend shows a dot
21 being the point where the water level data were
22 recorded with a little vertical stroke passing down
23 from the bottom. I note that OW-2 and OW-1, the data
24 sort of lie on the same line. At this point being the
25 end of test, approximately 3000 minutes, the pump was



1 turned off. One would expect the water levels to
2 return to their original position in generally the same
3 length of time that the pumping test was undertaken.
4 For a 3000 minute pumping test one might have expected
5 the water levels to recover to zero drawdown,
6 essentially the bottom of the graph, within 3000
7 minutes.

8 Commonly, for highly permeable strata,
9 it occurs less than that although one might have a
10 residual of a fraction of a centimetre of a drawdown
11 down at the end. Note, that the data are recorded
12 right up to the edge of the graph being 10,000 minutes.
13 I am indicating to the Board at the end of the test at
14 3000 minutes and the end of this graph at 10,000
15 minutes, we have recovery data for the period of 7000
16 minutes which is approximately 5-1/2 days as I recall
17 it. I am noting that for that 5-1/2 day period with
18 specific reference to this graph, as I read it for OW-
19 2, that the water level, the drawdown at the end of the
20 pumping interval was approximately five metres and 7000
21 minutes later it had recovered 4.2 of those metres of
22 drawdown. There was still 80 centimetres of residual
23 drawdown or drawdown that had yet to be achieved.

24 MR. ESTRIN: I am sorry, I wonder if the
25 witness could just go over that point on the graph



1 again?

2 MR. PETRIE: I am reading the numbers
3 off the lefthand edge of the graph so I have to move it
4 a little bit. I am referring to about 3000 minutes
5 after the onset of the pumping for the well OW-2. I
6 note at that time, drawing my eye laterally across the
7 page, the drawdown, as I read this graph is
8 approximately five metres.

9 So, in 3000 minutes of pumping the water
10 level at this well had drawn down five metres. The pump
11 is then turned off and I am following visually again
12 those points which relate to OW-2. I move out to the
13 end of the graph being 10,000 metres and ...

14 MR. McQUAID: Q. 10,000 minutes, you
15 said metres.

16 MR. PETRIE: A. 10,000 minutes, yes. I
17 am having trouble reading these dots again. I believe
18 I am reading this dot in error. I believe that is a
19 circle with a vertical line penetrating from the top
20 and as I read the legend I should have referenced my
21 remarks to OW-3. I would like to repeat my statements
22 with respect to that.

23 We note that OW-3 being the far right-
24 hand curve of the three solid curves drawn on this
25 figure had at the end of the test a total drawdown of



1 in excess of one metre but less than two metres.
2 Approximately 1.8 metres of drawdown. OW-3 has
3 indicated the legend on this figure being CC-OW-2.
4 With reference to drawing 18 I note that CC-OW-2 is
5 located to the west of PW-2. I am pointing to the
6 middle of the northern one-third of this site. I
7 indicate approximately 1.8 metres of drawdown at the
8 end of the test interval. The pump is turned off, the
9 water level starts to rise. I notice that 7000 minutes
10 later the amount of drawdown still in evidence, there
11 is about 80 centimetres, so approximately half. I say
12 approximately in a round number. Approximately half of
13 the drawdown achieved during the pumping interval over
14 3000 minutes is recovered following the termination of
15 the test for the next 7000 minutes.

16 Q. Can I refer you in the text to
17 page 42?

18 DR. KINGHAM: I wonder if before he
19 does that you can clarify just a couple of things you
20 just said. You drew our attention to the fact that
21 OW-1 and OW-2 behaved in approximately the same
22 fashion. In fact you drew our attention to the upper
23 right-hand portion of this diagram which shows the two
24 on about the same line.

25 MR. PETRIE: Correct.



1 DR. KINGHAM: You told us just a few
2 minutes before that that the response of the
3 observation wells to the pump test, the pumping well
4 led you to the conclusion that the granular unit was
5 discontinuous to the east. If you will, with reference
6 to the diagram that is up there, show us where OW-1 and
7 OW-2 are?

8 MR. PETRIE: OW-1 is HC2-85. HC2-85 is
9 in the immediate proximity of PW-2. OW-2 is not
10 indicated. I gather, I could provide a location.

11 DR. KINGHAM: I think you might find it
12 by flipping that page up and I want to know if I am
13 reading the right numbers here. On drawing 5 should I
14 be looking at CC-OW-1 in the middle of the field to the
15 east of the site?

16 MR. PETRIE: No, I believe not. I will
17 refer to the interrogatory responses which I believe
18 posed the same question of Trow and they provided in
19 exhibit H-84. Let me provide the number and then
20 confirm that this is the correct exhibit.

21 Yes, I am referring to Exhibit H-84 in
22 addendum B, I beg your pardon, addendum C for the Site
23 D portion of this document. It is in the front one
24 quarter of the report, addendum C is headed location
25 plan of pumping wells and observation wells. The first



1 page relates to PW-1. I am referring to the second
2 page which relates to PW-2. We notice on that page
3 PW-2 is located in the top right-hand corner of that
4 schematic. Moving south and west a total distance of
5 3.05 metres we come cross OW-1 which is referenced as
6 HC2-85. That borehole is located on drawing 18 of H-
7 39. It is also located on drawing 5 from H-39.

8 Moving further southwest again we come
9 to entry OW-2 being 12.19 metres distant, either from
10 the pumping well or from OW-1. OW-2 is not referenced.

11 DR. KINGHAM: I think that has cleared
12 up that doubt in my mind. I thought somehow they were
13 related. OW-1 is on drawing 5 and they are not.

14 The other question I have with regard to
15 this chart is what happened at OW-3 for the first 300
16 minutes and at OW-4 for the first 2000 minutes.

17 MR. PETRIE: These wells are located at
18 a greater distance from the pumping well. The stress
19 is initiated at the pumping well, it takes a measure of
20 time before that stress is recorded by a change in
21 water level at the wells. I am presuming that water
22 level data is available for this point in time,
23 however, this is the first change in drawdown recorded,
24 that would be my assumption.

25 DR. KINGHAM: So we would understand.



1 there to be zero change, close to zero change for a
2 series of dots running across the bottom of that chart
3 and then the response beginning to show after 2000 or
4 3000 minutes?

5 MR. PETRIE: That is my expectation,
6 yes. The statements I made with respect to the small
7 amount of water level recovery for well OW-3, one can
8 interpret that similarly for OW-4 in that we have data
9 points recorded for this well going up to the period of
10 10,000 minutes being 3000 minutes for the pumping test
11 and 7000 for the non-pumping portion. Those same data
12 are not available on this figure with respect to OW-1
13 and OW-2. I see no data points, as indicated by the
14 legend, for OW-1 and OW-2 beyond about 1000 minutes up.
15 I think that is the last one there.

16 I am referring to 0.4, OW-2, giving
17 approximately 3500 minutes in total of time which is
18 equivalent to about 500 minutes after the pump stopped.
19 I cannot make any conclusions regarding the recovery of
20 OW-1 and OW-2, the data are not on this figure.

21 DR. KINGHAM: Thank you.

22 MR. MCQUAID: Q. Mr. Petrie, I wanted
23 to sure for the record, since you did indicate
24 initially you had read the chart entry for OW-3
25 incorrectly. In the middle of that last paragraph on



1 page 42 is the text correct:

2 "OW-3 recovered only about half of the
3 approximately 1.75 metres of drawdown
4 achieved during pumping."

5 MR. PETRIE: A. That is correct.

6 Q. Would you point that out on the
7 overhead for us?

8 A. Referring to the middle of the
9 last paragraph on page 42 with specific reference to
10 OW-3, we are referring to recovered only about half the
11 approximately 1.75 metres of drawdown. I am referring
12 to the point here at OW-3 being the highest point on
13 this curve, approximately 1.75 metres of drawdown since
14 the test was initiated for a period of 10,000 minute on
15 that graph we have about half of that 1.75 metres
16 recovered. I am reading that point at about 0.08, the
17 last point for OW-3 at approximately 10,000 minutes on
18 that figure.

19 Q. You make a comment at OW-4 only
20 one centimetre recovery followed the 16 centimetres of
21 drawdown. Can you point out where on the graph that
22 is?

23 A. The highest point on the curve for
24 OW-4 occurs at about nearly 6000 minutes where we have
25 about 0.5 to 0.6 of a metre of drawdown at that point



1 in time. The next approximately 4000 minutes, the
2 first reading comes out at about 0.5. I am noting that
3 there is a small amount of recovery at that point. I
4 beg your pardon, have I read that correctly?

5 I made an error. We are 10 centimetres
6 of drawdown here. 20 centimetres of drawdown there. I
7 indicate in the text that that point reflects about 16
8 centimetres of drawdown. The far point being 10,000
9 minutes for OW-4 indicates about 15 centimetres of
10 drawdown. I am noting that there is a one centimetre
11 change in water level during that period of
12 approximately 6000 to 10,000 minutes.

13 Q. Could you tell us what the
14 significance of this lack of recovery is? What is the
15 significance of these figures respecting recovery?

16 A. Could I refer to the paragraph
17 above that, if I might first, Mr. McQuaid. We will
18 focus on the response of PW-2. PW-2 is the pumping
19 well. This graph is slightly different in format from
20 the previous ones. Drawdown is on the vertical scale.
21 It is not a logarithmic scale, it is a normal scale.

22 The notation on the bottom t/t' is, in
23 hydrogeologic notation, t being the time since the
24 start of the pumping test in total and t' , since the
25 time that the test had stopped. The test went for



1 approximately 3000 minutes. One minute later we would
2 have the entry t being 3001. The time since pumping
3 stopped being 1 minute, we would have a point way out
4 at 3000. It is approximately 3000 units on this graph
5 out here.

6 So I am noting that the time starts at
7 the right-hand edge of the graph and generally goes
8 left. Had the period of recording the water level
9 following the pumped interval been exactly the same
10 interval as that which pumping had occurred, then I
11 will point out where that point may lie on this graph.
12 Pumping occurred for approximately 3000 minutes. If
13 recovery data had been collected for the same period of
14 time we would have had -- t would have been 3000
15 minutes of pumping plus the 3000 minutes of recovery
16 being 6000 minutes. Dividing by the time at which the
17 pump stopped being at 3000 minutes we would have been a
18 way out here on this graph, being a point indicated by
19 two for t/t' . I note in the text it is playing with my
20 calculator from this data. Specifically I am
21 addressing the last data point, last being furthest to
22 the level on that figure. Water level data appeared to
23 have been collected for a four hour period following
24 this pumping test.

25 The point I wish to make from this graph



1 is, one, noting the alignment, as indicated by Trow by
2 this straight line, it does not appear that this well
3 would easily recovery to its initial water level data.
4 The initial water level being 0.0 on that graph.

5 Page 43 discusses the significance of
6 this data. The first paragraph on page 43, the
7 apparent lack of complete recovery is of significance
8 in characterizing the hydraulics of this unit. CRA
9 considers the incomplete recovery to indicate that the
10 upper granular unit does not comprise a continuous
11 permeable layer under the western portion of the site,
12 but rather an isolated lens of granular material
13 imbedded within the lower till.

14 Focusing on the interpretation provided
15 by Trow on drawing 18, it indicates to the reader that
16 the upper granular unit comprises a fairly extensive
17 blanket under the bulk of the western portion of the
18 site. It was my interpretation from this pumping test
19 that because the water levels do not recover following
20 pumping, that it was my opinion that we are not looking
21 at an extensive layer but rather an isolated pocket or
22 lens, a circular-shaped body just by way of example,
23 such that the long recovery time reflects the water
24 that has to seep into this layer from the enveloping
25 till strata rather than having a continuous blanket



1 extending westward from the site to which groundwater
2 may flow into the pumped system.

3 Again we address this in more detail in
4 part C of our report.

5 Q. Right. Would you continue then at
6 page 43 where you were beginning to address the lower
7 granular unit as we see it?

8 A. Certainly. A second pumping test
9 at a different well, being PW-1, was undertaken to test
10 the hydraulics of the lower granular unit. PW-1 is
11 located, it is not appropriate to reference drawing 18
12 given that this is specific to the upper granular unit.
13 PW-1 is located towards the south central portion of
14 the site immediately approximate to HC4-85. There is a
15 small "t" beside it and it is indicated in the legend
16 that that is the well nest from which the tritium data
17 were obtained.

18 I note at the beginning of page 43 with
19 respect to the lower granular unit that only two
20 observation wells are fully screened in this unit,
21 while a third being HC1-85-2 is partially screened
22 within this unit. The wells that are in this unit are
23 HC1-85-2. I will try and locate these for the Board.
24 HC4-85 is immediately adjacent to the pumping well.
25 HC1-86 is on the south property boundary and I am still



1 .looking for HCl-85, on the far northwest corner.

2 So you have three wells across the site,
3 HCl-85 on the far northwest corner, HC4-85
4 approximately in the middle of the south central
5 portion of the site and 1-86 on the south property
6 boundary which are screened within the lower granular
7 unit. Other wells penetrate this layer, but water well
8 screens were not installed at the appropriate
9 elevations.

10 Three slug tests were conducted by Trow,
11 one on each of these wells, and we note that the
12 geometric mean of these values is 5.9×10^{-6} . I just
13 contrast that by way of comparison to the hydraulic
14 conductivity for this unit as assigned by Trow being
15 3×10^{-4} . That value, 3×10^{-4} , just quickly on the
16 overhead, I am referring to the assigned value for the
17 lower granular unit, 3×10^{-4} as indicated on Figure
18 B.3.1, page 34 out of the Halton report.

19 As with the upper granular unit we note
20 that there are slug test data which do not indicate as
21 high a value as one has concluded from the pumping test
22 data, I beg your pardon, as high as Trow had concluded
23 from the pumping test data.

24 At the very bottom of page 43, I note an
25 aquifer transmissivity of 9.7×10^{-6} metres squared per



1 second was determined by Trow from the pumping test.
2 Using an aquifer thickness of 4.1 metres CRA calculates
3 the hydraulic conductivity of 2×10^{-4} . I note there
4 on the bottom of the first paragraph on page 44 that
5 this is consistent with the value calculated by Trow
6 for this unit.

7 Referring to one of the graphs provided
8 in Appendix H-39A for this pumping test I am plotting,
9 I have taken from Exhibit H-39A, the heading says
10 "Theis Recovery". It is the recovery for the lower
11 granular unit. This is the data for the water level in
12 the pumping well, being PW-1. On the left-hand axis we
13 have the drawdown in metres from the original drawdown.
14 the axis on the bottom is t/t' which references the
15 time since pumping stopped, I beg your pardon, the
16 total time from the start of the test until the time
17 the pump stopped.

18 The point interest is that as one casts
19 one's eyes down the dots which indicate the water
20 levels and the time they were taken and this one
21 appears to reach a point in excess of its initial water
22 level. I draw two conclusions from this. The first is
23 that if the well was to recover we choose the word well
24 recovery which is an ambiguous expression, this well is
25 going to recover in excess of its original water level.



1 I would like to conclude from that that
2 this represents the hydraulic response of a continuous
3 layer as opposed to a lens and I contrast that to the
4 response I mentioned a few minute ago for the pumping
5 well in PW-2 for the upper granular unit. It is not
6 appropriate to overline them but just by recollection
7 we note that the line at this point, PW2 appears to
8 want to intersect the access at the water level where
9 we still have residual drawdown in excess of one metre.

10
11 In contrast for PW-1 we have a water
12 level that is already from the data available, has
13 reached the original water level. The second point
14 that one may conclude from that is that perhaps the
15 water level when the test was started was not stable.
16 By that I mean the well was drilled, the screen
17 installed, I am talking about the well, specifically
18 the pumping test well, and some development activity is
19 undertaken. Development is a general procedure that
20 the well drilling industry uses to remove the fine
21 material that may have come into the well through the
22 screen during the screen installation process.

23 You remove the fine grain material and
24 this is my conclusion: that perhaps having done that
25 the water level in the well was lower, that is commonly



1 the case. The water level was still rising to its
2 original position prior to the test being started. I
3 do not have at my disposal the exact length and time
4 that may be. I understand the test was initiated quite
5 soon within a period of a day or two after the well was
6 drilled.

7 One may possibly conclude from this that
8 the water level had not reached its original or static
9 position or equilibrium position prior to the onset of
10 the test. The conclusion one might draw from that and
11 referring to the first complete paragraph on page 44.
12 I am reading from the last sentence being the third
13 sentence in this paragraph:

14 "This suggests that the water levels
15 were not stable prior to testing..."

16 That being the pumping test:

17 "...and indicates that the cone of
18 influence developed during this test may
19 be more extensive than that interpreted
20 by Trow."

21 And I reference page 43 of Exhibit H-39. Trow at this
22 point noted that one of their adjacent observation
23 wells had not responded to pumping.

24 I would also like to refer the Board to
25 Exhibit H-84 being the interrogatory response to the



1 Weir and Foulds submission, addendum B. Addendum B
2 being about 10 or 15 pages into the document. That
3 addendum is headed "Construction Record - Pumping
4 Wells, PW-1 and PW-2."

5 With reference to the data on that table
6 for PW-1, the first page of that record indicates on
7 the left the pumping well and then a series of columns
8 going observation well, screen level top and bottom,
9 water level before and after. The far right column
10 indicates a drawdown. I notice that for the lower
11 granular unit for piezometer or observation well OW-2
12 that the water level appears to have risen through the
13 test interval.

14 I note that the water level before reads
15 178.91. The water level after 178.96. The entry under
16 the column marked drawdown is 0.05. Those data
17 indicate to me that during the test interval the water
18 level at that well OW-2 which is located a total of 12
19 metres distant from the pumping well rose during the
20 test. This is again a reflection, to me, that the
21 water levels prior to testing may not have reached
22 equilibrium. They were still rising.

23 One cannot conclude from this data that
24 because one had recorded a water level rise at this
25 point, this point being OW-2, that the cone of



1 depression generated from this pumping did not extend
2 to that point. I am making the observation that with
3 the water levels rising one cannot be too categorical
4 on the conclusion one draws from where one sees a
5 response to pumping.

6 That's why I make it, to read the last
7 sentence again from the first complete paragraph on
8 page 44:

9 "This suggests that the water levels
10 were not stable prior to testing and
11 indicates that the cone of influence
12 developed during this test may be more
13 extensive than that interpreted by
14 Trow."

15 DR. KINGHAM: Mr. Petrie, it would be of
16 assistance to us if, over the coffee break, you could
17 mark on those last two overheads where a couple of
18 representative points on the log scale of that graph
19 and perhaps tell us what t'' is since that is the fixed
20 quantity. We understand that the clock is still
21 running on t but that t'' is a fixed quantity; is that
22 correct?

23 MR. PETRIE: The clock is still running
24 on both, t is the time from when the test started which
25 includes the total time for the pumping interval and



1 the incremental time after the pump stopped at which
2 you record a data point. t' or t'' as it is indicated
3 here, is the time since the pumping stopped.

4 What I can do, as you suggest, is
5 indicate the time since pumping stopped at which these
6 points may have occurred.

7 DR. KINGHAM: Thank you.

8 MR. McQUAID: Q. Now the last paragraph
9 on page 44, you have already commented on the recovery
10 plot on PW-1?

11 MR. PETRIE: A. There is one other
12 comment I wish to make here, I note from the text.
13 Again referring back to Exhibit H-84 addendum B, that
14 was the page I just referred a minute ago to the water
15 level record for OW-2. The PW-1 being the top entry on
16 that page, looking at the far right-hand column, the
17 drawdown as reported there as 6.6 metres. In other
18 words, at the end of the test the water level change in
19 the pumping well was 6.6 metres.

20 I note in the last paragraph on page 44,
21 with reference to the overhead I have before the Board,
22 I say approximately 0.5 minutes after the pump shut
23 down the water level had risen to a point of 0.985
24 metres below original static. I am referring to this
25 point being the far right-hand on this figure. I will



1 have to provide the calculations by which I interpreted
2 that this point occurs within half a minute after the
3 pump shut down. I note that the water level drawdown
4 is less than one metre below the original static level.
5 That indicates to me that the balance of that being 6.6
6 and 0.985. In other words, in excess of five metres.
7 That water level rise of five metres occurred within
8 the first minute of pumping. That is an indication to
9 me that this well was not highly efficient. It is
10 another way of saying that were one able to increase
11 the efficiency of this well, more water could perhaps
12 be pumped from it. It is not always easy to increase
13 the efficiency of the well in moderately permeable
14 material.

15 I am just providing that as an
16 indication that when we come later to an assessment of
17 purge well options for these granular strata, I am
18 concluding from this pumping well test data that more
19 water could perhaps be pumped from this well if one
20 were to spend more effort to make the well more
21 efficient.

22 Secondly, have done so, the cone of
23 influence from such a well may be much more extensive
24 than that developed or interpreted from the available
25 data from this test. That relates to the last sentence



1 on page 44, I note that:

2 "A more efficient well could be pumped
3 at a greater rate and produce a more
4 extensive cone of depression."

5 DR. KINGHAM: Again, so as I can
6 understand that, because I am not sure the words came
7 out right. I don't think we need the graph. You were
8 saying that within half a minute of turning the pump
9 off the water level bounced up by some 5-1/2 metres or
10 so?

11 MR. PETRIE: Correct.

12 DR. KINGHAM: Then in the remaining time
13 it returned to the start?

14 MR. PETRIE: Correct.

15 MR. McQUAID: Q. Then at page 45, you
16 are examining a different aspect of the matter, the
17 hydraulic gradients?

18 MR. PETRIE: A. Correct. The first
19 paragraph on page 45 relates to the lateral component
20 of groundwater flow in the weathered upper till. I
21 note from Trow's drawing 17 that flow within this unit
22 is directed both southwest and eastwards towards the
23 adjacent surface water courses. I note further that
24 Mr. Beechinor reported a horizontal gradient as related
25 in the transcripts, being Volume 29, page 6123. This



1 horizontal gradient had a mean value of 0.0052 and
2 further that Geocon, undertaking a similar exercise
3 provided a horizontal hydraulic gradient which averaged
4 0.008. I note the last sentence in that first
5 paragraph.

6 . CRA does not consider this difference as
7 significant. That is the horizontal hydraulic gradient
8 within the upper weathered till. However, CRA does
9 consider the method that Trow used to calculate the
10 gradients as inappropriate.

11 MR. HODGSON: My text has a "not" in
12 it.

13 MR. PETRIE: However, I stand corrected.
14 CRA does consider that the method Trow used to
15 calculate the gradient as inappropriate. The second
16 paragraph relates to the horizontal hydraulic gradients
17 in the upper granular unit. Trow provide a number from
18 the drawing 18 of 0.001 and I note that one of the
19 wells shown in this drawing, PW-1, is completed in the
20 lower granular unit. I further note that given the
21 uncertainty regarding the distribution of this unit and
22 a few piezometer screens within it, CRA considers that
23 flow direction and gradient cannot be determined with
24 confidence. I note that where in section B of the
25 report critiquing the data provided by Trow. Again in



1 the bottom paragraph we believe there is insufficient
2 data to determine the flow direction and horizontal
3 gradient in the lower granular unit.

4 Turning to page 46. The potentiometric
5 distribution at the overburden/bedrock interface is
6 shown by Trow on drawing 16, Exhibit H-39. We note
7 there that there is little range in the values
8 presented and the average hydraulic gradient of 0.001
9 is calculated by Trow. We have reviewed this drawing
10 and considered that an average gradient of 0.003 may be
11 more representative.

12 I note further that the contoured
13 distribution shows a general groundwater flow direction
14 to the south and southeast and further that CRA expects
15 a similar pattern of groundwater flow in the lower till
16 and the granular units. Just to repeat what I said
17 before, it is my opinion there is insufficient data
18 provided by Trow to demonstrate with confidence the
19 flow direction and horizontal gradients in both the
20 lower granular unit and upper granular unit. However,
21 the bedrock interface for which there is an
22 insufficient amount of data, it is my opinion that we
23 can conclude from that, there is a general south to
24 southeast direction of flow from which an average
25 gradient of 0.003 may be more representative.



1 DR. KINGHAM: Mr. Petrie, I would like
2 to when you refer to south and southeast you are
3 referring to the directions on these many diagrams with
4 conventional north up or the true directions.

5 MR. PETRIE: I am referring to the
6 compass direction as shown. And the last point, second
7 paragraph, page 46 notes, that I expect to have a
8 similar pattern of groundwater flow in the granular
9 units and the lower till as that which is provided by
10 Trow for the overburden/bedrock interface in drawing
11 16.

12 MR. McQUAID: Q. Right, now you are
13 addressing the vertical hydraulic gradients and there
14 are two pages, a page and a half. You have reviewed
15 what Trow did, can you just tell us, is there any
16 substantial difference that you have been able to
17 determine?

18 MR. PETRIE: A. No, there is no
19 substantial difference between our review of the
20 hydraulic gradient data and the review provided by
21 Trow's own data. I note that we undertook to generate
22 a suite of vertical hydraulic gradient data for the
23 site using all the available data and that data is
24 contained in H-39A being the appendix to the
25 hydrogeologic report and Exhibit H-85, that being the



1 Weir and Foulds submission. I beg your pardon.

2 Q. CELA?

3 A. Scanning this report I see a
4 complete set of water level for Site D so could I
5 correct an entry on the last line of page 46?

6 Q. The reference to Exhibit H-85
7 should be H-84 then?

8 A. Correct. We took all the
9 available water level data in those two documents
10 referenced and using the mid screen elevations for each
11 piezometer generated a suite of vertical hydraulic
12 gradient data. That suite of data is contained in
13 Appendix 1 or Appendix A as indicated on the tab. It
14 follows the same format as that which was used for our
15 previous report, the Site F report, being Exhibit
16 B-617.

17 I don't propose to go through that
18 complete data set, but I note on page 47, the bottom of
19 the first partially complete paragraph that a review of
20 this data shows the following. This data being that
21 which I have just referenced in Appendix 1. Strong
22 downward gradients ranging from 0.014 to 0.421 occur
23 between the unweathered upper till and underlying
24 strata. These values average approximately 0.2.

25 The second point to note is the downward



1 gradient ranging from 0.004 to 0.046 are found within
2 the underlying strata. I further note that upward
3 gradients of 0.021 occur locally within the lower till
4 at HC4-85. I also note that transient upward gradients
5 occur at several other locations reflecting seasonal
6 variations in piezometric levels. At some points in
7 time the gradients are directed up and at others they
8 are directed down. I note that the mean gradient at
9 these locations is directed downwards.

10 In general the vertical gradients
11 beneath the upper till are low. It simplifies it to
12 make the statement that across the upper till the
13 gradients are more steep. Within the lower till which
14 is the lower till the granular units into the top of
15 bedrock vertical gradients are less steep.

16 Q. Correct. Now, then beginning at
17 page 47 you are, I understand it, pulling together the
18 comments on the groundwater flow system and the overall
19 review that you have undertaken?

20 A. Correct. I note in the first
21 sentence there, the first paragraph at the bottom of
22 page 47 under that heading B.3.4:

23 "CRA is in general agreement with Trow
24 that the groundwater flow at this site
25 is predominantly directed downwards with



1 the bedrock being the receptor of the
2 bulk of the infiltration at the site."

3 I note at the top of page 48 that Trow undertook a
4 water balance. I reference Figure 3, page 66 of
5 Exhibit H-39 and in this water balance Trow indicated
6 that 22.8 per cent, that is my number calculated from
7 that figure, 22.8 per cent of infiltration at the site
8 migrates laterally off-site, while 71.5 per cent
9 migrates down to the bedrock.

10 In the following paragraph we note that
11 this calculation was based on the assumption that the
12 upper granular unit comprised a continuous strata. I
13 note, however, as shown by Trow, the upper granular
14 unit is not continuous beneath the whole of the site
15 referencing drawing 18 of Exhibit H-39. I note that
16 this has the effect of reducing the amount of lateral
17 off-site flow with a resulting increase in the
18 percentage of infiltration that reaches the lower
19 units:

20 I would also note that based on our
21 pumping tests we consider that the upper granular unit
22 can be interpreted as a lens which has implications
23 which I will address in part C concerning the
24 continuity of this unit off-site and the potential for
25 this unit to provide a pathway for groundwater flow



1 laterally off-site.

2 The last two paragraphs in that section,
3 hydraulic gradients both vertical and horizontal are
4 generally low, indicating a slow movement of the
5 groundwater. The last paragraph, CRA considers that
6 the infiltration value used by Trow, that is 9.6
7 millimetres per year, and that can be found on the
8 water balance figure, Figure 3, page 66 of H-39.

9 That value is low, however, I do
10 consider this value may reasonably represent the
11 infiltration rate through the unweathered upper till.

12 Q. Then you comment on the
13 hydrogeology, pages 48 and 49 and the top of page 50.
14 If you go through those quickly and indicate what your
15 overall conclusions were?

16 A. Correct. I note at the bottom of
17 page 48 reading from the text:

18 "CRA is in general agreement with the
19 site hydrogeology as provided by Trow.
20 However, there are some areas of
21 differing interpretations, as
22 follows:..."

23 Turning to page 49, the first point:

24 "1 - The hydraulic characterization of
25 the weathered upper till is based on



1 assumed values and is not supported by
2 the available field data. The assumed
3 values are very conservative."

4 That assumed value being a value of 1×10^{-5}
5 centimetres per second.

6 "Based on the tritium results, Trow
7 calculates a hydraulic conductivity of
8 3.0×10^{-7} centimetres per second for
9 this unit. CRA considers that the
10 results from the tritium data provide a
11 more representative value than the value
12 of 1.0×10^{-5} assumed by Trow."

13 Trow have erred on the conservative side with that
14 assumption. We agree that they are, indeed,
15 conservative.

16 "2 - The use of slug tests alone may
17 not provide a reliable estimate of
18 hydraulic conductivity at low permeable
19 materials."

20 A concern at this point is that the hydraulic
21 conductivity of the unweathered upper till is an
22 important consideration for assessing the suitability
23 of a site for landfilling. CRA would recommend and has
24 completed laboratory determination of the hydraulic
25 conductivity of this till. This determination is



1 reported in section C.2.2.2 on page 87 of this report.
2 This report being Exhibit B-618.

3 I note here that the resulting mean
4 value of that information which we have provided at
5 section C.2.2.2 is 1.4×10^{-8} centimetres per second
6 and I note that that is significantly lower than the
7 8×10^{-8} centimetres per second reported by Trow.

8 The third point there, on page 49,
9 "The apparent lack of complete recovery
10 following the pumping test of the upper
11 granular unit indicates that this unit
12 comprises an isolated lens and not a
13 continuous layer extending westward from
14 the site."

15 The fourth point over on page 50,
16 "For the lower granular unit a more
17 efficient pumping well could produce a
18 greater yield and hence a more extensive
19 cone of depression."

20 These points which are summarized are a
21 critique of the Trow hydrogeology are again addressed
22 in part C of our report which provides CRA's
23 interpretation of the hydrogeology of this site.

24 Q. Now you are addressing another
25 section of the analysis undertaken by Trow, and that is



1 the evaluation of contaminant migration beginning on
2 page 51?

3 A. Correct.

4 Q. As I understand the report, you
5 are looking at it in the unweathered upper till and in
6 the granular units? Is that correct?

7 A. Sorry, could you repeat that?

8 Q. The weathered upper till on page
9 52 and in the granular units?

10 A. That is correct. If I can just
11 refer to the Figure B.4.1. At this point in the review
12 Trow had defined the contaminant pathways that
13 potentially may provide for the flow of groundwater
14 emanating from the landfill off-site. I am showing the
15 Board a figure taken from Trow, the source is
16 identified at the bottom of the page on which we note
17 that there was no leachate collection system in
18 operation. This is the engineering options for the
19 site which Mr. Crutcher will address.

20 With the leachate collection not
21 operating or failing, or never built in the first
22 place, we have two potential pathways. One being
23 lateral from the landfill, lateral through the
24 weathered till and the second one being downward
25 migration through the upper till, that is the



1 unweathered upper till, and the downward migration
2 through the lower till and we can divert to off-site
3 lateral migration in the granular units or further
4 migration to the bedrock and then off-site through the
5 shale bedrock.

6 Noting at the right-hand side of this
7 table we have a column headed, "Contaminant Arrival
8 Times at Site Boundary." These were taken from
9 portions of the text noting at A contaminant arrival
10 times from Trow, page 102, Exhibit H-39. We note that
11 for the hydrogeologic conceptualization provided by
12 Trow that they record a contaminant arrival time at the
13 site boundary of five years for lateral migration in
14 the weathered upper till. Sixty years to the site
15 boundary for downward and then lateral migration
16 through the granular units and a figure of 360 years
17 for contamination exiting the landfill to the bedrock
18 and thence laterally within the bedrock to reach the
19 site boundary at 360 years.

20 The second portion of this figure
21 addresses the leachate collection system in operation.
22 As one reads from this figure, Trow had indicated that
23 for the engineered system operating that the only --
24 that being what is known as the hydraulic trap -- that
25 the only potential pathway for contaminant loss from



1 such a landfill is down into the unweathered upper till
2 and further that that migration downwards is due to
3 diffusion. We note also from Exhibit H-86A, Figure 1,
4 page 7 that the diffusive migration of chloride at
5 steady state is approximately three metres. In other
6 words, chlorides exiting from the landfill under the
7 driving force of diffusion would reach a point of about
8 three metres and stay there. It is not a continuing
9 source loss through the unweathered upper till.

10 So, in reviewing this section we are
11 focusing principally on two pathways. Laterally
12 through the weathered till and downwards through the
13 unweathered till and laterally through the granular
14 units.

15 I note on page 51, point No. 1 there,
16 with the leachate collection system in operation
17 diffusion downwards into the unweathered till
18 represents the only contaminant loss from the landfill
19 into the sub-surface. For point No. 2, for a condition
20 where the leachate collection system or a portion
21 thereof has failed, contaminants can migrate laterally
22 in the unweathered till.

23 Q. I am sorry, it says, weathered
24 upper till?

25 A. I am sorry, I will repeat that



1 again. It says can migrate laterally in the weathered
2 upper till and secondly vertically downward through the
3 unweathered upper till and lower till and thence
4 laterally in the granular units and bedrock.

5 So, the two pathways defined under entry
6 No. 2 there, on page 51, followed from when the
7 leachate collection system or a portion thereof has
8 failed. The condition where the landfill is operating
9 as designed, pathway No. 1 being the diffusive loss
10 from the landfill represents the only migration pathway
11 from the landfill.

12 Q. You pointed that one out on the
13 overhead at page 53?

14 A. That is correct.

15 Q. And over at page 52 we see that
16 there is a consideration given to the migration times
17 that were given with respect to weathered upper till?

18 A. Correct. Under the heading of the
19 weathered upper till I am noting that Trow has
20 concluded that contaminants can migrate to the site
21 boundary in five years. I would like to point out that
22 that consideration was based in part on an assumed
23 hydraulic conductivity of 1×10^{-5} which I have
24 indicated to the Board I believe is very conservative
25 based on the tritium data provided by Trow, a value in



1 the order of 10^{-7} is more appropriate.

2 I am concluding at the last sentence of
3 the first paragraph under weathered upper till, an
4 arrival time of five years is considered by CRA as
5 unreasonable.

6 Q. Just give us the mathematics or
7 the -- how we transfer the difference in k to, between
8 the figure that was assumed by Trow, the figure for
9 tritium.

10 A. The values provided by Trow
11 which lead to that five year number are reported on
12 Table 10, page 88 of Exhibit H-39. Table 10 provides
13 Trow's summary of the linear groundwater velocity. We
14 note that for the first entry, the heading at the upper
15 portion of this table is no leachate collection system
16 in operation.

17 Looking at the far left-hand column
18 being hydrostratigraphic units we have the weathered
19 upper till. Moving to the far right we have a linear
20 groundwater velocity of 13 metres per year. Noting
21 that the middle column has an entry hydraulic
22 conductivity in centimetres per second and they have a
23 value of 1×10^{-5} . If a value of 10^{-7} was inserted at
24 that point, the linear groundwater velocity would be
25 100 times smaller, namely, 0.13 metres per year.



1 Q. Correspondingly the time then
2 would increase by the same number?

3 A. Rounding it out to a factor of
4 100, correct.

5 Q. Then there is a comment made in
6 the second paragraph on page 52 of Exhibit B-618, to
7 the effect that the experience at other sites of
8 landfills has not detected a serious problem like that?

9 A. That is correct. Trow recognized
10 that their value of five years, at least it was my
11 opinion that Trow recognized that their value of five
12 years seemed like a very rapid velocity such that were
13 that typical in landfills in Ontario one might have
14 expected to encounter contaminants adjacent to other
15 sites.

16 Recognizing that a number of sites in
17 southern Ontario are founded on tills in which the
18 upper portion is expected to be weathered in some
19 fashion. I note there on the page IX of Exhibit H-39, I
20 am reading from the bottom five lines, page IX of
21 Exhibit H-39:

22 "However, at landfills situated on
23 weathered clay tills in Ontario there
24 have been no cases where contaminant
25 migration through the fractures has been



1 documented."

2 It was my opinion that contaminant migration through a
3 weathered till surface does not lead to widespread
4 contamination based on the experience of landfills in
5 Ontario.

6 Q. Then, beginning at the bottom of
7 page 52 and continuing over to page 54 the text seems
8 to be addressing the figure on page 55, as I understand
9 it?

10 A. Yes. Recognizing we have some
11 uncertainties regarding the hydrogeologic conditions of
12 the weathered upper till, we had to evaluate the
13 engineered options that were available to the engineer
14 for this potential flowpath.

15 DR. KINGHAM: I wonder if before we go
16 into that you can just complete the thought you gave us
17 a minute ago when you said an arrival time of five
18 years is considered by CRA as unreasonable and then you
19 gave us a reference to page 9. Is there a linear
20 relationship between your arrival time and the linear
21 groundwater velocity?

22 MR. PETRIE: Yes.

23 DR. KINGHAM: So, if you are dropping
24 the linear groundwater velocity by two orders of
25 magnitude are you increasing your projected arrival



1 time by two orders of magnitude?

2 MR. PETRIE: Yes.

3 DR. KINGHAM: From five years to five
4 hundred years?

5 MR. PETRIE: That is what the
6 mathematics says. I would point out, however, on
7 reading the last sentence of the second paragraph under
8 the weathered upper till. However, it is recognized
9 that the hydrogeologic conditions governing flow in
10 such zones are not fully understood. It is to that end
11 that one has to evaluate engineering contingencies for
12 this horizon.

13 MR. McQUAID: Q. Mr. Crutcher, I was
14 going to ask you very briefly if you could explain
15 these four solutions that we see depicted on page 55
16 and described in the text on page 54?

17 MR. CRUTCHER: A. We do not consider
18 that lateral migration through the weathered upper till
19 to be much of an issue. This can be readily and quite
20 easily engineered around. In fact we have outlined
21 some of the options available. Those are graphically
22 presented on Figure B.4.2.1. On the landfill site you
23 can visibly inspect the face of the excavation to
24 determine whether in fact the fracturing is of any
25 significance. At that time, or prior, depending on



1 your orientation of when is the best time to do that,
2 you have a number of options right at that time.

3 You can extend a granular drainage
4 system along the edge of the slope that will allow a
5 significant variation in the permeability such that
6 there is preferential flow along the granular layer
7 into the leachate collection drain.

8 Q. You are really describing with
9 your pointer right now the second engineering solution
10 on page 55; is that correct?

11 A. That is correct.

12 Q. Just describing that you have a
13 granular -- two points to it -- that is a granular
14 section between the refuse and the fill?

15 A. That is correct.

16 Q. Then it goes down to a leachate
17 drain?

18 A. Correct. The other option that
19 you have at the time of excavation is the remolding of
20 the sidewall of the site. That essentially would
21 entail excavation out of a small portion of the
22 sidewall, recompact it in place and ensuring that
23 fractures are limited in that portion of the site.

24 Q. That is solution one as you see
25 it?



1 A. That's right. Both are easily
2 implemented and can be dealt with. In fact the
3 remolding option is how we, at CRA, have dealt with a
4 fracture zone at other sites.

5 Q. And solution 3 is, construction of
6 a clay cut-off wall that would be some distance removed
7 from the waste and the side of the till. Would you
8 just explain the configuration that we see cross-
9 hatched?

10 A. Essentially if at a later time
11 after the construction of the site you are concerned
12 about the migration of contaminants laterally through
13 the weathered portion of the till, it is essentially
14 straightforward to excavate what we refer to as a cut-
15 off trench. It is excavating out the weathered portion
16 and again recompact the material external to the
17 landfill site. It is very similar to option No. 1.

18 The fourth option which in fact is the
19 option that Trow has presented in their design report,
20 is putting a perimeter drain outside of the landfill
21 site to capture any contaminants that may be migrating.

22 The purpose of this section was just to
23 quickly outline that there are a number of engineering
24 options available to deal with it. The fracturing
25 through the tills is not an uncommon item. It is dealt



1 with on a regular basis at other sites.

2 MR. MCQUAID: Mr. Chairman, I am going
3 to go into the granular unit section now. This would
4 be an appropriate moment.

5 MR. LANCASTER: Perhaps we will take ten
6 minutes now then. Thank you.

7 ---Recess

8 MR. LANCASTER: Please be seated.

9 MR. MCQUAID: Q. Mr. Petrie, returning
10 to Exhibit B-618, page 56 there is a section on the
11 second area of contaminant migration which Trow
12 addressed and which you are addressing as well in this
13 part, beginning on page 56?

14 MR. PETRIE: A. Correct. I noted
15 earlier with reference to Figure B.4.1 on page 53, that
16 there were two potential pathways by which contaminants
17 might leave a landfill in the event that the landfill
18 was not operating as designed. One of these was
19 addressed by Mr. Crutcher as being the lateral flow in
20 the weathered upper till. This portion of the report
21 on pages 56 and 57 focuses on the lower pathway, one
22 that went through the till units to the granular unit
23 and then laterally off-site within the granular unit.

24 I note that Trow considered the upper
25 granular unit as the most significant pathway for off-



1 site groundwater flow and evaluated contaminant arrival
2 times at the site boundary in this granular unit only.
3 They didn't focus exclusively on the lower granular
4 unit. They felt the upper granular unit was of the
5 most concern.

6 I note on page 56 that these evaluations
7 were performed under the following assumptions:

8 1. Of the upper granular unit, the
9 UGU as I have indicated here, is continuous under and
10 beyond the western half of the site; and,

11 2. That the hydraulic conductivity
12 determined from the pumping test provides an average
13 value from this unit.

14 Picking up on the first point that the
15 upper granular unit is continuous beneath and beyond
16 the western portions of the site, I note in the
17 paragraph that follows that, CRA would agree, it would
18 be prudent to use this assumption given that the nearby
19 domestic wells exploit the overburden as a water supply
20 source.

21 What that paragraph means is: that it is
22 prudent to consider for the purposes of impact
23 assessment, i.e., the potential contaminant travel
24 times within any one groundwater pathway, that given
25 that domestic wells exploit the overburden adjacent,



1 i.e., westward from the site, that the granular unit
2 that is encountered beneath the site may extend
3 westward to encompass those wells.

4 I note at the bottom of that second to
5 last paragraph on page 56, this assumption provides the
6 worst case scenario. Obviously if the upper granular
7 unit was not continuous to that point, then groundwater
8 flow within that unit is unlikely to extend to that
9 point.

10 I note that the last paragraph on this
11 page, page 56, the impact assessment conducted by Trow
12 shows that for the proposed landfill operating as
13 designed, there will be no groundwater quality impact
14 at the site boundary in the granular units. My
15 reference there is to Exhibit B-259. I don't have a
16 copy of that, it was a graph showing just two sets of
17 axes for which there was no chloride data indicating
18 that there was no groundwater quality impact at the
19 site boundary for the landfill operating as designed.

20 I further note that for the condition
21 where the proposed landfill fails to perform as
22 designed, and further, that no corrective action is
23 implemented, a period of 60 years will elapse before a
24 groundwater quality impact is registered at the site
25 boundary in the granular units.



1 That is noting again that the granular
2 unit is continuous from beneath the site to westward
3 and secondly that the hydraulic conductivity determined
4 from the pumping test provides an average value for
5 this unit. I previously indicated to the Board that
6 based on some of the slug test data and the grain size
7 data for the upper granular unit that portions of this
8 unit may be less permeable than that determined from
9 the pumping test in the vicinity of the pumping well.

10 I note on page 57 in the second
11 paragraph that for lower hydraulic conductivities in
12 either the till unit or the granular unit, the travel
13 time will be longer. The last paragraph on page 57
14 sums up our conclusions regarding our critique of the
15 contaminant travel times for a failed landfill within
16 the granular units.

17 While CRA is in general agreement with
18 the results of the impact assessment, the assumptions
19 used by Trow lead to the over-estimation of the
20 groundwater velocity and an under-estimation of the
21 time of arrival.

22 Q. Just backing up to that second
23 last paragraph, I wanted to ask you to be a little more
24 specific. You have made the comment, the general
25 comment that the lower hydraulic conductivities in



1 either of the till units or the granular unit, the
2 travel time will be longer. What are your views, if
3 any, on whether the lower hydraulic conductivities in
4 either of those till units or granular units are likely
5 to be encountered?

6 A. For the unweathered upper till,
7 that portion of the till that directly underlies the
8 landfill, we will demonstrate in part C that based on
9 laboratory determinations of the hydraulic conductivity
10 of that unit a value less than that provided by Trow,
11 Trow used a value of 8×10^{-8} . Our laboratory
12 determinations indicate a geometric mean value of $1.4 \times$
13 10^{-8} centimetres per second. That is for the
14 unweathered upper till.

15 One could note that recognizing that
16 ratio is about a factor of six, one would expect six
17 times longer for the time of travel across that unit.
18 That unit being the unweathered upper till.

19 For the granular units I note that --
20 let me just find the place earlier in the report -- for
21 the upper granular unit, I am referring now to page 40.
22 The two slug test results provided in Appendix 12 of
23 Exhibit H-39A show that for the upper granular unit the
24 values reported are 1.1×10^{-6} , 4.0×10^{-5} . I also
25 note that some grain size provided at borehole HC-4-85



1 in which there was 4 per cent clay reported indicates
2 to me that the hydraulic conductivity of the upper
3 granular unit may be less than that provided from the
4 interpretation of the pumping test data.

5 I have not provided a new number for the
6 hydraulic conductivity of the upper granular unit. I
7 just note that given these variations the value for the
8 hydraulic conductivity as determined from the pumping
9 tests may be high relative to the bulk of the data for
10 that unit. Where a lower hydraulic conductivity
11 applied to that unit then the travel time through that
12 unit would be longer, recognizing again that this
13 consideration assumes that the upper granular unit
14 continues westward from the site and -- correct -- that
15 assumption is assuming that the upper granular unit
16 provides a continuous layer and that the landfill has
17 failed and no remedial action is implemented.

18 Q. Does that complete then the
19 examination of the contaminant travel times for those
20 two main areas?

21 A. That is correct.

22 Q. Then we go to page 58 to a section
23 on landfill design considerations.

24 I understand, Mr. Crutcher, this is a
25 section you have prepared and will be commenting on?



1 MR. CRUTCHER: A. That is correct.

2 Q. Could you just explain to us what
3 has been considered here and how that relates to the
4 Trow design considerations?

5 A. What we did was review the Trow
6 design aspect as provided in the hydrogeologic report
7 and provided a number of comments. We did an
8 independent check on some of the design criteria
9 utilized by Trow as compared to the actual design as
10 presented by Mr. Hiraishi.

11 Firstly, Trow does not discuss which
12 portions of the site they consider as hydrogeologically
13 suitable or preferable. That question was posed to
14 Mr. Sobanski, and he indicated essentially he felt the
15 complete site was suitable, however, he had a
16 preference to the western two-thirds, because there was
17 more data in that particular area so it would give him
18 a higher level of confidence.

19 The western two-thirds is the area of
20 the proposed landfilling area. We have taken a look at
21 the data and from our opinion of the complete site it
22 was considered hydrogeologically suitable.

23 Q. What do you mean the whole of the
24 original site?

25 A. I will just get a plan out of the



1 site. I will be referring to drawing 2, so I will put
2 that up and use it as a reference. Drawing 2 from
3 Exhibit H-41.

4 I am referring to the whole site, the
5 complete site boundary, the complete L-shape of the
6 site. I am referring to the western two-thirds is
7 actually the leg of the L where the proposed landfill
8 site is to be situated.

9 Q. All right. At the bottom of page
10 58 there is a general discussion of the hydraulic trap
11 as found in the Trow documents. I think that has been
12 discussed, would you just summarize there the concept
13 of the hydraulic trap?

14 A. The basis of the design, one of
15 the principle basis of the design is this site will be
16 designed on the principle of a hydraulic trap. This
17 essentially indicates inward gradients into the site.
18 What we undertook to do was to evaluate that in some
19 detail to see if in fact that design has been met by
20 the actual concept design as presented in H-41.

21 Q. All right. And over at page 59
22 you comment on the hydrogeologic elements of that trap
23 as presented by Trow?

24 "1. Maintain a maximum leachate level
25 of 1.5 metres above the landfill floor.



2. Allow for an additional seasonal piezometric fluctuation of 0.4 metres, so the floor elevation should lie 1.9 metres below the piezometric elevation of the underlying granular units and bedrock."

A. That is correct. Those are the principal design features given to Mr. Hiraishi for the design of the landfill site. So, the subsequent section which is essentially presented on Figure B.5.1 and Table B.5.1 present the results of our analysis and I will refer to those two figures.

I should note on Table B.5.1 which is found on page 62, in reviewing the numbers on the table, we discovered some minor discrepancies in the numbers. This came about when we were preparing our design and operations report. A similar table as presented in that report. We felt it would be wise to correct this table. It has no effect on the text per se but we felt it would be wise to have the correct table in place so there is no confusion.

DR. KINGHAM: Does it have any effect on Figure B.5.1?

MR. CRUTCHER: No, it does not.

MR. McQUAID: I have handed out to my



1 friends a copy of page 62R. The R designates that it
2 has been revised and it can just be inserted.

3 MR. CRUTCHER: What I would like to note
4 is the procedure we utilized so the Board has an
5 appreciation of how the determination of the hydraulic
6 trap is undertaken. We took from drawing 2 of Exhibit
7 H-39B which is the design and operations report for the
8 site, and I have presented this on the board, the
9 actual configuration of the landfill site and the five
10 cells.

11 On that plan we have superimposed the
12 location of the wells and, as you may refer to the
13 legend, I will refer to cell 4 as an example. It
14 applies to each cell, but I will use that as an
15 example. We have located in cell 4, HC2-86. From the
16 log we have determined the base elevation. That is the
17 bottom of the upper till unit and we have plotted that
18 with the two wells, and we have done that for the
19 complete figure.

20 We also plotted, the water level, the
21 lowest water level in April '86 from all the
22 piezometers. So whatever the lowest water level was,
23 whether it be in the overburden or the bedrock and used
24 that as the basis of criteria.

25 If I refer to Table B.5.1R, again I



1 would refer to cell No. 4 as an example. We have taken
2 the maximum base of the upper till, being the elevation
3 175.5. Then the base elevation of the landfill. You
4 can obtain that from drawing 2 from H-41. The base
5 elevation of the landfill you can see on the contours
6 here ranges from 178.5 to 179.1 which is the numbers
7 reflected in this portion of the table.

8 From these two numbers we can then
9 calculate the minimum upper till thickness. It is a
10 matter of subtraction of the lowest elevation against
11 the base of the upper till. In this particular case we
12 determined that is approximately 3 metres.

13 Then we can also determine the maximum
14 leachate level. You recall the design criteria was 1.5
15 metres above the base. You take the highest elevation
16 of the base, that being 179.1, adding 1.5 metres, you
17 get 180.6. The piezometric elevation, the lowest
18 piezometric elevation in April, 1986 from HC2-86 was
19 181.16. We rounded that to 181.2. By subtracting the
20 piezometric elevation from the maximum design
21 elevation, we then calculate the minimum hydraulic trap
22 head. You will recall that the design was specified
23 such that we would allow a factor of safety of 0.4
24 metres. That was intended to allow for a fluctuation,
25 a seasonal fluctuation in water levels.



1 Firstly you will note on Table B.5.1R
2 that we do maintain the hydraulic trap in all cases.
3 However, in cells 1 and 5, the 0.4 criteria has not
4 been met. We have reviewed this in some detail in the
5 design and operations and this can be overcome by a
6 minor design modification on the site which we will
7 discuss in some detail at that time.

8 I should also like to note that Trow in
9 their impact assessment used the thickness for the
10 unweathered upper till at four metres. In our review
11 of the minimum upper till thickness, I should note that
12 is minimum, they did not meet that four metre
13 criterion. It varied from 2.6 metres to 3.6 metres. I
14 should note that that is the minimum. I believe that
15 the Trow number was using more of an average across the
16 site and in our review of the numbers on an average
17 basis the four metres would be a fairly representative
18 number. There are areas due to the contouring of the
19 base that that criterion has not been met.

20 The other item I would like to address
21 is on the bottom of page 61. This addresses the design
22 leachate elevation. As indicated the design leachate
23 elevation was based on the criteria of maintaining at
24 or less 1.5 metres above the base of the landfill.
25 That elevation is quite critical on the design



1 hydraulic conductivity used for the waste. Trow
2 utilized a design hydraulic conductivity of 1×10^{-4} .
3 We note subsequently in that paragraph that the
4 hydraulic conductivity of refuse is quite variable, but
5 typically is expected to range from 10^{-1} to 10^{-4} .

6 I would like, due to the wording in
7 that, I think 10^{-1} is a little on the far end of the
8 range. In fact I think a more appropriate value would
9 be 10^{-2} . The design criterion of 10^{-4} is more in the
10 area of concern, but I think again for clarification of
11 the record, 10^{-2} would be more appropriate. 10^{-1} would
12 be an exceptional case.

13 CRA considers that the value of 10^{-4} is
14 conservative and provides a realistic assessment of the
15 magnitude of leachate mining. I should also note that
16 CRA uses 10^{-4} for designs that we are concerned with
17 throughout the province.

18 On page 63, we discuss the inflow
19 volumes that Trow had calculated due to this hydraulic
20 trap and note that the rate of inflow, that being
21 approximately 3.6 litres per minute is equal to or is
22 approximately equal to the yield of an average domestic
23 well. We consider that a very low amount of volume of
24 liquid to deal with.

25 We also conclude that the extraction of



1 this amount of water would have a negligible impact on
2 the groundwater levels. We conclude that on the basis
3 of such a low volume. We also note that the
4 calculations that Trow undertook for the impact
5 assessment, assumed no recharge, or no infiltration and
6 we did not think that was appropriate; but our overall
7 conclusion is it is a very small amount of water.

8 We draw an overall conclusion on the
9 landfill design aspects that CRA is in general
10 agreement that a hydraulic trap landfill design can be
11 implemented at this site. We go further to say that,
12 however, a modified design will have to be considered
13 in order to achieve the hydraulic trap design in a
14 portion of the site, meaning cells 1 and 5 where there
15 was a minor discrepancy on the design criteria. We
16 discuss this in more detail in part C of our report.

17 Q. Then, as I understand the report,
18 you are then discussing the contingency options
19 proposed by Trow in their report at pages 64 and 65?

20 A. That is correct, and Mr. Petrie
21 will address those items.

22 Q. Right. Could you just comment on
23 the Trow contingency program as set out in their report
24 and indicate whether CRA has any agreement or
25 disagreement with the Trow recommendations?



1 MR. PETRIE: A. We evaluate contingency
2 options for two potential groundwater flow pathways.
3 One being laterally through the weathered upper till
4 and the second one being vertically down through the
5 till units. That is laterally in the granular units.
6 We note on page 64, the second paragraph, that we are
7 assuming that regular maintenance of the engineered
8 components of the landfill will be undertaken to ensure
9 that the hydraulic trap, as proposed, is functioning
10 correctly.

11 Then we note that should excess leachate
12 heads develop within the landfill, then the hydraulic
13 gradient will be directed downwards across the
14 unweathered upper till, i.e., the hydraulic trap will
15 have failed in some fashion. That is what I meant in
16 the next sentence. In such a situation the hydraulic
17 trap will have failed and leachate will begin to
18 migrate into the underlying unweathered upper till. It
19 will also potentially migrate laterally within the
20 weathered upper till in that case.

21 The contingency options we are
22 discussing are predicated on the situation where the
23 hydraulic trap has failed in some fashion and we now
24 have the potential for groundwater contaminant
25 migration beyond the domain of the landfill.



1 We first note at the bottom of page 64,
2 that contingency measures can be implemented to reduce
3 the level of leachate mounding within the landfill and
4 restore the hydraulic trap. These measures which one
5 would generally consider as to be some sort of purge
6 well within the landfill, the cleaning of drainage
7 structures within the landfill, these measures were not
8 discussed directly in the Trow report. However,
9 Mr. Sobanski indicated under cross-examination and I
10 refer to the transcripts of Volume 28, page 5939 that
11 purge wells could be put into the landfill to extract
12 leachate in order to reduce leachate mounding and
13 restore the hydraulic trap.

14 The first point I want to make is that
15 one having identified a failure in some fashion of the
16 hydraulic trap there are some immediate actions that
17 can be implemented with respect to restoring that
18 hydraulic trap, i.e., lowering the leachate level
19 within the landfill. Assuming the leachate level can
20 be lowered and the hydraulic trap restored to its
21 original design condition, then the potential for
22 groundwater contaminant to flow away from the landfill
23 is reduced to zero.

24 Page 65, the first complete paragraph,
25 we note, however, that in the most unlikely event that



1 no contingency measures are implemented to restore a
2 failed hydraulic trap, then leachate may migrate from
3 the landfill via the following pathways. I indicate
4 two pathways there, laterally in the upper weathered
5 till and downwards to the granular units and hence
6 laterally.

7 With respect to the weathered upper
8 till, Mr. Crutcher discussed the engineered options
9 available to an engineer back in section -- I am
10 recalling the Figure B.4.2 on page 55. He had two
11 levels of contingencies. That may not be the
12 appropriate word. The first level is during the
13 construction phase or the excavation phase such that
14 were the qualified professional to indicate to the
15 design engineer that there is significant fracturing
16 exposed in the sidewalls of the construction two
17 options were indicated there, which Mr. Crutcher
18 outlines in Figure B.4.2 on page 55, that one, the
19 clays could be over-excavated and remolded and two, one
20 could put a drainage layer along that surface and
21 connect it into the proposed leachate collection
22 system.

23 Were the hydraulic trap to fail and
24 secondly were contaminant migration within the
25 weathered upper till to be identified, were that level



1 to be of concern, then perimeter drains can be
2 installed to intercept this flow.

3 Again back to page 35 where we had
4 Figure B.4.2, alternatives three and four provided on
5 that Figure 3, being a construct clay cut-off wall,
6 simply to dam or prevent continued lateral movement
7 within that zone, or option four which I understand is
8 what Trow has proposed, is a collection system placed
9 in the upper weathered till to collect any groundwater
10 flow migrating in that unit and pump it out. In other
11 words, prevent it migrating beyond the point of the
12 drain.

13 Q. Then the last paragraph of this
14 section, the second paragraph on page 66, you summarize
15 Mr. Sobanski's indication that the potential for
16 contaminant migration in this zone is not a concern.
17 To summarize the next sentence, it reads, "CRA
18 agrees..."?

19 A. "CRA agrees with the above and
20 points out, as indicated by
21 Mr. Sobanski (Volume 34, p.7431), that
22 determining the linear groundwater
23 velocity in this zone..."

24 This zone here refers to the weathered upper till:

25 "...is not all that critical given the



1 contingency options available."

2 Q. Then would you comment on the
3 lateral migration in the granular units, the second
4 unit or pathway of concern?

5 A. Yes. Starting in the middle of
6 page 66, we are addressing lateral migration in the
7 granular units. The first point I note is that, as
8 demonstrated by the pumping test, groundwater flow in
9 the upper granular unit can be controlled by pumping.
10 I will refer to drawing 18 again, which provides Trow's
11 interpretive extent of the upper granular unit.

12 DR. KINGHAM: It occurs to me now that
13 it might be useful at some point in the future if we
14 had a huge cork board that fitted over the easel with a
15 bunch of thumbtacks, it would be a lot easier on the
16 tendons and grip of the witness with those clips.

17 MR. PETRIE: I understand. I lost my
18 train of thought.

19 As demonstrated by the pumping test,
20 groundwater flow in the upper granular unit can be
21 controlled by pumping. The upper granular unit pumping
22 test was conducted at PW-2. Drawdown was identified in
23 HC2-85 immediately approximate to this well. An
24 observation well which I recall being OW-2 which is not
25 indicated on this figure, another observation well, CC-



1 OW-2 and lastly, down at HC2-86. Can I just make sure
2 I have that correct?

3 I am just looking at the text on page 45
4 of H-39. The last line of the first paragraph reads
5 that the measured drawdown at HC6-86. I am noting, I
6 believe that to be an error. I believe it should be
7 HC2-86. I would prefer to refer to the drawdown graphs
8 and tell the Board that I have indeed identified the
9 correct wells in which a response was monitored in the
10 upper granular unit.

11 MR. McQUAID: Q. I don't see a
12 reference to HC2-86 on pages 66 or 67. Is there a
13 point in the text that should be changed?

14 MR. PETRIE: A. No, I did not indicate
15 this in the text. I am just referring to the first
16 paragraph there that from the pumping test conducted by
17 Trow on the upper granular unit that a response was
18 recorded in a variety of positions in that aquifer
19 beneath the site. I am referring again to the appendix
20 in which they provide the pumping test data. It was
21 indeed in HC2-86 that provided a response.

22 On drawing 18 of Exhibit H-39, pumping
23 well PW-2 towards the north of the site was pumped and
24 the response was recorded in three wells, one of which
25 is not located on this figure close to that pumping



1 well. A response was also recorded, a small response
2 was also recorded at HC2-86 located further to the
3 south. I am concluding from that statement that as
4 concluded from this pumping test, a groundwater flow in
5 the upper granular unit can be controlled by pumping.
6 I am not addressing the number of wells, I am just
7 noting that one can pump that unit and extract
8 groundwater and influence the groundwater levels over a
9 large portion of that unit.

10 The last paragraph on page 66 addresses
11 the pumping rate that would be required from such a
12 well. The required pumping rate is expected to
13 approximately equal the infiltration to the landfill,
14 i.e., the amount of water one would have to pump out of
15 the granular unit would in part depend on one's
16 interpretation of where that unit is, but roughly the
17 amount of water that migrates down to that unit is
18 entering in through the top of the system, i.e., is
19 approximately equal to the infiltration to the
20 landfill.

21 Trow calculate a rate of 12.6 litres per
22 minute for infiltration to this unit for the area they
23 consider. I note that a hydraulic gradient of 0.5 was
24 used in this calculation to reflect the effects of
25 leachate mounding, i.e., in the event that the



1 hydraulic trap has failed, leachate builds up within
2 the system and can seep from the base of that landfill,
3 Trow used a hydraulic gradient of 0.5 to describe that
4 condition of leachate build-up.

5 I notice at the bottom of page 66 it
6 says in an earlier section addressing contaminant
7 arrival times Trow used a gradient of 0.85 to reflect
8 the effects of leachate mounding. I therefore take
9 that gradient 0.85 and redo Trow's calculations and
10 note that under this gradient of 0.85 an infiltration
11 rate to the upper granular unit, 21.4 litres per
12 minute, or 4.7 gallons per minute is calculated.

13 I note that this rate is approximately
14 equal to the yield of about four domestic wells and as
15 such is not expected to have any discernable effect on
16 groundwater levels in the area. It should be noted
17 that at present there are four domestic wells on Site
18 D. It is expected that pumping from these wells will
19 be discontinued should landfill development proceed.

20 CRA concludes, therefore, that the
21 operation of a purge well system will not impact
22 present water levels. Again we are referring to a
23 purge well system in either the upper or the lower
24 granular unit on that basis.

25 I might also note that in the next



1 paragraph on page 67 that Trow had calculated the long-
2 term impact on water levels resulting from purge well
3 operations. They concludes that water levels at
4 domestic wells to the west of the site would be lowered
5 by about 1.7 metres after 27 years of continuous
6 pumping.

7 I wish to point out, however, some
8 concerns I have with the method of arriving at that
9 calculated drawdown. In the next paragraph, implicit
10 in this calculation, and it is detailed in Appendix 16
11 of Exhibit H-39A, is the assumption that all of the
12 pumped water was drawn from within the upper granular
13 unit and that infiltration was nil. The calculation
14 used in this, the formula used in this calculation is
15 developed from pumping well tests. Pumping well tests
16 are typically short-term events, i.e., one day or two
17 days. On the basis of the mathematics for pumping well
18 analysis assumes for the sake of convenience that there
19 is no infiltration into the system and that all the
20 water pumped comes from the unit being pumped. As I
21 just indicated, with respect to a short-term event like
22 a pumping test that is perfectly reasonable. However,
23 for assessing the effects of long-term performance of a
24 well, one should also consider the infiltration that
25 would enter that system over the period of time in



1 question. In this case we are looking at 27 years.

2 I note that on the bottom of this second
3 to last paragraph on page 67, CRA considers it
4 unreasonable when examining the effects of pumping on a
5 scale of years, to use this type of assumption. I
6 would refer back to the last portion of the first
7 paragraph on page 67 where I note that at present there
8 are four domestic wells on-site. It is my expectation
9 that pumping from these wells will be discontinued
10 should a landfill development proceed.

11 It is also my expectation, based on the
12 calculated numbers one sees at the very top of that
13 page, that the yield from four domestic wells is
14 approximately equal to the value of the infiltration
15 calculated using the numbers at the top there. The
16 infiltration rate to the granular units.

17 Put in simple terms, there are four
18 wells on-site. Should these wells stop pumping, water
19 levels might be expected to rise in some fashion very
20 slightly. For purging then to be initiated because of
21 concerns with contaminant problems, one would not
22 expect to see a lowering of water levels beyond those
23 which would presently happen at the site.

24 At the bottom of page 67 and following,
25 I undertake some calculations to the effect, the



1 drawdown which one might have in the upper granular
2 unit at some distance from the well. On the top of
3 page 68 I indicate the variables which I used in this
4 calculation. I will note that the fifth variable
5 entered there, t being 100 days. I undertook this
6 calculation using a set of pumping test mathematics for
7 which I used a t of 100 days. I compared that to the 27
8 years that was provided in the Trow document.

9 Q. Why did you use 100 days?

10 A. Because I believe that 100 days is
11 the time that it may be significant. I note a drawdown
12 of 0.76 metres was calculated.

13 Q. Zero point seven six metres was
14 calculated?

15 A. That is the calculated drawdown
16 after 100 days pumping for a point located 150 metres
17 from the pumping well. The next paragraph on page 68
18 indicates that it was also assumed for the purpose of
19 this calculation that the upper granular unit extends
20 beneath the site and westward to beyond First Line
21 Road. CRA considers that the upper granular unit is
22 not continuous beneath and westward from the site.

23 So that calculated drawdown of 0.76
24 metres was contingent upon the continuity of the upper
25 granular unit which I have already called in to



1 question based on my review of the pumping test results
2 and which we will discuss further in part C.

3 Just to repeat a couple of the points I
4 raised earlier. Given the above calculated drawdown,
5 that being 0.76 metres, and the assumed abandoning of
6 the four domestic wells currently on-site, CRA
7 concludes that the operation of the contingency purge
8 well system for the upper granular unit will not have a
9 discernable impact on the present groundwater levels
10 adjacent to the site.

11 Reading on, a purge well(s) operating at
12 the above rate would be required only in the event of
13 total failure of the landfill system. A much reduced
14 pumping rate would be required for a partial failure of
15 one cell. For such a failure, estimated at say 10 per
16 cent of the area of the landfill, the pumping rate --
17 reading over on page 69 -- would reduce to 2.14 litres
18 per minute. The calculated drawdown thus reduces to
19 0.076 metres.

20 I note there the second complete
21 paragraph on page 69 that the same arguments apply to
22 the potential effects of pumping from a purge well
23 system completed in the lower granular unit. However,
24 because of the lower transmissivity, more pumping wells
25 may be required than for the upper granular unit to



1 control a totally failed landfill. However, a lower
2 transmissivity results in a lower calculated drawdown
3 at the nearby domestic wells.

4 I conclude at the bottom of page 69, CRA
5 concludes that contaminant migration, were it to occur
6 in the granular units, can effectively be controlled by
7 operation of a purge well system without interfering
8 with groundwater levels in the area.

9 DR. KINGHAM: Before you leave that
10 section I notice that throughout it, apart from a
11 reference to 12.6 litres per minute in the very first
12 part of B.6.2 on page 66, you used the larger value of
13 21.4 litres per minute reflecting a mounding and a
14 corresponding gradient of 0.85. Which do you believe
15 to be the case, a hydraulic gradient of 0.5 or a
16 hydraulic gradient of 0.85?

17 MR. PETRIE: I believe we addressed that
18 in part C. I believe a gradient of 0.85 is more
19 appropriate to a failed condition.

20 MR. McQUAID: Mr. Chairman, I wanted to
21 indicate to the Board we are at the end of the day. We
22 are just going to another section and we wouldn't get
23 very far into it. Mr. Crutcher, Mr. Petrie and I are
24 going directly to a meeting of the City of Burlington
25 Council and we would appreciate a break at this point.



1 The reason I came out to Mr. Petrie is
2 he indicated there was one additional page, correction
3 page that was to be handed out and I wanted to hand it
4 out to my friends just at the break. Have you got
5 that, Mr. Petrie?

6 MR. PETRIE: I have.

7 MR. McQUAID: Q. Can you just indicate
8 it is page 86 revised?

9 MR. PETRIE: A. It is 86R, R standing
10 for revised Table C.2.1R, there being some additions to
11 this table, as indicated by the single star in the
12 notes. The single star, says, reported 9-03-88, the
13 9th of March, 1988, the values on those tables, or the
14 columns on those tables indicated with a single star
15 are recent additions to that table.

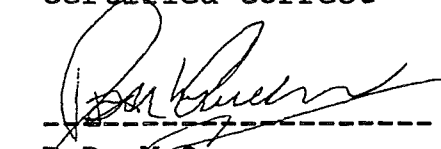
16 DR. KINGHAM: Otherwise the values are
17 all the same, is that correct?

18 MR. PETRIE: Correct.

19 MR. LANCASTER: We will adjourn until
20 9:30 tomorrow morning.

21 ---Adjournment at 4:26 p.m.

22 Certified Correct

23 
24 -----
25 P.D. McQueen

(Page 26400 follows)

