

T. Vigod

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-QP-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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I N D E X

WITNESSES:

<u>DR. RONALD KERRY ROWE</u>	(Sworn)	18604
<u>DR. DAVID LEONARD CHARLESWORTH</u>	(Sworn)	18604
Examination in Chief by Mr. Estrin		18606

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2 Consolidated Hearings Act, 1981, S.O. 1981, c. 20;

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15 under, the Conservation Authorities Act, R.S.O. 1980,
16 c.85, as amended;

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20 plan control of the sanitary landfill site;

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33 "Agriculture" to permit a regional sanitary landfill
34 site and ancillary uses;

35 - and -
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38 Honourable Claude F. Bennett, Minister of Housing on a
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BEFORE: H. H. Lancaster, Q.C. - Chairman

Dr. D.J. Kingham - Member



Hearing conducted at The Oakville
Granary Commercial Centre, 105 Robinson
Street, Oakville, Ontario, on Monday,
January 25, 1988

VOLUME 79

APPEARANCES:

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



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APPEARANCES (Cont'd):

1

2

C. Stevenson
P. Hancock

3

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

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J.H. Olah

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for the Halton Region
Conservation Authority

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Re: PD M~~Q~~en

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Oakville, Ont.
January 25, 1988

1
2 --- Upon Commencing at 9:30:

3 MR. LANCASTER: Good morning, please be
4 seated.

5 MR. TIDBALL: I see Mr. McQuaid isn't
6 here. Maybe he is making his way down. I got a phone
7 call from Ms. Vigod who asked me to pass on to you that
8 she will be here for the evidence of these two
9 witnesses except for today. She is required to be in
10 Federal Court. There is some possibility she will be
11 here later today.

12 MR. ESTRIN: Perhaps while we are
13 waiting the witnesses could be sworn.

14 DR. RONALD KERRY ROWE (Sworn):

15 DR. DAVID LEONARD CHARLESWORTH (Sworn):

16 MR. ESTRIN: While we are waiting there
17 is one document, Dr. Rowe's curriculum vitae which was
18 not given a number due to an oversight on my part on
19 Friday. I think you will find it tucked inside, the
20 olive coloured one that is the list of publications,
21 Exhibit M-443. Might I suggest that that be marked as
22 443-A?

23 DR. KINGHAM: M-443-A.
24
25



1 ---EXHIBIT NO. M-443-A: Curriculum Vitae of
Dr. R. K. Rowe

3 DR. KINGHAM: The Board assumes that
4 Mr. McQuaid was informed of the fact that we would be
5 into hydrogeology this morning was he, does anybody
6 know?

7 MR. ESTRIN: I can only assume
8 Mr. Tzekas so informed him.

9 MR. HODGSON: There is no one in the
10 Burlington office, no coats, nothing. One alternative
11 would be to permit Mr. Estrin to qualify his witnesses.
12 I don't know how long that would take. I can't imagine
13 that would prejudice Mr. McQuaid. If he hasn't arrived
14 at that point ...

15 DR. KINGHAM: My inclination would be to
16 have someone call his office to make certain he is on
17 his way.

18 MR. LANCASTER: In the meantime we can
19 qualify the witnesses. Here he is. I won't make the
20 obvious statement. We weren't too concerned,
21 Mr. McQuaid.

22 DR. KINGHAM: Now that we have finished
23 with the hydrogeology evidence we can move on!

24 MR. LANCASTER: Mr. Estrin.

25 MR. ESTRIN: First of all, Mr. Chairman,



1 before we get to the qualifications of the two
2 witnesses there are one or two corrections which have
3 to be indicated to one report at least. That is
4 Exhibit M-437, the Geocon report on Site F.

5 EXAMINATION BY MR. ESTRIN:

6 Q. Dr. Charlesworth, you could
7 perhaps just rise and assist me in confirming these
8 corrections are to be made. I believe, first of all,
9 on the summary page, (i) in the first paragraph, the
10 second line it reads:

11 "Surficial deposits in the upper
12 weathered zone..."

13 MR. LANCASTER: Whereabouts?

14 MR. ESTRIN: In the first paragraph, the
15 second line against "surficial deposits in the upper
16 weathered zone", if you would delete the word
17 "weathered".

18 Q. Then at page 4-5 the second
19 paragraph from the bottom in the second line it refers
20 to piezometers installed in 8 locations?

21 DR. CHARLESWORTH: A. That is correct.

22 Q. That is fine. Finally one more, a
23 real one, at page 4-9 in the third line there is a zero
24 missing referring to, it says "She derived a range for
25 the porosity of .00..." there should be an extra zero



1 there, .0007 per cent.

2 DR. KINGHAM: So that is three zeros, 7?

3 MR. ESTRIN: Correct. Other corrections
4 were previously made. We have advised other parties of
5 previous corrections to be made in the report and we
6 have written them into the copies already filed with
7 the Board.

8 First of all, Mr. Chairman, Dr. Kingham,
9 we intend to have a panel of these two gentlemen. They
10 have prepared different reports on the two sites but
11 ultimately their work closely interrelates. According,
12 we thought it expedient to do it in this manner. I am
13 sure in the overall result it will certainly save time
14 rather than having each of them up here and cross-
15 examining them and having them re-examined.

16 Obviously, much as we have seen with
17 other panels there will be certain aspects of their
18 testimony that will be of their own and at other times
19 there will be, obviously, an interplay on specific
20 topics as we go.

21 First of all I would like to begin with
22 Dr. Charlesworth and his qualifications. The Board
23 has his curriculum vitae, Exhibit M-439. If I could
24 take you through this Dr. Charlesworth.

25 Q. You obtained first of all a



1 Bachelor of Science in Geology in 1965 at Manchester
2 University in England?

3 A. That is correct. That was honours
4 geology.

5 Q. Then you went on, I take it,
6 shortly thereafter to do a Master's of Science work in
7 hydrogeology. Can you tell us just a bit about that?
8 That seems an early date, 1966 in relation to this
9 evolving field?

10 A. Yes. In fact this was the first
11 year at which the Master's degree in hydrogeology was
12 offered, I think, in Britain, in general. Certainly at
13 the University of London. That is a minor inaccuracy
14 there. I completed the work in 1966, the degree was
15 actually awarded, Mr. Chairman, in 1967, although I
16 started working late in 1966. This was a degree that
17 was awarded by course work and examination and covered
18 the various aspects of hydrogeology.

19 Q. After that degree was obtained, I
20 believe, looking through your CV that you started into
21 the real practice of hydrogeology; would that be fair?

22 A. That is correct. I went from
23 London University to what was then the Water Resources
24 Board in England where I worked for a year in the
25 groundwater division of the Water Resources Board.



1 Q. That is referred to at page 5 of
2 your curriculum vitae, I believe?

3 A. That is correct.

4 Q. At that time you were doing, among
5 other things, aquifer tests and geological evaluations
6 of sites, for example, dams?

7 A. That is right. I did a number of
8 aquifer tests or pumping tests with a view to
9 determining appropriate quantities for water supply and
10 I looked at some evaluation of potential dam sites and
11 some general water resources evaluations.

12 Q. Then you continued, looking on the
13 bottom of page 4 of your CV, I gather you then began
14 some work for the government of Jamaica, water
15 resources division? Can you tell us a bit about that?

16 A. Mr. Chairman, I was recruited
17 through the British Ministry of Overseas Development as
18 part of their overseas aid program, then the Ministry
19 of Overseas Development. I took two tours of duty with
20 them in Jamaica working for the water resources
21 division of the government of Jamaica, although in
22 reality I was working with the United Nations Food and
23 Agricultural Organization, water resources project.

24 Q. Some of the work that was involved
25 there I think is summarized at the top of page 5, some



1 of the tests you had to do included pumping tests,
2 field analysis and interpreting laboratory analysis of
3 groundwater chemistry?

4 A. Yes. The work of the United
5 Nations project was assessing the water resources of a
6 number of basins in Jamaica and the work there
7 consisted of the drilling of small diameter and large
8 diameter boreholes, carrying out pumping tests and
9 sampling of water in terms of water quality and the
10 assessment of appropriate yields of basins of
11 watersheds.

12 Q. You say you undertook computer
13 modelling of groundwater flow. Just give us a bit of
14 insight into that. Was that an early application in
15 your view of computer modelling in this area?

16 A. At this time, it was a relatively,
17 it was a relatively new tool in groundwater work at
18 that time. Groundwater in the 1960's was primarily
19 water resources oriented. There has, over the years,
20 been a change as we have got more into waste
21 management. At that time most of the work was water
22 resources and one of the new techniques that had been
23 applied was computer modelling. This was an attempt to
24 determine the safe yields of basins and to simulate the
25 flow within a watershed.



1 Q. Right. Then, you did some work
2 and a couple more years of work in England, as I
3 understand it, looking at the period of 1974 to '75,
4 that was just before you came to Canada?

5 A. Yes, between 1972 and 1974 I went
6 back to the U.K., where I undertook research for a
7 doctorate in hydrogeology, so that came between these
8 two periods.

9 Q. I notice if we go back to page 3
10 then, you joined James F. MacLaren Limited in 1975 in
11 Toronto and you were with them for five years in
12 various positions during various tasks. Also during
13 that period I see you also received your Ph.D in
14 hydrogeology. Can you tell us how those two things
15 work?

16 A. Yes. I worked on my Ph.D between
17 1972 and 1974. At that time I had a two year research
18 studentship at the University of Aston-in-Birmingham.
19 At the end of the two years I still had some work to do
20 on my Ph.D so I worked for a year in Britain and then I
21 came to Canada, I think with about six weeks work left
22 to do on my Ph.D but subsequently submitted somewhat
23 more than six weeks later.

24 Q. That Ph.D was subsequently awarded
25 and it says on page 1 of your CV through the Department



1 of Civil Engineering?

2 A. Yes. This is correct. I received
3 my studentship through the Department of Civil
4 Engineering with primarily hydrogeological work that I
5 was doing. I had a supervisor both within the geology
6 department and the civil engineering department, but my
7 principal supervisor was in civil engineering.

8 Q. Was there some overlap then seen
9 by those two departments at that time in this area?

10 A. Yes, I think hydrogeology is one
11 of these fields that can be approached from a number of
12 directions. Some people have a geological background
13 and other people come into groundwater or hydrogeology
14 from an engineering background. Certainly at that time
15 a number of people in civil engineering, I would say at
16 that time they were becoming more interested in
17 groundwater particularly -- a lot of work was being
18 done with computer modelling in the engineering
19 department at that time.

20 Q. Just briefly, what is the
21 relevance, if any, of your Ph.D work to the issues that
22 are before this Board?

23 A. I feel that it is relevant in that
24 the work that we have been doing here requires a basic
25 understanding of hydrogeology. My Ph.D obviously



1 covered, you needed that basic requirement. I also did
2 some computer modelling within the work that I was
3 doing for my Ph.D. I prepared a groundwater model of
4 data that I had collected in Jamaica and so I suppose
5 there is some relevance there although I must stress it
6 is a different type of modelling. It is modelling of
7 groundwater flow on a basin-wide scale. Certainly not
8 contaminant modelling in the way that people have been
9 doing it with the current project, but I feel that
10 there is some relevance.

11 Q. What about some of the tasks that
12 your field was involved with that led to those results,
13 is any of that relevant?

14 A. Yes, I feel the field work was.
15 The field work was actually done prior to my leaving
16 Jamaica and it involved the drilling and testing of
17 boreholes and chemical analysis, geological mapping. I
18 think that is all relevant background to this type of
19 project.

20 Q. Now, can we come very briefly to
21 page 3 of your curriculum vitae. The positions you
22 held at MacLaren, James F. MacLaren at that time was
23 what, engineering?

24 A. James F. MacLaren were
25 environmental consultants. They were originally a more



1 traditional type of consulting engineers, who in the
2 early seventies were one of the first companies to get
3 involved in the environmental field. I was working
4 principally in the environmental aspects of the work
5 they were doing.

6 Q. You were manager in both the earth
7 sciences division and the hydrogeology division?

8 A. That is correct, when I joined it
9 was strictly a hydrogeology division but the scope of
10 the work we were doing was expanded to include
11 analysis, terrain analysis, soil science.

12 Q. During that time, looking at pages
13 3 and 4 of your curriculum vitae it would appear that
14 you not only did water resources work but you began to
15 get into contaminant groundwater work. Is that fair?

16 A. Yes, that is correct. During my
17 time with MacLaren's I continued to be involved in some
18 water resources projects but the work tended to break
19 down almost into the field of international work which
20 was still very much geared to water resources and the
21 work within Canada that I was involved in tended to be
22 environmental waste management, waste disposal,
23 remedial work, this type of thing.

24 Q. For example, looking at Key Lake,
25 Saskatchewan, it says:



1 "Technical advice to the Key Lake Board
2 of Enquiry and review of groundwater
3 aspects of the environmental impact
4 assessment submitted by the Key Lake
5 Mining Corporation."

6 What were you advising them on?

7 A. There was a hearing into the
8 application by Key Lake Mining Corporation to open up a
9 uranium mine in Key Lake. I was the adviser to the
10 Board on groundwater aspects or to assist them in
11 evaluating the submissions by the proponents of this
12 scheme.

13 Q. There were differing submissions
14 on those technical issues at that time?

15 A. That is correct, yes.

16 Q. Now, just continuing
17 chronologically and we will come back to some of the
18 specific projects later. You went on to work for
19 Lavalin-MacLaren Plansearch Inc., from 1980 to 1983 and
20 at that time you were the manager and chief
21 hydrogeologist of earth sciences group. Again, what
22 was the major portion of your work that might be
23 relevant here?

24 A. I should point out that
25 essentially James F. MacLaren metamorphosed into



1 MacLaren Plansearch when they were taken over by
2 Lavalin. They actually split the company into MacLaren
3 Engineering and MacLaren Plansearch. Plansearch being
4 short for planning and research. I continued to be
5 involved in the same type of work that I had been doing
6 with James F. MacLaren, which was a combination of
7 environmental waste disposal type of work and water
8 resources projects.

9 Q. From '83 to '86 and perhaps today,
10 you are in effect a private consultant?

11 A. That is correct. I resigned from
12 MacLaren's in 1983 to work as a private consultant. I
13 still do a lot of work for MacLaren's but in 1987 I
14 incorporated my own practice under the name of David L.
15 Charlesworth and Associates.

16 Q. For the purposes of the matter
17 that is before this Board, your reports are offered
18 under the firm name of Geocon. Can you just explain
19 that?

20 A. Geocon are a geotechnical
21 consulting firm. They are also owned by Lavalin. They
22 were approached by the Town of Milton with a view to
23 supplying services on this project and they were
24 familiar, I had worked with them on some other projects
25 so Geocon approached me with a view to doing the hydro-



1 geological work on this project.

2 Q. I wonder if you could just review
3 for us some of the specific kinds of work you are
4 involved in now and have been in the most recent years
5 that might be most relevant before the Board in the
6 area of waste management. First of all I think you can
7 break it down, you are involved in site selection?

8 A. Yes, I have -- I am involved in
9 some other studies comparable to this study that is
10 before the Board at the moment. I am working on the
11 Waterloo-Kitchener solid waste master plan which went
12 through a process of site selection, although the
13 recommendations that have come out of that are to
14 proceed on the existing sites including the expansion
15 of one site.

16 I am also working for the Region of Peel
17 in their quest to find a new landfill site within the
18 City of Brampton. I was involved in the civil work for
19 the Ottawa-Carleton Regional Municipality. I am not
20 actively involved in that at the moment due to my
21 commitment on these other projects.

22 In the past I have done some work for
23 the City of Fredericton and the City of Moncton in
24 terms of looking at appropriate sites for solid waste
25 disposal. Those were on a much smaller scale, the



1 ones that I have just mentioned. I have just also
2 looked, been involved in projects which are looking at
3 existing landfill sites. Some which come to mind were
4 the hearings for the Holbrook landfill in Oxford County
5 which was an application to extend the life of the
6 landfill there. There were two submission before the
7 Environmental Assessment Board. I am currently
8 involved in investigation of the Albion landfill at
9 Caledon. That is also for the Region of Peel in terms
10 of assessing whether that site can be extended or not.
11 These all involve extensive field programs, testing,
12 drilling, installation of piezometers. I am currently
13 involved in studies at the Cambridge landfill which is
14 part of the master plan for the Region which I referred
15 to a few moments ago.

16 I have also been involved in a number of
17 studies in a review capacity. For example, looking at
18 the work done by others, I recently completed a study
19 for the Ministry of Health with regard to the
20 Whitchurch-Stouffville landfill. They were doing an
21 epidemiological study. You may remember, Mr. Chairman,
22 this was quite a controversial landfill. It went
23 through a lengthy hearing process. The Ministry of
24 Health have just completed an epidemiological study of
25 the area around to see if they could determine any



1 impact on the health of the residents.

2 I was asked to prepare, I suppose you
3 may call it, a risk model in defining the areas they
4 should look at to compare high risk, medium risk and
5 low risk zones. I have also been involved in numerous
6 small landfill studies and some work on radioactive
7 waste disposal sites. A number of years ago I was
8 working in the Port Hope area for the AECB and what was
9 then Eldorado Nuclear.

10 Q. When you say you have been, in
11 some of these, you have been reviewing work by other
12 consultants as well, for example?

13 A. For example, the Erb Street
14 landfill in Waterloo is part of, an expansion of that
15 landfill is part of the proposal within the solid waste
16 master plan for the Region and the work at that site
17 was being done by another company, initially sub-
18 consultants to MacLaren. I was retained by MacLaren to
19 review the work they were doing.

20 Q. You have done that on more than
21 one occasion I take it?

22 A. Yes, that is correct.

23 Q. I wanted to ask you about
24 experience with regard to rock, fractured rock. Can
25 you give the Board some indication of any experience



1 with fractured rock?

2 A. I have had some experience in
3 northern Saskatchewan. Now, the rock itself is
4 different than the shale we have been looking at in the
5 Burlington area. This was in connection with
6 environmental impact assessments, but proposed uranium
7 mines. However, they are fractured crystalline rocks
8 and the techniques we were using to investigate the
9 groundwater flow within those rocks involved techniques
10 which have been used in this case at Site F. Fracture,
11 fracture logging and packer testing.

12 I did that at three sites in northern
13 Saskatchewan. The Wollaston Lake project for Canadian
14 Occidental, the Dawn Lake project for Asamera and
15 subsequently for the Saskatchewan Mining Development
16 Corporation, and also at Rabbit Lake, originally for
17 Gulf Minerals and subsequently for Eldorado.

18 The techniques we were using there are
19 relevant to this occasion. I have also done some work
20 in the Oakville area with regard to land farming, the
21 disposal of waste within the petrochemical industry
22 where they dispose on the land and allow the microbes
23 to break them down and we did work for Shell Canada and
24 BP, and subsequently PetroCanada. That involved
25 drilling and installing piezometers into the Queenston



1 shale.

2 Q. There is a lot of material
3 contained in your curriculum vitae. I don't think we
4 need to spend any more time. I am sure if there are
5 other relevant matters it will come out unless you
6 think there is something else that is particularly
7 important?

8 A. I think that should give a
9 reasonable indication.

10 Q. You have been at this how long,
11 Dr. Charlesworth?

12 A. I can't believe it, but I guess
13 that comes to 22 years.

14 Q. Did you have occasion to look at
15 Mr. Sobanski's curriculum vitae or not?

16 A. Yes, I looked at his curriculum
17 vitae.

18 Q. Can you just comment in a very
19 general way about how you view your experience and his
20 experience in a general way?

21 A. I would think there are a number
22 similarities. I think it is fair to say there are a
23 number of similarities in our experience. He actually
24 has a slight edge on me in years of experience there.
25 We both started practicing I guess in the sixties and



1 probably actually came into hydrogeology at about the
2 same time. From my recollection went through the same
3 kind of process. Started out in water resources, water
4 supply type work and got into environmental waste
5 disposal waste type work as the whole field of
6 hydrogeology developed in that area. Maybe the
7 difference is, I think, Mr. Sobanski's experience in
8 water resources was more in Ontario. Mine tended to be
9 international in third world countries.

10 Q. With all of that background,
11 Mr. Chairman, I ask that Dr. Charlesworth be qualified
12 to give opinion evidence on matters related to
13 hydrogeology.

14 MR. LANCASTER: He is so qualified.

15 MR. ESTRIN: Before we hear from
16 Dr. Rowe, you will find he is a civil engineer among
17 other things.

18 Q. I wonder, Dr. Charlesworth, if
19 there is anything you wanted to add with regard to the
20 relationship you see between hydrogeology and civil
21 engineering, as you have experienced it. Or do you
22 want to leave that until after we have heard something
23 from Dr. Rowe?

24 A. Mr. Chairman, I guess I touched on
25 that in talking about my own background. Hydrogeology



1 is a strange kind of subject. People do use
2 hydrogeology or groundwater in the whole area of
3 groundwater. People come to it in different
4 directions, some from a geological background and some
5 from an engineering background.

6 The one area in which I am -- and
7 particularly from the geotechnical engineering
8 background. Geotechnical and civil engineers need to
9 have an understanding of groundwater as it relates to
10 engineering projects such as de-watering, seepage
11 through dams, slope stability. The laws that govern
12 the movement of groundwater under a dam or into an
13 excavation are the same physical laws that governs the
14 movement of ground water on a large basin in Saudi
15 Arabia.

16 So, the same fundamental understanding
17 of groundwater movement is developed in the training of
18 geotechnical engineers particularly and also civil
19 engineers, as hydrogeologists. We just tend to come
20 from a different angle. The area in which we tend to
21 meet increasingly in recent years has been in waste
22 management. That is when the hydrogeologist is moving
23 down from the scale of watersheds to specific sites and
24 the geotechnical engineer is approaching it probably
25 more from that small scale in many ways.



1 Both bring the same understanding in
2 terms of the basic physics and mathematics of
3 groundwater movement.

4 MR. ESTRIN: Thank you.

5 Q. Dr. Rowe, Mr. Chairman, it would
6 be handy if you were to now get out Exhibit M-443 and
7 actually M-443-A, particularly the curriculum vitae.

8 Dr. Rowe, looking at your curriculum
9 vitae, your present position is stated as a Professor
10 in the Faculty of Engineering Science at the University
11 of Western Ontario but I believe there is a further
12 position there that we should add?

13 DR. ROWE: A. Yes, Mr. Chairman, I am a
14 Professor and Research Director in the Geotechnical
15 Research Centre which is part of the Faculty of
16 Engineering Science.

17 Q. So you are a research director in
18 the geotechnical research centre. What is the
19 geotechnical research centre?

20 A. The geotechnical research centre
21 was set up to try and facilitate technology transfer
22 between work being done in the university and what was
23 going on in industry or in practice. The idea was that
24 we set up the research centre, we would have corporate
25 members, these corporate members are usually people or



1 always people from industry, consultants, for example.
2 They would pay a fee for which they would get advance
3 information, reports, information before they appeared
4 in refereed forums which often takes a year or two.

5 Also we conduct specialist work for
6 consultants. For example, we do testing for them if
7 they approach us about modelling, review particularly
8 tricky issues. That is the type of work they are
9 doing.

10 Again I emphasize we are working for
11 consultants. We are trying to facilitate technology
12 transfer from the research level out into industry.

13 Q. When you say working to assist
14 consultants and for consultants, have any of the firms
15 that are involved in this hearing, for example,
16 utilized the services of the geotechnical research
17 centre?

18 A. Yes, I think that is quite true.
19 There are a number of us work in the geotechnical
20 research centre. In fact there are four professors.
21 The two of us who are most related to the subject of
22 this hearing, Professor Quigley, whose name has come up
23 several times and myself. I think between the two of
24 us we have done work for all of the parties here, Trow,
25 Golder's, Geocon, MacLaren's. I think Dr. Quigley



1 has done some work for CRA, Morrison Beatty.

2 Q. Let us look if we could then at
3 your academic background. You have a B.Sc. and an
4 honours B.E., what is that?

5 A. I have a Bachelor of Science
6 degree with majors in mathematics and computer science.
7 I have a Bachelor of Engineering in Civil Engineering
8 with first class honours.

9 Q. Ultimately you did receive your
10 Ph.D in 1979. Again from that university, I am not
11 sure if you wanted to tell us anything specifically
12 about that in relation to topics here or not?

13 A. I conducted Ph.D research in
14 geotechnical engineering. That research involved
15 developing finite element and finite layer models for
16 application for a range of problems involving soil
17 structure interaction.

18 Also involved in that research was not
19 only developing models, performing laboratory tests,
20 comparing results with theoretical predictions with
21 laboratory results and wherever decent field data was
22 available, comparing the prediction with field
23 behaviour.

24 Q. What relevance then does all of
25 that have to the topic that you are going to be



1 addressing before the Board?

2 A. It is to say a background in
3 modelling techniques which involves not only developing
4 a model but realizing that a model is only part of a
5 more complete picture one has to determine what the
6 parameters are going to be. One has to identify what
7 are the key mechanisms. One then formulates what your
8 model is going to be. You put your parameters into the
9 model. You then very carefully evaluate the results of
10 the models. The model is used as a guide to the
11 engineer because the results of any model are only as
12 good as the parameters that go into it, and this is
13 true of all geotechnical engineering. Not just the
14 area we are talking about here.

15 Q. On your curriculum vitae
16 you indicate you are a civil engineer specializing in
17 geotechnical engineering. We have heard a bit from
18 Dr. Charlesworth about his view of the relationship of
19 geotechnical engineering and hydrogeology. Could you
20 comment from your perspective?

21 A. Geotechnical engineering
22 encompasses pretty well all engineering that deals with
23 soil and rock. The geotechnical engineer will
24 typically have a bachelor's degree either in civil
25 engineering or geologic engineering. These days will



1 usually have taken a post-graduate degree in
2 geotechnical engineering.

3 The geotechnical engineer is involved in
4 assessing field conditions, determining what are the
5 key mechanisms in a particular problem, choosing
6 appropriate parameters, combining these with
7 theoretical models to make predictions of what is going
8 to happen and then using engineering judgment, forming
9 an opinion as to the suitability of that particular
10 solution to an engineering problem.

11 Q. What about the range of kinds of
12 problems you may deal with?

13 A. The range of problems that one
14 could deal with could be from tunnels. For example,
15 the effect of buildings on tunnels or vice versa. It
16 could be the performance of embankments, slope
17 stability, flow through dams. It could be problems
18 related to settlement either due to the structure being
19 constructed on a clay-type soil or it could be
20 settlement due to people pumping water in clay-type
21 soil.

22 Of course, the topic we are hearing
23 here, waste disposal.

24 Q. As a geotechnical engineer, how
25 are you concerned with the flow of water or other



1 materials through soil?

2 A. Well, the flow of water through
3 soil is a very critical and central part of
4 geotechnical engineering. In fact in my undergraduate
5 soil mechanics course, three-quarters of that course is
6 related to the effects or simulating flow of water
7 through soil. So, flow is a very important part of
8 geotechnical engineering.

9 One obvious example is if we are dealing
10 with flow of water through a dam. The less obvious
11 examples would include settlement. When we are talking
12 about settlement of a structure on a clay-type soil,
13 that settlement or the rate of settlement is related to
14 the hydraulic conductivity. It is related to how fast
15 water can get out of the soil from beneath the
16 building. So that hydraulic conductivity, for example,
17 is important to that type of modelling.

18 The other interesting thing is that when
19 one is concerned about simulating something like the
20 rate of settlement of a building, the equations that
21 govern that are precisely the same diffusion equations
22 we are concerned about in modelling contaminant
23 migration through a barrier. So the equations are
24 similar, we are dealing with the same basic concepts,
25 so though obviously the emphasis changes depending on



1 the problem.

2 Q. What about the famous or otherwise
3 Darcy's law?

4 A. Darcy's law is essential. It is
5 fundamental to geotechnical engineering as of course is
6 the hydraulic conductivity which Darcy's law is about.

7 Q. What can you say to the Board with
8 respect to your background in particular versus that of
9 Dr. Charlesworth in talking about the matters you are
10 both going to be addressing?

11 A. Well, both, I think
12 Dr. Charlesworth indicated that both the geotechnical
13 engineer and the hydrogeologist are interested in the
14 problems of contaminant migration but we are coming at
15 it from different directions. The way I view it,
16 historically the hydrogeologist is being concerned with
17 water resources, typically with flow of water through
18 permeable units. Now, of course, they are becoming
19 more concerned about the less permeable units, the clay
20 materials as opposed to the sand and gravel.

21 The geotechnical engineer has also been
22 involved in both of these areas but a lot of our
23 concern has been on the less permeable materials.
24 Clay-type materials. Because those are the ones that
25 will often cause problems for the geotechnical



1 engineer. We are both interested but approach from a
2 somewhat different direction.

3 I think another important distinction is
4 that the hydrogeologist typically has a background in
5 geology or earth science; whereas if we are comparing
6 that with the civil engineer who has become a
7 geotechnical engineer he would not have had as much
8 geologic training, but would have had in general more
9 training in the quantity sciences, mathematics and that
10 sort of thing.

11 So, there is a slight difference in the
12 background although we are approaching the same point.
13 Where I would find a distinction is if there is a
14 problem that relies on geological interpretation I
15 would consult with a hydrogeologist such as Dr.
16 Charlesworth.

17 However, in a problem where one has to
18 identify what the situation is, identify the key
19 mechanisms and the problem you have got to select
20 parameters, you have got to do modelling and you have
21 got to make an engineering judgment on results of all
22 that modelling. That is well within the purview of the
23 geotechnical engineer.

24 Q. Thank you. Can you comment, first
25 of all, with respect to your background and experience



1 generally and that of Mr. Feenstra whom we have heard
2 and you have heard some of his testimony and read his
3 report?

4 A. Mr. Feenstra is a hydrogeologist
5 and I am a geotechnical engineer. The comments I
6 raised before are obviously relevant. In addition,
7 Mr. Feenstra, for example, has given evidence on the
8 chemistry. I am not a chemist and would not presume to
9 offer opinions as to the composition or how one organic
10 chemical might break down to another. I think
11 Mr. Feenstra has addressed that issue and that is
12 beyond my expertise.

13 Nevertheless, when we come to the area
14 of modelling it is fair to say I have considerably more
15 experience in modelling than Mr. Feenstra has. The
16 basic understanding of the mechanisms affecting the
17 migration of contaminants through soil and rock. This
18 is based not only on modelling but on the laboratory
19 tests that we have done to validate our models. The
20 tests that we do in the laboratory to determine
21 parameters and comparison with observed field
22 behaviour.

23 Q. I wonder then if we could turn to
24 some specifics of your curriculum vitae. First of all
25 I am not going to take us through obviously all of it,



1 but I think we want to deal with those matters that are
2 most relevant to the quality of your work, to the
3 extent you have been awarded honours or awards and
4 secondly the specific work that is most relevant to the
5 topic before the Board.

6 In the category of awards and honours,
7 just looking at that in your CV can you tell us first
8 of all, you were awarded the university medal in 1975
9 with first class honours. That is, I take it, some
10 distinction?

11 A. A university medal is a very great
12 honour.

13 Q. Then we are going to see the
14 Canadian Geotechnical Society coming up more than once.
15 The first reference is in 1984 a prize for the best
16 paper in the Canadian Geotechnical Journal. First of
17 all what is the Canadian Geotechnical Journal?

18 A. The Canadian Geotechnical Journal
19 is an NRC journal, it is a refereed journal. It is
20 generally regarded as one of the best geotechnical
21 journals in the world.

22 Q. Then you got another prize from
23 the American Society of Civil Engineers in 1985?

24 A. That is correct. That was for a
25 paper published in the American equivalent of the



1 Canadian Geotechnical Journal.

2 Q. In 1985 you received an honourable
3 mention for two other papers from the Canadian Society?

4 A. That is correct.

5 Q. Let us turn to page 2 of your
6 curriculum vitae. You contributed a paper and got a
7 certificate and the paper is entitled "Leachate
8 Migration through Clay below a Domestic Waste Landfill,
9 Sarnia, Ontario" you wrote that with Dr. Quigley, did
10 you?

11 A. That is correct. That is a paper
12 dealing with the observed contaminant migration profile
13 beneath a landfill in Sarnia and modelling of that and
14 the discussion of the interplay between the two.

15 Q. The next item is distinguished
16 geotechnical lecturer for 1986. Is that by invitation?

17 A. Yes, once a year they have an
18 endowment to invite anyone from around the world they
19 believe can contribute significantly to their students
20 by giving special lectures and holding a special class
21 for them. There is one person invited a year. One
22 person a year. I was honoured to be one of those
23 people.

24 Q. I see you got a prize for the best
25 paper for 1986 again from the Canadian Geotechnical



1 Society?

2 A. That is correct.

3 Q. Then something I specifically
4 wanted to ask you about. You were off in Regina
5 earlier in 1987. I know we were trying to get some of
6 this material together. You gave a paper which we see
7 the title of there "Contaminant Migration in
8 Groundwater: The Role of Analysis in the Design of
9 Barriers". What can you tell us about your implication
10 and what you were doing?

11 A. Again I was honoured to be invited
12 by the associate committee for geotechnical research.
13 Each year they invite one person to present this
14 special presentation at their annual conference. It is
15 called the "Colloquium". It is a sponsored
16 presentation of a paper and I was honoured to be asked
17 to present that dealing with essentially the subjects
18 we are going to be talking about at this hearing.

19 Q. I understand that was a three day
20 conference involving between 200 and 300 people working
21 in this area?

22 A. That is correct.

23 Q. I wanted to ask you whether you
24 could tell the Board of any common theme that is
25 running through your papers, your research?



1 A. Yes, I think that is an important
2 point. You can see if one just takes a cross-section
3 which I have been fortunate enough to have been given
4 honours. One sees that the topics vary from
5 embankments to tunnels to contaminant migration.
6 However, there is a very, very common theme through all
7 of these in that the objective of my work is to use
8 theoretical modelling in solving practical problems.
9 That means that the modelling cannot be treated in
10 isolation.

11 One has to assess the field conditions.
12 One has to identify the key mechanisms, one must
13 determine the relevant parameters, and then do your
14 modelling. Then critically evaluate the results of
15 that modelling to form an engineering judgment. Make
16 your comments or opinion and then it is highly
17 desirable to monitor the performance, to check how that
18 geotechnical project performs relevant to what you said
19 it would do. This is true of landfills, it is true of
20 buildings, it is true of tunnels, it is true of all
21 geotechnical engineering. One common thing in all of
22 those papers is not only modelling but modelling
23 prediction and comparison with observed field
24 behaviour.

25 Now, there is another topic on page 2 of



1 your curriculum vitae, other related experience under
2 the sub-topic of industrial experience. Your work in
3 Canada at least seems to refer to a number of
4 consulting firms that the Board may well recognize.
5 Can you just give us a bit of an idea of what you were
6 doing here?

7 A. I have done a lot of things. Some
8 of the ones that are more relevant to this particular
9 hearing, I have been involved back in 1981 with Geocon
10 in reviewing some of the work they were doing on the
11 Rabbit Lake operation. In particular I was involved in
12 reviewing contaminant migration from the Town's
13 disposal into groundwater. I have done work, for
14 example, for Morrison & Beatty on the Warwick landfill.
15 This is a situation that has some similarities to Site
16 D in that there is a relatively impermeable zone. Far
17 more permeable zone beneath it. One is concerned with
18 the potential impact so I was involved in modelling in
19 that case using techniques very similar to what I used
20 in analysis of Site D.

21 I have been retained to do work on the
22 Cambridge landfill to determine diffusion co-
23 efficients and to make some assessment of attenuation.
24 Of course my work on the Halton landfill we will be
25 discussing. I have also been retained to review



1 contaminant geotechnique relating to Peel. In
2 addition, my research has been very relevant to this
3 hearing. I have been involved with my colleague Bob
4 Quigley in research relating to the Confederation Road
5 landfill, and I think it is fair to say that it is
6 probably the best researched and documented landfill on
7 record.

8 I have been involved in developing
9 techniques for determining appropriate parameters such
10 as diffusion co-efficients and partitioning or
11 distribution co-efficients which influence the
12 attenuation of contaminants as it moves from landfills.

13 Q. On that last topic we see a list
14 of consulting firms. I take it in effect when you are
15 doing that you are a consultant's consultant?

16 A. That's right. We pride ourselves
17 in that we do not go and compete with consultants. We
18 have consultants come to us and provide them with
19 advice.

20 Q. The research, the studies you
21 mentioned with regard to the Confederation landfill,
22 who is funding that research?

23 A. That research has been funded by
24 NSERC, National Sciences and Engineering Research
25 Council of Canada.



1 Q. In addition to your research
2 projects, I understand you have opened new projects in
3 the last month, which ones in particular would be of
4 relevance here?

5 A. I have reviewed the ones relevant
6 to contaminant technique. I have worked on a number of
7 other projects, evaluation of sewer cover structure in
8 Toronto, evaluation of raw settlement for (inaudible)
9 in Calgary, evaluation of potential effects of a
10 structure on the Detroit-Windsor tunnel. Partly doing
11 work on the effect of putting a structure on the
12 Toronto subway at York Mills.

13 I have reviewed reports on the Park
14 condominium. I have done work for a reinforced earth
15 company developing design approaches in the last four
16 months.

17 Q. When we see you come to page 3 of
18 your curriculum vitae, we see you are a registered
19 engineer in the province of Ontario?

20 A. That's correct.

21 Q. We come down to contributions to
22 the profession and we see you are an associate editor
23 of the Canadian Geotechnical Journal from 1983 to the
24 present. Can you tell us briefly about that?

25 A. The associate editors are the



1 people who deal with papers. One of the ways the
2 Canadian Geotechnical Journal works is the papers are
3 submitted to an editor who sends them to an associate
4 editor who co-ordinates the reviews and gives an
5 opinion to the editor on whether a paper should be
6 rejected, accepted or accepted with modifications. So,
7 I have been intensively involved with reviewing other
8 people's papers.

9 Q. You are also on the editorial
10 board of the Journal of Geotechnical Engineering, the
11 American Society of Civil Engineers?

12 A. That is correct, and I fullfil a
13 similar function there.

14 Q. Just on page 4 a couple of items,
15 about halfway down, you were chairman on the sessions
16 on theoretical soil mechanics for the 10th Canadian
17 Congress of Applied Mechanics?

18 A. That is correct.

19 Q. Is that of some relevance being
20 the chairman of the session on application of numerical
21 models to practical problems in Ghent?

22 A. I think that again emphasizes the
23 point I made earlier that the emphasis on my work is
24 taking a theoretical model, the concept of modelling,
25 and applying it in practice.



1 Q. Turning to page 5 I want to ask
2 you about the Ann Arbor Conference. One says invited
3 keynote speaker, the ASCE specialty conference on
4 geotechnical aspects of waste disposal?

5 A. I was invited by the American
6 Society of Geotechnical Engineers to provide a paper
7 which was a reviewed paper.

8 Q. You have indicated at the bottom
9 of page 5 that you have reviewed papers for those
10 various journals. The one I understand is not on here,
11 you are on the editorial board for the International
12 Journal for Numerical and Analytical Methods in
13 Geomechanics.

14 A. That is true.

15 Q. I just want to look at your papers
16 for just about one or two minutes, just very briefly, a
17 couple of them. In particular under the heading
18 "Publications" looking at the second page of the
19 publications. These are all in the first category in
20 refereed journals?

21 A. That is correct.

22 Q. With regard to papers 21 and 22,
23 can you give us a bit of a background as to why these
24 may be relevant to the matters in hand?

25 A. Paper 21 which was published in



1 Geotechnique introduced the concept of modelling
2 contaminant migration in multi-layered systems using
3 semi-analytical techniques. Reference 22 which
4 appeared in the Journal of Geotechnical Engineering,
5 the American Society of Civil Engineers introduced the
6 concept of modelling the massive contaminant.

7 This is something that will be important
8 and I will be discussing for both Site F and Site D.
9 In fact that paper is included in section 4 of the
10 handout.

11 Q. Geotechnique can be described as
12 the premier geotechnical engineering journal in the
13 United Kingdom?

14 A. Yes, I think that in general would
15 be true.

16 Q. Coming to the next page, a couple
17 of references there. Paper No. 26 with Booker?

18 A. That paper was published in the
19 Canadian Geotechnical Journal. It introduced a two-
20 dimension finite layer theory. What we talked about a
21 moment ago was one dimensional. We pushed it a step
22 further to two dimensions and what is also important
23 about that paper is that it demonstrates how important
24 it is to consider a range of cases when one is
25 assessing impact of a landfill. That paper demonstrates



1 that if you just pick one or two numbers you can be
2 very much misled as to what the potential impact may
3 be.

4 Q. Just one other point with regard
5 to the Canadian Geotechnical Journal, I understand
6 Dr. Cherry is, as you are, an associate editor?

7 A. Yes, we are two of a number of
8 associate editors of that journal.

9 Q. Then paper 28, what is the
10 relevance of that?

11 A. That paper expands on paper No. 26
12 in that it develops the finite layer theory to two and
13 three dimensional layered systems. It examines
14 attenuation for hydrogeologic settings similar to that
15 at Site D. In fact this is the theory that I used in
16 the analysis of Site D.

17 Also, this is the theory that I used
18 when I modelled Trow's better fit model at Site F.
19 That paper is given in section 3 of the document.

20 Q. The next paper, No. 33, is that of
21 relevance?

22 A. Yes, it is of relevance in
23 developing some analytical solutions.

24 Q. The next one with Dr. Quigley?

25 A. Yes, that is a paper of some



1 relevance although not as relevant as the others.

2 Q. No. 35

3 A. Yes, that paper is relevant I
4 guess in a number of ways. It deals with laboratory
5 techniques for determining diffusion and distribution
6 or partitioning co-efficients. We developed these
7 techniques for getting parameters to use in predicting
8 impact of landfills on groundwater quality.

9 I think there is also something else
10 important that this laboratory work has done. It has
11 allowed us to check the theoretical model. One could
12 determine a diffusion co-efficient from one test using
13 an analytic solution and then we can actually simulate
14 the situation where -- perhaps I might sketch it.

15 In a laboratory test we have the soil
16 and we have the source or the leachate, if you like.
17 Now, in the laboratory we can actually put a known mass
18 and volume of leachate into that source and we can
19 monitor what happens to the concentrations with time as
20 contaminant moves down into the soil.

21 As mass is removed from the reservoir by
22 going into the soil there is a decrease of
23 concentration within the source solution. That is, of
24 course, what happens at a landfill. Mr. Sobanski
25 essentially alluded to that in his testimony. So we



1 are simulating a situation that is similar to what
2 happens in a landfill. Obviously it is in a controlled
3 laboratory setting but it is exactly the same equation,
4 exactly the same model used to simulate both.

5 We can get, from another test, the
6 diffusion co-efficient and we can then use the model to
7 -- the theoretical model to predict what is happening
8 in the laboratory and we can compare that with
9 laboratory results as a check on our theoretical
10 formulation.

11 Q. Just quickly, identifying papers
12 that might be relevant just to show some of your
13 experience, would No. 57 be of some relevance to the
14 topic?

15 A. Yes, it would.

16 Q. And 59?

17 A. Yes.

18 Q. How about No. 61?

19 A. Yes, that is relevant and in fact
20 that introduces the basic concepts that are expanded
21 upon in the paper we were just talking about, No. 35.

22 Q. You told me that you think 62, 63
23 and 66 are also of relevance to the opinions you are
24 going to be offering?

25 A. That is correct.



1 Q. Then what about 68, this paper
2 with Dr. Quigley?

3 A. It is the paper we discussed
4 earlier, yes, and it relates to a field situation.

5 Q. Then turning the page, page 72 is
6 also relevant background?

7 A. That is correct.

8 Q. What about 74?

9 A. That is the paper published or I
10 talked earlier about my presentation at the ASCE
11 conference, that is the written paper.

12 Q. Then there is one No. 76?

13 A. Yes, that is of particular
14 relevance. That is the theory that I will be
15 presenting to you relevant to matrix diffusion, the
16 modelling of matrix diffusion. That has been accepted
17 for publication.

18 Q. And 78 I take it is also of some
19 relevance?

20 A. That is correct.

21 Q. Wait a minute, that is not an
22 article, that is a book?

23 A. No. 81 is a book.

24 Q. Yes, what about that? No. 81?

25 A. John Booker and I were invited to



1 write a chapter in a book being set up by John Wiley &
2 Sons. That chapter which we have written draws
3 together the recent developments that we have made in
4 modelling contaminant migration. It essentially draws
5 together what we have published in the journal papers
6 we have discussed.

7 Q. That chapter is contained at Tab 2
8 of this document?

9 A. That is correct.

10 Q. I am not going to -- you have also
11 included a list of your scholarly addresses. We can
12 see there is obviously a number of them that relate to
13 contaminant migration?

14 A. That is correct. Perhaps these
15 have been to some extent alluded to. Unless there is
16 anything particular you want to draw to our attention
17 about those I want to come to the research grants. That
18 is at page 12 and Dr. Rowe you told me that these
19 research grants set out here are not all the research
20 grants that you have but are only those related to
21 contaminant transport?

22 A. That is correct.

23 Q. We heard a minute ago about the
24 NSERC grant. That is \$115,000?

25 A. That was a strategic grant.



1 Strategic grants are awarded by a special committee of
2 NSERC for problems which are considered to be of
3 strategic importance to Canada. The competition for
4 those grants is very, very tough. We were very
5 fortunate to have been awarded that grant.

6 Q. You have indicated the average
7 operating grant, the next line \$43,000 and indicates
8 the average?

9 A. That is my personal NSERC
10 operating grant. These grants decided by a peer review
11 committee which consists of academics, people from
12 industry, consultants for example and people from the
13 government. They look at all of the professors within a
14 certain area, in my case civil engineering. They make a
15 decision as to how much granting money they are going
16 to award to the individual largely based on track
17 record. My grant is \$43,720 which is approximately
18 twice the average grant.

19 Q. I take it these grants are
20 somewhat competitive?

21 A. They are very competitive.

22 Q. What do you do in the way of
23 teaching modelling?

24 A. Well ...

25 Q. Moving off this and particularly



1 your experience with modelling?

2 A. My experience with modelling, I
3 think you can see from my CV it goes right back to my
4 Ph.D and for the past 12 years I have been involved in
5 applying modelling to practical problems. You have
6 seen I have written somewhat over 80 papers dealing
7 with the subject. I also teach modelling in my
8 graduate courses. I have developed my own finite
9 element programs and my own finite lab problems and
10 applied these to solving practical problems.

11 Q. Now, you have heard Mr. Hiraishi
12 or I understand you have read some of his evidence.
13 Would you classify yourself as a design engineer?

14 A. No. Mr. Chairman, I think it is
15 appropriate to make it quite clear that over the past
16 nine years I have not been involved in the day-to-day
17 design of engineering structures. However, my work is
18 such that I am a specialist oriented towards providing
19 the design engineer with advice and input and
20 developing techniques that can be used by the design
21 engineer.

22 As a result of the very applied nature
23 of my work, I am frequently involved in reviewing
24 current design approaches as well as developing new
25 ones both from the perspective of grants, sponsored



1 research but also from the perspective of providing
2 consultants with specific suggestions or numbers
3 relevant to particular projects. In fact, I think over
4 the last 12 months, I have been involved in nine such
5 projects.

6 Q. Well then, you are not a design
7 engineer. Are you qualified to offer an opinion on
8 proposed designs from an engineering perspective?

9 A. Yes. To the extent that they are
10 involved with contaminant geotechnique. I would not
11 presume to talk about berming of a landfill or
12 trucking.

13 Q. Could you perhaps summarize for
14 the Board what you regard to be your area of expertise?

15 A. Yes. I believe that my expertise
16 is in combining sound engineering principles and
17 judgment with modern modelling techniques to try and
18 provide an indication of the potential performance of a
19 range of engineering structures or problems. This
20 expertise includes but is not restricted to the
21 assessment of impact or potential impact of a landfill
22 on groundwater quality.

23 MR. ESTRIN: Mr. Chairman, I would ask
24 with all that that Dr. Rowe be qualified to give
25 opinion evidence with respect to contaminant migration



1 and potential impacts on groundwater quality?

2 MR. LANCASTER: Yes, he will be so
3 accepted.

4 DR. KINGHAM: I wonder if you can
5 explain. I notice in your publications and scholarly
6 addresses, more than three-quarters of them, in fact 78
7 per cent of them are really directed towards
8 geotechnical engineering. We have in Dr. Charlesworth
9 somebody we have already qualified to give opinion
10 evidence in hydrogeology. Would you say that the
11 contaminant migration part of your work which is that
12 other 22 per cent is a strong enough forte that you
13 feel comfortable with the contaminant migration side as
14 opposed to the geotechnical engineering side? You made
15 the distinction for us and it is clear from your work
16 that it has been more on changes in soil structure
17 settling buildings and so on. At least that is my
18 reading of your publication list. Is that too fine a
19 distinction as you converge geotechnical engineering
20 and hydrogeology?

21 DR. ROWE: I think it is. You are quite
22 right, I have done a lot of work in areas that are not
23 narrowly defined as contaminant geotechnique. I have
24 published a lot of papers. If you were just to pay
25 strict attention to papers I have published relative to



1 geotechnique comparing the ones not listed there, I
2 think there is about 18 listed there, I have written
3 over 20 on that subject. There are not that many
4 people around who have written as many papers in good
5 forums on the subject. I have developed what I think
6 are regarded as some very useful and very powerful
7 tools for analyzing the problem we are going to be
8 dealing with. I also have a broader engineering
9 perspective of the problem than perhaps a
10 hydrogeologist might have.

11 Hydrogeology is part of a much broader
12 issue. I think the problem that you are raising is one
13 related to terminology. There is a question as to
14 whether we are talking here just about hydrogeology and
15 I would submit that the issue is broader than that.
16 One is concerned about the engineering aspects of it,
17 for example. One is concerned about the engineering
18 failures of a leachate collection system. One is
19 concerned about making an engineering opinion as to
20 what the impact of a given landfill on a site will be.

21
22 The techniques that I bring to bear on
23 this are the same techniques I bring to bear on any
24 geotechnical problem. I think it is worth noting that
25 people like Dennis Reed who heads up Golder's



1 contaminant section are civil engineers just as I am.

2 DR. KINGHAM: I am not challenging the
3 nature of civil engineering in this. It is just that I
4 might have thought from the background you had that you
5 were coming here to tell us about stability of the
6 formations that were likely to be put on soil that
7 might or might not be stable, but that is not the
8 nature of your expert opinion here. It is rather that
9 portion of your work that has had to do with
10 contaminant migration and that is what you really want
11 this witness qualified in as I understand it?

12 MR. ESTRIN: That is absolutely correct,
13 Dr. Kingham. Specifically as qualified to give opinion
14 evidence with respect to contaminant migration and
15 potential impacts on groundwater quality.

16 MR. LANCASTER: Thank you.

17 MR. ESTRIN: I don't think we are here
18 to tell you there is an earthquake problem under either
19 site.

20 DR. KINGHAM: Or the sites would settle?

21 MR. ESTRIN: No. We are about to get
22 into the description phase of when these gentlemen were
23 retained and what they were asked to do and that will
24 probably take half an hour or so I would guess. I am
25 quite prepared to continue or would you prefer...



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

3 DR. KINGHAM: I wonder if I might ask?
4 Will you be giving a sort of thumbnail sketch of how
5 you are going to move through this field before we get
6 into hearing the specific evidence?

7 MR. ESTRIN: I can tell you right now if
8 you wish.

9 I plan next to ask these gentlemen to
10 review when they were retained, what they were
11 essentially asked to do and what they did in a general
12 way with respect to both sites. Then, we will hear in
13 the course of that some general conclusions from
14 Dr. Rowe with regard to Site D, if you like in passing,
15 because what I intend to do is turn the discussion
16 after that topic, after that general topic to Site F
17 and go into that in some detail and ask both of them
18 about their work, starting first of all with
19 Dr. Charlesworth.

20 So, probably after we hear a bit more
21 about Dr. Rowe with respect to what he did and the
22 general work plan and methodology and his overall
23 conclusions on Site D, we probably won't be hearing
24 from him for the balance of the day or even tomorrow.

25 My intention will be to take



1 Dr. Charlesworth into his report on Site F and to go
2 through that. After we are finished that to then have
3 Dr. Rowe discuss his work with respect to Site F.

4 After that to have questions of a
5 general nature to both of the gentlemen.

6 DR. KINGHAM: You just said then to ask
7 Dr. Rowe of his work related to Site F?

8 MR. ESTRIN: Both of them have done a
9 report with respect to both sites from a different
10 perspective. Dr. Charlesworth from a general
11 hydrogeological analysis similar to the kinds of topics
12 we raised with Mr. Sobanski. Dr. Rowe's efforts are
13 largely centered on modelling of contaminant migration
14 at both sites.

15 So, I would expect we are going to be
16 essentially this week, perhaps we will get to Site D,
17 but I expect most of this week will be taken up with
18 the two reports on Site F.

19 DR. KINGHAM: Then they are both going
20 to tackle the full reports they have on Site D?

21 MR. ESTRIN: That is correct.

22 MR. LANCASTER: Fifteen minutes.

23 ---Recess

24 MR. LANCASTER: Please be seated. We
25 have been asked to remind you once again regarding



1 parking. Those here on a regular basis, or a more
2 regular basis have been asked to park behind the
3 barrier to allow visitors to the building -- they don't
4 have the controls to lift the barrier. If you try to
5 remember to park downstairs, there is lots of room on
6 the second floor. Mr. Estrin.

7 MR. ESTRIN: Q. Dr. Rowe, a couple of
8 points that arose just before coffee. First of all
9 that mouthful that we mentioned, referring to page 5 of
10 your curriculum vitae. It was at that point where we
11 indicated you were on the editorial board of another
12 publication and it came out rather quickly. What is
13 that publication again?

14 DR. ROWE: A. It is the International
15 Journal for Numerical and Analytical Methods in
16 Geomechanics.

17 Q. What kinds of things does that
18 deal with, how would that be relevant?

19 A. It is a journal focused on
20 modelling as it related to geomechanics.

21 Q. Another matter. Dr. Kingham
22 raised with you the suggestion that a good percentage
23 of your previous published papers did not deal with
24 contaminant migration. Did you have an opportunity
25 look over your work.



1 First of all, give the Board an
2 indication say in the last five years what percentage
3 of your work dealt with contaminant migration?

4 A. In the last five years
5 approximately 50 per cent of my time has been devoted
6 to contaminant migration.

7 Q. What about your papers since 1984?

8 A. Since 1984 43 per cent of my
9 journal papers and 47 per cent of my conference papers
10 are related to this. One of the reasons, there is a
11 time lapse between when one does research and it
12 appears in a forum.

13 DR. KINGHAM: We had actually noticed
14 that change in time and the noticed the shift away from
15 geotechnics to contaminant migration. I think we have
16 taken your point, Mr. Estrin.

17 MR. ESTRIN: Q. Dr. Rowe, let us turn to
18 the topic of when you were retained and what you were
19 doing in the first phases of your work. First of all
20 you were retained when approximately?

21 DR. ROWE: A. I was retained in July of
22 1986.

23 Q. What was it you were asked to do
24 at that time?

25 A. I was asked to examine the



1 available data relating to Site F, to comment on the
2 additional work required, to establish whether there
3 would be reasonable natural attenuation from Site F or
4 whether a liner would be needed.

5 Q. What about with respect to Site D
6 at that time?

7 A. I was asked to take a preliminary
8 look at the very limited data about one Site D and to
9 indicate if there are any problems.

10 Q. Back in July of '86 we did not
11 have available the two major Trow reports?

12 A. That is correct.

13 Q. Then in the summer of 1986 what
14 did you do and did you make some recommendations?

15 A. In August I reviewed a number of
16 documents primarily relating to the previous work at
17 Site F and I made a number of recommendations. I
18 recommended that a hydrogeologist be engaged. I
19 recommended that the concept of the discharge zone be
20 critically examined. I recommended that the Waterloo
21 data regarding the migration from Bayview Park be
22 critically examined. I recommended that the
23 implications of uncertainty with respect to groundwater
24 velocities be examined and that we await more
25 information with respect to Site D before we did



1 anything.

2 Q. Then what about the next five or
3 so months, August to November, 1986, what did you do,
4 if anything, at that point?

5 A. Between August and November I
6 reviewed approximately 37 reports and other documents
7 relating to Site F and environs of course. These
8 reports which ranged from reports by Dr. Cherry on his
9 work regarding the NSP site and Bayview Park. I also
10 looked at a series of reports from Morrison Beatty. I
11 looked at Janet Hewetson's thesis. I looked at
12 excerpts from the City of Burlington response to the
13 Halton landfill assessment.

14 Q. That aspect prepared by Conestoga-
15 Rovers?

16 A. That is correct.

17 I looked at the Ecoplans, CRA,
18 Bayview Park, Indian Creek contamination investigation?
19 I looked at Gartner Lee's continued use report for the
20 Burlington landfill.

21 Q. The 1984 documentation?

22 A. That is correct. I looked at
23 Kevin Wrigley's review of the Burlington landfill
24 expansion study and of course by that time I have had a
25 chance to look at THCL's reports on Sites D and F.



1 Q. All right. Did you have any
2 general conclusions at that point with regard to Site
3 F, we are now into November '86?

4 A. I had a number of preliminary
5 conclusions. Firstly, based on THCL's report it
6 appeared there would be adequate attenuation and that a
7 liner was not required at Site F.

8 Secondly, I felt that THCL may have been
9 too conservative in their modelling of Site F both in
10 terms of their groundwater velocities and in neglecting
11 matrix diffusion which they recognized but didn't
12 attempt to take account of. I felt that the impact
13 downgradient might in fact even be less than what they
14 were saying it would be.

15 The third conclusion I had was that
16 their hydrostratigraphy should be checked by a
17 hydrogeologist. I felt that their contaminant
18 migration analysis should also be checked. On the more
19 general review of the information available I thought
20 the interpretation by Heweston, Cherry and others
21 associated with the Waterloo work was questionable and
22 needed re-examination.

23 I thought that we should take a careful
24 look at the data relating to the existing landfills and
25 in particular the Burlington landfill to see how that



1 might assist us with the selection of what are
2 reasonable parameters, the modelling, what is going on
3 at Site F.

4 Q. Do I take it that at that point
5 you had in mind the notion of doing some modelling?

6 A. That is correct.

7 Q. At Site F. At that point had you
8 reached any conclusions with regard to Site D. This is
9 November 1986?

10 A. Yes, Mr. Chairman, I had reached
11 some preliminary conclusions at that site. I thought
12 that the hydraulic trap as proposed by THCL was a neat
13 idea for a difficult site, but I was concerned that
14 there are potential problems. I was concerned with the
15 accuracy of their contaminant migration analysis. I
16 was initially skeptical about the validity of the curve
17 that they had used for concentration varying with time
18 within the landfill. Although, I should point out,
19 that as subsequent data became available and as I did
20 my own analysis approaching the problem from a
21 different perspective, I ended up concluding that what
22 they had done with regard to modelling concentration
23 variations seemed reasonable.

24 I was concerned that there did not seem
25 to be sufficient factual information regarding Site F



1 to be as confident of their parameters as they appeared
2 to be. I felt that it would be prudent to examine the
3 implications of reasonable uncertainty with respect to
4 these parameters. That is a standard engineering
5 practice.

6 Q. I am sorry, F or D?

7 A. I am talking about Site D. I
8 finally felt that the contingency measures which had
9 been proposed for Site D required careful evaluation.

10 Q. Now, perhaps Dr. Charlesworth if
11 we could ask you to come forward. We are up to about
12 December 1986. Can you tell us about the point when
13 you and Geocon were retained?

14 DR. CHARLESWORTH: A. That is correct.
15 We were retained in December 1986. Going back to that
16 point I was going on an overseas project so the real
17 work it would be fair to say did not start until the
18 end of January of 1987.

19 Q. What did you do, let us say, in
20 February and March in 1987?

21 A. We reviewed pretty much the same
22 documents that Dr. Rowe has just referred to. The Trow
23 reports and all the other relevant material, the
24 Conestoga-Rovers report, the Gartner Lee reports in the
25 case of Site F.



1 We took a fair bit of time and worked
2 our way through all of those reports.

3 Q. What was it you were essentially
4 trying to do in that period with these reports?

5 A. We were trying to prepare to give
6 an opinion on whether the reports done by Trow were
7 adequate or raised any concerns in our mind or if there
8 were any problem areas that we saw.

9 Q. How did you approach that in this
10 period?

11 A. Well, after reviewing the reports
12 and this I would say was towards the end of that period
13 of March, we had some discussions with Mr. Estrin with
14 regard to our very preliminary conclusions. I would
15 say that at that stage we felt that if the data, pretty
16 well everything stated by Trow was proven to be
17 correct, then neither site gave us any serious concern.
18 I meant that is their interpretation of the geology and
19 hydrogeology. We did have some concerns at that point
20 about the accuracy of some of their interpretations and
21 we felt that it behove us to attempt some sort of
22 reinterpretation ourselves by redrawing some of the
23 cross-sections and reinterpreting the geological data.

24 Q. Did you proceed to do that in the
25 next couple of months or so?



1 A. Yes, we proceeded to do that, I
2 would say between the periods April, May, June of 1987.
3 I also discussed with Mr. Estrin what additional field
4 work, if any, needed to be carried out. We came up
5 with some recommendations for a limited field program
6 and I think it was at the end of March we implemented
7 one aspect of it. We tied into Dr. Rowe's work. We
8 retained the services of a drilling contractor to
9 obtain some samples of shale from Site F to enable Dr.
10 Rowe to do some tests, which I am sure he will be
11 talking about, on the sample.

12 Q. You mentioned in your report about
13 mini-piezometers. Did you also during that period
14 April to June get involved with those?

15 A. Yes, that is right. That was in
16 April. One of the concerns we had, in fact one of the
17 concerns that Dr. Rowe had mentioned and has mentioned
18 here today, was the question of the discharge zone at
19 Site F and whether this really was a discharge zone.
20 We looked at ways of assessing that and one of the
21 methods that we thought worth trying without carrying
22 out an extensive drilling program which we didn't feel
23 we should get into at that point, was to install some
24 mini-piezometers and by that I mean shallow piezometers
25 in areas where we expect there to be discharge or where



1 Trow had said they would discharge.

2 These were small piezometers installed
3 by hand to see if there was an upward gradient in those
4 wetlands or springs.

5 Q. During this period also with
6 respect to assessing the Trow report with regard to
7 Site D, you have referred to some information that came
8 from Morrison Beatty?

9 A. Yes, we had the benefit, I think
10 it was four detailed borehole logs which Morrison
11 Beatty had drilled at an earlier stage and logged which
12 I understand was not available to Trow at the time they
13 prepared their report. We also had access to those
14 samples and we looked at those at the Morrison Beatty
15 offices.

16 Q. Then perhaps, Dr. Rowe, if you get
17 back up there. Did you together make some type of
18 field visits?

19 DR. ROWE: A. I personally visited
20 the site in April in conjunction with Dr. Charlesworth.

21 DR. CHARLESWORTH: A. I made a number
22 of visits over the course of last year. I had a visit
23 before that, before the one with Dr. Rowe and then with
24 Dr. Rowe. We also visited the site when the sample
25 was being collected subsequently to be sent to



1 Dr. Rowe's laboratory, that was Site F.

2 Q. During this period, Dr. Rowe, you
3 told us that perhaps by the end of '86, certainly you
4 had some notion you wanted to do some modelling with
5 regard to Site F. During this period in the spring of
6 '87 when Dr. Charlesworth was considering the data, did
7 you discuss with him your notion of doing some
8 modelling and if so can you give us the substance of
9 where that discussion led you?

10 DR. ROWE: A. Yes, Mr. Chairman. As
11 Dr. Charlesworth indicated during the period of January
12 and March he was reviewing the report, so essentially I
13 waited while he caught up with what I had had the
14 opportunity to do earlier. Then in the April to June
15 period of 1987, as Dr. Charlesworth mentioned, we had
16 some samples taken from Site F of the shale and I had a
17 number of diffusion tests conducted firstly to obtain
18 proof that matrix diffusion would occur and secondly to
19 establish what likely diffusion coefficient might be.

20 I also held discussions with
21 Dr. Charlesworth regarding the hydrogeology at both
22 sites. Based on that discussion, those discussions,
23 developed a view on what modelling should be done. I
24 had initially intended modelling Site F based on a
25 hydrostratigraphic interpretation similar to what Trow



1 had prepared. After discussions with Dr. Charlesworth
2 he indicated to me that there might a better or more
3 reasonable way of looking at the site and so I then
4 focussed my attention on his interpretation of the
5 geology, hydrogeology in my modelling which is included
6 in my Site F report. I subsequently went back and in
7 this period of time THCL had come up with what they
8 call their better fit model in September. I did some
9 contaminant migration analysis based on their better
10 fit model as well. So I looked at both Dr.
11 Charlesworth's interpretation of the hydrostratigraphy
12 and also THCL's interpretation. I should perhaps also
13 point out, Mr. Estrin, during the period of April to
14 June I had discussions with Mr. Lottimer of THCL
15 regarding their finite element analysis that they did
16 at Site F.

17 Q. This was to clarify some aspects
18 of Trow's report?

19 A. Yes, that's right.

20 Q. When did your modelling, first of
21 all the modelling at both sites is a different approach
22 at both sites in a simplistic -- I don't know if it is
23 accurate to say that -- can you describe it?

24 A. The modelling that I did based on
25 Dr. Charlesworth's hydrogeologic interpretation at Site



1 F is different to the modelling which I did at Site D.
2 However, the modelling I did using Trow's
3 interpretation at Site F is using exactly the same
4 techniques I used at Site D.

5 Q. Approximately in what period of
6 time was the modelling work actually done?

7 A. The bulk of the modelling -- the
8 modelling was done between June and December of '87.
9 In that period of time I reviewed additional reports
10 and data such as Gartner Lee plume delineation study
11 monitoring reports, CRA's reports on Bayview Park.
12 Their comments on the Gartner Lee monitoring. I had
13 some brief discussions with Mr. Feenstra regarding what
14 he had done with respect to modelling and we developed
15 the scenarios to be considered for Sites D and F. This
16 was all done in the period June to December of '87.

17 Q. Of course you were here to hear
18 some of the testimony of Mr. Sobanski?

19 A. I heard some but not all.

20 Q. Did you hear any of Mr. Feenstra,
21 or were you away at that point?

22 A. I have read Mr. Feenstra's
23 transcript.

24 Q. In fact with regard to the
25 transcripts generally, can you tell us whether you have



1 reviewed, as you understand it, all of the transcripts
2 related to hydrogeology?

3 A. Yes, I think that is true.

4 Q. Now, we are into this period of
5 the latter half of 1987. Just before Dr. Rowe
6 continues, maybe I can ask Dr. Charlesworth to tell us
7 what further work was done by your office in, say, the
8 period June to September, 1987?

9 DR. CHARLESWORTH: A. Yes, in the
10 period of June to September we carried out some
11 additional field work in terms of establishing a
12 monitoring program to measure water levels on a weekly
13 basis in a number of Trow's boreholes at both Site D
14 and Site F, or a number of the boreholes that Trow had
15 monitored, they were not necessarily all Trow's
16 boreholes. That was carried out for roughly a two
17 month period in the summer.

18 We also continued looking at the
19 interpretation of the geology and maybe adjusting that
20 in some ways. We assisted Mr. Estrin in preparing
21 questions for cross-examination as well during that
22 period.

23 Q. Were you here for Mr. Sobanski's
24 evidence or a large portion of it?

25 A. I was here for a portion of



1 Mr. Sobanski's evidence.

2 Q. Towards the end of 1987 did you do
3 some work with regard to your reports?

4 A. Yes, towards the end of 1987 it
5 was decided we should prepare a report on the work we
6 had done and that was done, these are the two reports
7 which are dated, I believe, October and November maybe
8 of 1987.

9 Q. Perhaps you can just indicate,
10 generally, the relationship, if any, between your
11 reports and Dr. Rowe's reports. Can you give you the
12 Board an indication of whether your reports in your
13 view stand on their own or not?

14 A. Oh, yes, I feel that our reports
15 stand on their own. Some of the information or data
16 that we generated, some of the conclusions we drew were
17 used by Dr. Rowe in his modelling, particularly at Site
18 F. The reports themselves are self-standing.

19 Q. We will be hearing later on today
20 a good deal about your report on Site F. I wonder then
21 if I could return to Dr. Rowe then and you told us that
22 you started to do the modelling in the latter half of
23 '87.

24 First of all, what scenarios did you
25 choose to model for Site D?



1 DR. ROWE: A. Well, the scenarios we
2 selected and modelled for Site D were developed based
3 on questions that I had had in reading the Trow reports
4 and on questions raised in cross-examination of
5 Mr. Sobanski primarily and following discussions with
6 Dr. Charlesworth as to what might be reasonable
7 uncertainties with respect to Site D.

8 I looked, in particular, at three
9 different types. The totally independent types of
10 scenarios. I examined the effect of uncertainty
11 regarding a number of the parameters. The data as you
12 will see, Mr. Chairman, when we come to my Site D
13 report, I considered 12 different cases.

14 In addition to those 12 cases there is a
15 13th case which is implicit. That is Trow's
16 presumption of a working hydraulic trap. When you put
17 that together with the 12 cases I address in my report
18 you have 13 cases which I believe form an envelope of
19 where the truth is likely to lie with respect to Site
20 D. No one can stand up here and do a model and tell
21 you exactly what the concentration is going to be at
22 any specific point at a specific point in time at
23 either site.

24 There are uncertainties and what one
25 does in an engineering situation like this is one looks



1 at a reasonable variation of parameters. You look at
2 the envelope of likely situations and then you form an
3 engineering judgment. That is what I did.

4 Q. We will be coming to your Site D
5 work in detail, but generally what did you conclude
6 with respect to Site D?

7 A. Well, based on the information
8 that was available to me and the results of my
9 analyses, I concluded that there is a reasonable
10 likelihood that groundwater contamination will occur
11 off-site due to the proposed landfill at Site D.

12 Q. Then, perhaps we can ask the same
13 questions with respect to Site F. First of all how
14 were the scenarios that you chose to model selected?

15 A. Again I followed a similar
16 pattern. I held discussions with Dr. Charlesworth
17 concerning the hydrostratigraphy. Factors such as
18 fracture spacing, fracture porosity, hydraulic
19 conductivity, hydraulic gradient and the active flow
20 zone. I modelled the scenario suggested by
21 Dr. Charlesworth paying particular emphasis on the role
22 of matrix diffusion as an attenuation mechanism.

23 I also looked at the implications of his
24 scenario with respect to what one might expect to be
25 happening at the Burlington landfill.



1 Q. Why did you want to pay attention
2 to the Burlington landfill?

3 A. The Burlington landfill has been
4 indicated by various people, sited in an environment
5 very similar to where the proposed Site F is going to
6 be sited. The downgradient edge of the landfill is
7 much closer to where the downgradient edge of Site F is
8 going to be than, say, the Bayview Park which is much
9 further north on the site.

10 I felt that of the two existing
11 landfills Burlington was the more relevant to look at.
12 In addition we had the benefit of the plume delineation
13 study which had been conducted by Gartner Lee. I
14 indicated then that I took Dr. Charlesworth's
15 parameters and I did a model and looked at what the
16 implications would be with respect to Burlington and
17 then looked at what the implications would be compared
18 with the proposed Site F.

19 In addition to that I also looked at
20 some cases worse than that proposed by Dr. Charlesworth
21 to give myself, as an engineer, a feel for what
22 happened and what might be reasonable. I tested these
23 additional cases against the Burlington landfill. I
24 formed some conclusions as to what might be reasonable
25 parameters and then I modelled Site F using these worst



1 case scenarios than that suggested by Dr. Charlesworth.

2 Q. Some of the effects of
3 uncertainty, were these examined in a particular
4 context?

5 A. Yes, indeed. We heard, I think on
6 a number of occasions that there is uncertainty with
7 respect to issues like fracture spacing, fracture
8 porosity, fracture opening size. I agree there is some
9 uncertainty and what I did was model the reasonable
10 range of that uncertainty to get a feeling for it and
11 an understanding of how important it was and what the
12 implications of that uncertainty would be.

13 Q. Why is it that you modelled in
14 addition to, modelled the better fit model in addition
15 to the first idealization of the site that you did
16 model?

17 A. Well, as we have heard there are a
18 number of ways hydrogeologists can interpret the data
19 at Site F. Trow had their interpretation.
20 Dr. Charlesworth has his interpretation and I felt it
21 would be prudent to examine what the implications would
22 be of either case or both cases. As it turned out
23 Dr. Charlesworth's interpretation is more of a worst
24 case than Trow's. That is where the focus of my work
25 has been but I satisfied myself that if the



1 hydrogeology and if the hydrostratigraphy is as said by
2 Trow, then there will be adequate attenuation.

3 Q. So what conclusions did you reach
4 having done modelling of both sites in a general way?

5 A. Firstly I think with respect to
6 Site F, based on the information that is available to
7 me and the analyses I performed, I concluded that the
8 impact of Site F on groundwater quality south of the
9 403 would be minimal.

10 Looking then at the two sites, given
11 that the Region has a choice between Site D and F, Site
12 F was clearly superior, in my opinion, to Site D from
13 the perspective of potential impact on groundwater
14 quality and on the water supply of local residents.

15 Q. Dr. Rowe, thank you. We may not
16 be hearing from you for a few minutes, indeed a few
17 hours. If you do feel that you have something to add
18 to one of Dr. Charlesworth's points as he goes along,
19 you will let us know.

20 We heard, Dr. Charlesworth, as a result
21 of your review of the Trow documents with regard to
22 Site F, we heard him say that you felt that a simpler
23 approach than Trow had taken to the hydrostratigraphy
24 might be appropriate for modelling.

25 Perhaps in a very general way what was



1 it that you said to Dr. Rowe that influenced what it
2 was that he initially modelled for Site F?

3 DR. CHARLESWORTH: A. In reviewing the
4 Trow report, the Trow data for Site F I felt that, I
5 had difficulty reconciling their very detailed
6 breakdown of the hydrostratigraphy with the data that
7 was there.

8 Now, I don't mean to be unduly critical
9 of Trow on that aspect. I think what they tried to do
10 was the right thing to do. I think they got carried
11 along, there is a lot of pressure in this kind of study
12 to show that you know exactly what is going on. The
13 pressure comes not from the hydrogeologist but from the
14 other parties that are involved.

15 Hydrogeology is, I am not afraid to say,
16 is somewhat speculative in most cases. I think that
17 probably they felt they had to go further in their
18 classification to show that they had this
19 understanding. I think it also tied into their model
20 that maybe the tail started to wag the dog a little bit
21 there. You do the model and then the model looks good
22 and then it starts to influence your interpretation of
23 the geology. That is always part of the process.

24 I also felt that so much had been done
25 in this general area by so many consultants over the



1 years that maybe it was the time to stand back and look
2 at it in simpler terms. That is what I tried to do.

3 Q. With respect then to what you
4 generally indicated to Dr. Rowe as to how he should
5 approach modelling the hydrostratigraphy, can you tell
6 us in a general way what you suggested versus what
7 Trow had conceded. Very generally.

8 A. I suggested that it could be
9 modelled in a simple system. I felt that the -- it was
10 my opinion after reviewing the data that you could
11 break down the groundwater system at that site into
12 essentially, into two major units.

13 Now, the demarcation between them is not
14 necessarily clear or well defined but I thought that
15 there was what I called a shallow system where
16 generally and the water quality data played a large
17 part in this. We had a shallow system where the water
18 quality was saline, but it is not as saline as the
19 deeper water and then we had the deeper water, which in
20 my mind, probably presented a more sluggish system.

21 I felt that the important thing for
22 Dr. Trow to be modelling.

23 Q. Dr. Rowe?

24 A. Dr. Rowe. Dr. Trow. Yes. Dr.
25 Rowe or Dr. Trow too I guess. To be modelling, was



1 this what I perceived to be the more active system
2 where contaminant migration, if it occurred in that
3 system, would be a problem.

4 Q. Putting it simply, is the hydro-
5 stratigraphy that you suggested be modelled as complex,
6 less complex or whatever compared to Trow's?

7 A. It is less complex than Trow's.

8 Q. Is your scenario, as you suggested
9 it to Dr. Rowe, as favourable to Site F as Trow's?

10 A. In terms of favourable?

11 Q. Or is it more conservative?

12 A. It is probably more conservative
13 than Trow's.

14 Q. By conservative here, you mean
15 what?

16 A. I mean that it is in terms of
17 waste management or waste disposal, it would be a worst
18 case for movement of contaminants.

19 Q. Now, very generally, what type
20 of -- we are going to go through the report, but very
21 generally what are the type of parameters you gave to
22 Dr. Rowe in respect of his initial modelling of Site F
23 other than the better fit model?

24 A. We gave him values for the unit he
25 is going to model, a shallower flow system. We gave



1 him hydraulic conductivity, gradients, porosity, and
2 those are the main factors. We also commented on
3 velocity of groundwater movement.

4 Q. Can we then come to your report on
5 Site F which I think will help us understand in a more
6 lucid way than my questioning perhaps what you did and
7 what your conclusions were?

8 Let us first of all turn to the
9 introduction which is at page 1-1 and 1-2. You have
10 already told us about what you were retained to do.
11 You referred to the various reports in a general way.
12 Perhaps you could just elaborate on the third paragraph
13 of page 1-1?

14 A. My comment on ...

15 Q. Why it was interesting, beyond
16 interesting, whatever.

17 A. It is interesting, because of this
18 highly saline nature. It is somewhat unusual from the
19 landfill situation that you are normally looking at to
20 have this highly saline water. You have this
21 groundwater flow that is predominantly in this
22 fractured medium, which can complicate the situation
23 and most important of all in this case, in terms of its
24 being interesting, is that you have these two existing
25 landfills which are in the same essentially geologic



1 environment. Whatever theories you have you can
2 compare with how those two landfills have actually
3 behaved.

4 Q. How important is that in your
5 experience in terms of trying to make predictions?

6 A. I think it is very important. It
7 is one thing to make predictions about groundwater
8 movement and contaminant movement but, as I have said,
9 there is always this element, some degree of
10 speculation in groundwater. To be able to look at how
11 a site has actually behaved I think is very important.
12 Particularly in a geological environment which,
13 although I am presenting a simple model, you can argue
14 in detail is quite complex.

15 Q. All right. In the last paragraph
16 of page 1-1, you say:

17 "From the results of the various
18 investigations a good understanding of
19 the sub-surface conditions, in a general
20 context, has been obtained. Although
21 there are different interpretations of
22 the details of the groundwater regime,
23 the majority of reviewers have concluded
24 that landfilling in this area does not
25 pose a threat to the environment. We



1 agree with that opinion."

2 Some of the reviewers that you had in mind in making
3 that statement were whom?

4 A. In looking back through the
5 various reports, comments and reviews that have been
6 made about either of the two existing sites or proposed
7 sites, Site F or the work done when the site was
8 proposed there at an early stage, people who have
9 concluded, who have had differences -- maybe in the
10 details of their reports -- in their descriptions of
11 the details of the full system, but they have concluded
12 that one or other of these landfills or proposed
13 landfills are safe are people like Gartner Lee looking
14 at the Burlington site. Morrison Beatty doing work for
15 National Sewer Pipe. Cherry and Lush doing work some
16 time ago. Keros Cartwright, an independent consultant
17 who looked at the National Sewer Pipe proposal. Trow of
18 course who are the proponents here. In terms of the
19 functioning of Bayview Park with a leachate toe drain
20 collection system, I would say Conestoga-Rovers.

21 Q. Just if we could turn to the last
22 paragraph of your introduction on page 1-2. You have
23 already indicated that you differ from Trow with
24 respect to the detailed interpretation of the
25 hydrogeologic regime. Is that what you said a moment



1 ago?

2 A. That is correct, yes.

3 Q. I wanted to draw your attention to
4 the last sentence of that paragraph and to ask you to
5 give us your opinion, generally speaking, does it
6 matter in your view whether Trow is right or you are
7 right with respect to how this hydrogeologic regime
8 works?

9 A. I think looking at all the data
10 which is now available to us which includes the work
11 done by Dr. Rowe, I would say that whether my scenario
12 or Trow's scenario are the ones that you accept, the
13 site is still a safe site for waste disposal.

14 Q. Did you have any initial
15 impression in reviewing the report on Site F. I ask
16 that in the perspective of -- we have heard it said
17 that usual landfill in Ontario is situated on a nice
18 till clay plain?

19 A. Before I looked at all the
20 information I think it is fair to say that when first
21 faced with the idea of a landfill on the Queenston
22 shale, any aspect, yes, I have some reservations.

23 Q. Why?

24 A. Because it does not, as you
25 alluded to a moment ago, Mr. Estrin, it does not fit in



1 with the classic thinking and I say classic, but
2 classic within the last few years, thinking of the
3 landfill site in terms of situated on a sort of uniform
4 till deposit. The flow, as we have heard, is flow
5 through fractures. There may be concerns about getting
6 a complete understanding of that flow if you are merely
7 placed with a predictive situation.

8 Q. What about your opinion after you
9 had reviewed all of the data? Did it in any way
10 change?

11 A. Yes. I came to the conclusion
12 that a landfill at this site was acceptable, this would
13 be a safe site for a landfill.

14 Q. Is that conclusion based, to what
15 extent if any was that conclusion based on Dr. Rowe's
16 modelling or were you able to arrive at that conclusion
17 on your own?

18 A. I had arrived at that conclusion
19 on my own but Dr. Rowe's modelling gave another level
20 of comfort.

21 Q. I want to take you to the summary
22 of your report which is found in Roman numerals right
23 after the table of contents. Did you, just looking for
24 a moment, skipping down to the third paragraph, you
25 make some comment with respect to the groundwater in



1 the Queenston shale, the last two sentences in the
2 third paragraph and have reached some conclusion with
3 respect to what indeed may be the value of that saline
4 groundwater?

5 A. Yes, I looked at the data, the
6 extent of the data that is available on the quality of
7 the groundwater in the Queenston shale. As you have
8 heard from the evidence from Trow it is generally
9 extremely saline. I could think of no reasonable use
10 for that as a resource. It seems to me that its
11 greatest value may in fact be in the area of waste
12 disposal, given the crisis that faces waste disposal in
13 the province, if not in the country.

14 Q. Let us back up in this summary and
15 let us perhaps illustrate, for the moment, you have an
16 overhead I would like you to get ready.

17 Dr. Charlesworth, you have put up an
18 overhead that is headed, can you bring it down a bit?
19 Perhaps turn the projector straight on the wall. You
20 put up an overhead showing "Sketch Showing Shallow or
21 Upper Zone in Shale." Can you refer to that with
22 regard to the first two or three paragraphs of your
23 summary so that we have a better understanding of your
24 analysis of the flow system?

25 A. As the title says, this is a



1 sketch but I think it serves to illustrate the point I
2 am trying to make. When I refer to a shallow system or
3 a shallow zone, I have marked on this figure, and this
4 is the area where generally, at least in the vicinity
5 of the proposed Site F, and there I am talking about
6 this zone here, the water is of, less saline than it is
7 at depth.

8 That suggests to me that there has been
9 some movement, more active movement of groundwater
10 which has resulted from recharge or precipitation.

11 Q. So you have got a shallow zone
12 marked on this overhead and, Mr. Chairman, can we make
13 the hard copy the next exhibit?

14 MR. LANCASTER: 445, M-445.

15 ---EXHIBIT NO. M-445: Sketch Showing Shallow or
16 Upper Zone in Shale

17 DR. CHARLESWORTH: I should say, there
18 may be a little ambiguity here in matters of
19 terminology. I am calling all of this the shallow
20 zone. I recognize that within the shallow zone there
21 will be some water which reappears very quickly at the
22 surface, in my second paragraph, I have said the
23 shallow system. It would have been less ambiguous to
24 say part of the shallow system is of limited extent
25 with water reappearing at the surface within relatively



1 short distances. That is water that doesn't move very
2 far into the ground at all.

3 MR. ESTRIN: Q. What would the
4 other part of the shallow system be?

5 DR. CHARLESWORTH: A. The rest of the
6 shallow system, I believe, moves laterally downwards
7 and towards the lake within the shale and does not
8 reappear at the surface. Certainly within the vicinity
9 of the site or I believe in the discharge zone that
10 Trow postulated. I think that is one of the
11 fundamental differences between, certainly Trow's
12 scenario as presented in the report and my
13 interpretation; although I would add that Trow's sort
14 of modified interpretation based on their better fit
15 model approaches this somewhat. The discharge zone
16 they refer to in their report becomes less significant
17 in their better fit model.

18 The discharge zone that Trow were
19 referring to is this zone south of the 403 and north of
20 the railroad tracks where they see water coming down
21 and coming up in that zone. I believe that the water
22 that goes down into this zone will move latterly
23 towards the lake.

24 Q. The O/B on this exhibit stands for
25 what?



1 A. Overburden. That is the till and
2 then the overlying lacustrine deposits.

3 DR. KINGHAM: When you referred to
4 shallow zones you mean both the overburden and part of
5 that sub-strata?

6 DR. CHARLESWORTH: Certainly within this
7 site my shallow zone is down here. I recognize the
8 fresh water lens or the rind that Mr. Sobanski referred
9 to. It will be sitting on top of that and I don't see
10 that as part of the shallow zone at Site F. I think it
11 is another freshwater lens above that. Even this water
12 becomes rather saline.

13 I drew this line somewhat arbitrarily to
14 roughly represent, initially anyway, the 5000 parts per
15 million chloride contour. That seemed to be a fairly
16 sharp, seemed to be a fairly sharp increase at that
17 contour in some of the boreholes. I said we will treat
18 everything above that as water that is a mixture of
19 water that has been retained in the rock.

20 I think the salinity here is probably
21 connate water, water that has been trapped in this
22 situation probably since the deposition. Whether it is
23 water that has been picked up from minerals in the
24 rock, there doesn't seem to be evidence for that.
25 Nevertheless, if there was an active system you would



1 tend to have that flushed out. We have water that is
2 more saline than seawater. Here we have this brackish
3 zone going up into the fresh zone.

4 DR. KINGHAM: Just so we understand in a
5 very general way you are going to get into many details
6 on this I am sure. Is this the essential difference
7 you are telling us that when freshwater comes into this
8 shallow zone you are going to be assuming it goes down
9 to the dotted line more or less and then across as
10 opposed to what we were presented with earlier where it
11 gets into the shallow zone and not called that, but
12 nevertheless, gets into that shallow zone and then
13 heads across and emerges between 403... is that the
14 essential?

15 DR. CHARLESWORTH: That is the essential
16 difference. I believe, what proportion does get down
17 into the even deeper zone, it is difficult to define.
18 I believe that once water by-passes the very shallow
19 system it recharges on the elevated areas and comes out
20 in the gullies that are on the site. Apart from that
21 water, if it by-passes that system, I don't believe it
22 reappears at the surface down in that discharge zone.

23 MR. ESTRIN: Q. Dr. Charlesworth, a
24 couple of points that might be worth illustrating in
25 coloured pen. First of all, that dashed line on this



1 overhead, that corresponds, it is meant to indicate a
2 rough demarcation line of some sort?

3 DR. CHARLESWORTH: A. It is roughly on
4 this sketch, it is a demarcation, it is roughly based
5 on the chloride content of the water.

6 Q. You mentioned 5000, is that the
7 demarcation?

8 A. Yes. It is not carved in stone,
9 but is approximately right.

10 Q. Perhaps you could indicate that on
11 that overhead so if we go back to it we know what that
12 line. Approximately. If you feel that it is not
13 appropriate?

14 A. I think probably at this point it
15 is not appropriate.

16 Q. This is a schematic you are
17 showing us?

18 A. Right.

19 Q. With respect to -- you mentioned
20 that there were really two aspects to your shallow
21 zone, one of which you said had some discharge on Site
22 F if I have understood it?

23 A. Some will discharge on site within
24 the creeks and within the depressions.

25 Q. Would you be able to show by some



1 arrows how that might work?

2 A. It is rather difficult on this
3 cross-section just because of the scale of it. I
4 haven't actually shown the water table on there. If
5 you were to assume I suppose, if you were to assume the
6 water table was close to the surface and then you
7 looked at it in cross-section across here where you
8 have got hills and valleys, then this would be the kind
9 of water that recharged, that recharged and then came
10 out in the valley bottoms rather than moving down and
11 flowing latterly within the system.

12 Q. Then in addition to that, if that
13 occurred and if that was involved with leachate at some
14 point, how would that relate to a concept known as
15 leachate springs which we have heard something about at
16 the Bayview Park site?

17 A. Well, from the evidence I have
18 seen of the flow system here, the leachate that -- any
19 leachate that got into the groundwater I believe could
20 be collected on the site or it would move downgradient
21 within the shale. I do not believe it would discharge
22 off-site other than ultimately wherever the whole
23 system discharges, whether that is Hamilton Harbour or
24 Lake Ontario.

25 DR. ROWE: A. Mr. Chairman, I think I



1 should point out that in my modelling of
2 Dr. Charlesworth's concept of this site, I was
3 essentially modelling contaminant lying in this zone
4 here.

5 Q. You mean this shallow zone here?

6 A. What Dr. Charlesworth has called
7 the shallow zone.

8 Q. Dr. Charlesworth, were you able to
9 just generally put some parameters on the generalized
10 depth of that shallow zone? Perhaps it varied, but
11 perhaps you could give us the range of it?

12 DR. CHARLESWORTH: A. It varies but if
13 you stick to the 5000 contour it varies from probably
14 20 plus metres to 10 or even as low as 5 metres. In
15 general terms, I would consider it in the order of 20
16 metres. I think for modelling purposes Dr. Rowe used
17 25 metres. I think that is a reasonable figure for
18 modelling.

19 Q. When you say you used depths of 20
20 varying down to something less, where was the 20 metres
21 in relation to the proposed Site F. Where was the zone
22 thickest, if you like?

23 A. My zone?

24 Q. Your zone, the shallow zone?

25 A. Back in this area here. It is



1 thickest there. If you follow the chloride it thins as
2 you go towards the south.

3 DR. KINGHAM: Just for the record the
4 thickest here means to the most northerly side of your
5 chart, at the top?

6 MR. ESTRIN: Right.

7 Q. Now, you say in the fourth
8 paragraph of the summary that the salinity of the
9 groundwater in the shale is probably derived from the
10 sea in which sediments were originally deposited
11 hundreds of millions of years ago? Are you referring
12 to any particular aspect of that system or all of it?

13 A. All of it, that is where the
14 salinity comes from. Where you have lower salinity
15 values it suggests to me that is where there has been
16 mixing between meteoric water or recharge water and the
17 original connate water.

18 Q. What is connate water?

19 A. Connate is water that was trapped
20 in the sediments at the time of deposition.

21 Q. What is it you are saying with
22 respect to whether meteoric water has gotten down to
23 this other zone?

24 A. It suggests to me that things are
25 moving very slowly in that deeper zone. There has not



1 been a flushing out of the system.

2 DR. KINGHAM: For simplicity can we call
3 meteoric water rainwater?

4 DR. CHARLESWORTH: Yes.

5 MR. ESTRIN: Q. For our purposes does
6 it matter where the salt comes from?

7 DR. CHARLESWORTH: A. I don't think it
8 is particularly important. I guess you may get into an
9 argument about that but I don't think it is
10 particularly important. The fact it is there and
11 whether it has been flushed out or not, is I think the
12 important factor.

13 Q. Now, at this point I would like to
14 turn to page 7-1 of your report which has some
15 conclusions on it and ask you to direct yourself to the
16 fifth paragraph there. It seems to be the same topic
17 but a different angle of it.

18 A. What I am really saying here, is I
19 am trying to say two things in one maybe. Water that
20 does not reappear on the site where it would be
21 collected will move downgradient. It may move within
22 this shallow zone. It still doesn't matter because it
23 is not going to reappear at the surface until it has
24 flowed some considerable distance through the rock. It
25 may move into a much more sluggish system which is



1 highly saline water which also doesn't matter.

2 I don't see, and we will discuss this in
3 more detail, but I don't see evidence for it
4 discharging close to the site but off the property. I
5 think that is the important point that I am trying to
6 make. If you are going to model it then you should
7 model it in this zone to see what happens anyway.
8 Certainly it doesn't matter what happens when it gets
9 down into the deep zone.

10 Q. You will be telling us later on
11 this afternoon what you did to reach these conclusions.
12 with regard to this zone. I am just trying now to, in
13 a summary, way understand your overall conclusions.

14 Now, can we go to the sixth paragraph on
15 your summary page, Roman numeral (i). Again you refer
16 to the fact that several studies have been done in an
17 attempt to define the extent of groundwater
18 contamination at the two existing sites. After
19 reviewing the results of these investigations we have
20 concluded there is no evidence of unacceptable off-site
21 migration of contaminants from the site through the
22 groundwater regime.

23 First of all, would you give the Board,
24 do you agree with that statement?

25 A. Yes, I agree with that statement.



1 I made it.

2 Q. Secondly, could you give the
3 Board, please, your terms of reference, your definition
4 in this context of the term "unacceptable off-site
5 migration"?

6 A. In this context when I said
7 unacceptable I was referring to the fact that some
8 studies have concluded that contaminants have been
9 found in some holes. Where this occurred they were all
10 below the drinking water standards. Also as we heard
11 from Mr. Feenstra there was evidence or there was not
12 evidence to relate them directly to the landfill.

13 So, all that has been found is rather
14 tenuous evidence and it certainly was well below this
15 drinking water standard. That is what I meant by
16 unacceptable.

17 Q. That definition or that
18 explanation, is it particularly being addressed to your
19 statement about Site F here, when you start relating to
20 the drinking water standards?

21 A. Yes.

22 Q. All right, then really to complete
23 some type of overview if we look at page Roman number
24 (ii) of your summary, you have already told us about
25 the first paragraph. Then you will be commenting with



1 respect to the use of groundwater south of the site and
2 put that into context?

3 A. Yes, I will.

4 Q. Then, with regard to the last
5 paragraph perhaps you can just elaborate briefly on
6 your overall conclusion and put this into perspective?

7 A. The last paragraph?

8 Q. Yes. I take it you did reach some
9 overall conclusion with respect to Site F relative to
10 Site D?

11 A. I concluded that there is very
12 poor groundwater quality at Site F. There are no
13 essential water supplies being placed at risk by Site F
14 and particularly important I think we have two
15 landfills that we can look at and see how they have
16 behaved.

17 In addition, sort of as a bonus I think
18 that the gravity-fed leachate collection system which
19 has no reliance on a hydraulic trap or pumping. All
20 these things together in my opinion make Site F
21 preferable to Site D as a location for the landfill.

22 MR. ESTRIN: Mr. Chairman, I am about to
23 move into some of the detailed sections of the report
24 so perhaps this would be an appropriate time.

25 MR. LANCASTER: Yes, a quarter to two.
---Luncheon Adjournment at 12:23 p.m.



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

2 MR. LANCASTER: Please be seated.

3 MR. ESTRIN; Q. Let us turn, if we
4 could, Dr. Charlesworth to your Exhibit M-437, page 2-
5 1, physiographic and geological setting.

6 In this there is a brief page and a half
7 on this point. In terms of the physiographic and
8 geologic setting you made, you told us about some field
9 trips you made to the sites?

10 DR. CHARLESWORTH: A. That is correct.

11 Q. Did that allow you to determine
12 whether or not you agreed with Trow's description of
13 the physiographic and geologic setting?

14 A. The physiographic contributed to
15 the geological as well as looking at the geological
16 data available.

17 Q. With respect to those
18 categorizations did you agree or disagree with them?

19 A. I would agree with Trow's
20 categorization.

21 Q. Now, if we can come to page 3-1,
22 the discussion of groundwater occurrence and use. You
23 looked at this topic, what did you do essentially to
24 form some opinions on this topic?

25 A. Essentially I reviewed the data



1 presented by Trow with regard to the location of wells.
2 I also, on the whole general topic, looked at the water
3 level data.

4 Q. What were your important
5 conclusions with respect to this topic?

6 A. I guess the first conclusion just
7 refers to the general regional flow pattern and
8 certainly on a regional basis, disregarding discharge
9 areas I agreed with the general picture presented by
10 Trow. It is fairly obvious that flow is from the high
11 lands out towards the lake.

12 In terms of groundwater use I think it
13 was important to see that there are virtually no
14 groundwater users downgradient of this site. Certainly
15 there are no households that need to be dependent on
16 wells.

17 Q. Did you consider the information
18 that was tendered by the West Burlington Citizens
19 Group, Exhibit 227?

20 A. Yes, I did.

21 Q. I am showing you a copy of that.
22 That, Mr. Chairman, is subject to further proof.
23 Assuming that, assuming the facts in there are proved,
24 what conclusion or how, if at all, did it change the
25 previous opinion you had reached about the situation?



1 A. This information would not change
2 my previous conclusion with regard to groundwater use
3 downgradient of this site.

4 Q. Did you look at the other
5 information that is attached there, for example,
6 attached to the exhibit is an analysis of well water
7 provided by Ms. Vigod?

8 A. Yes, I looked at the analysis.

9 Q. First of all, what does the data
10 indicate to you in terms of its quality for drinking
11 water, say with regard to nitrates?

12 A. I notice that a number of the
13 wells appear to exceed the provincial guideline in
14 regard to nitrates.

15 Q. Of what significance are nitrates
16 in drinking water supply?

17 A. Nitrates pose a health hazard to
18 children and to unborn, children who are being breast
19 fed. So nursing mothers, pregnant women and children
20 should not drink water containing nitrates.

21 Q. What is the provincial standard
22 for nitrate?

23 A. I believe that is 10 parts per
24 million.

25 Q. Now, there is an analysis



1 contained in this exhibit with respect to the amount of
2 chlorides in these wells. The values, ignoring the
3 upgradient one for a moment, say of 413, look at the
4 ones downgradient of Bayview Park or the proposed Site
5 F.

6 What conclusion can you reach with
7 regard to this data considering this data and your
8 previously expressed opinion that the saline
9 groundwater within the shale would not discharge to the
10 surface?

11 A. These relatively low chloride
12 values and I say relatively low, certainly in the
13 context of this area, indicate to me that there is no
14 discharge of water from the shale into the aquifer that
15 these wells are taking their water from.

16 Q. Typical values there being what?

17 A. They vary, 25, 62 parts per
18 million, 51. A matter of tens of parts per million.
19 It is slightly elevated but not significantly with
20 regard to contributions from the shale.

21 Q. Now, the other aspect of this
22 matter that you discuss in your report is -- is this
23 groundwater or is this freshwater lens within its
24 surficial deposit. Looking at page 3-2 of Exhibit M-
25 437. You expressed there certain opinions with regard



1 to the extent and therefore, the significance or lack
2 of significance of that freshwater lens.

3 Can you expand on this? In terms of
4 providing a municipal water supply is this freshwater
5 lens of use or not?

6 A. It is my opinion and I haven't
7 done any test drilling or test pumping. There are two
8 factors here. It does not appear to be a source of nor
9 would I expect it to be a source of -- a major source
10 of supply for municipal wells. However, given that we
11 have saline water at depth in the shale, I would think
12 that if it was possible, and I don't believe that it
13 is, but if it was possible to develop a high yielding
14 well in this lens then you would have almost a classic
15 situation of where you lower the level in the
16 freshwater, you draw up the saline water from beneath.

17 So, in terms of a large supply I don't
18 think that it is a viable proposition.

19 Q. Dr. Charlesworth, have you had
20 personal experience investigating situations that are
21 similar or analogous to that potential problem you are
22 now putting forward, say in your work in Jamaica or
23 elsewhere?

24 A. I was going to say certainly in a
25 different clime than we have here today. In Jamaica



1 the aquifer I was studying there had the problem of
2 seawater intrusion. So, you had fresh water over
3 saline water. It is not obviously strictly the same,
4 but it is a freshwater lens situation.

5 I think I might also comment there, and
6 I think comment in the report, Mr. Chairman, that given
7 the urbanization that exists in that area I would have
8 some concerns about relying on wells in that general
9 area as a source of drinking water. Now, I am
10 referring to individual domestic wells. It is certainly
11 not a pristine area.

12 DR. KINGHAM: Because ...

13 DR. CHARLESWORTH: Because of man's
14 activities and urbanization.

15 DR. KINGHAM: Because of other
16 pollutants produced by urbanization that would get into
17 the water.

18 DR. CHARLESWORTH: Yes.

19 MR. ESTRIN: Q. In fact,
20 Dr. Charlesworth, you will be discussing with the
21 Board, I believe, some history of this area in
22 particular and perhaps evidence of past industrial
23 activity in that general vicinity?

24 DR. CHARLESWORTH: A. It is not
25 strictly the area that I am thinking of. I guess they



1 overlap.

2 Q. I wonder if we could turn to the
3 next chapter of your report which deals with
4 groundwater movement at page 4-1 of Exhibit M-437. I
5 would like to turn to, turn you first to page 4-2 where
6 you state one conclusion in regard to this general
7 topic of hydraulic gradients. Could you read the
8 second paragraph?

9 A. Certainly.

10 "It is our conclusion that downward
11 gradients do indeed predominate within
12 the vicinity of the site, but we also
13 note that even downgradient, between
14 Hwy. 403 and Hamilton Harbour, where
15 lateral gradients are believed to
16 predominate, downward gradients do still
17 occur within the shale."

18 Q. Would you also go to page 4-7 on
19 that same point and just read the first three
20 paragraphs there?

21 A. "In summary, this review of the
22 water level data suggests that downward
23 gradients predominate at Site F, and
24 even to the south of the site. Though
25 there are local complexities which



1 probably vary on a seasonal basis in the
2 case of the shallow flow system.

3 Close to the area in which Trow
4 postulate there is a discharge zone,
5 (i.e., south of the railroad tracks),
6 their monitoring holes do not show
7 upward gradients in the shale. Thus,
8 unless there is a reversal of gradients
9 within a relatively short distance the
10 idea of a discharge zone appears
11 somewhat doubtful.

12 Between the C.N. tracks and Hamilton
13 Harbour there are, at a number of
14 locations, upward gradients within or
15 into the surficial deposits. However,
16 based on the water quality data, there
17 is no evidence of discharges at the
18 surface from the regional (saline) flow
19 system in the shale."

20 Q. Of what significance overall are
21 these conclusions with respect to hydraulic
22 conductivity in terms of assessing, in terms of
23 hydraulic gradients, in terms of assessing potential
24 impact of the site?

25 A. They are important because in



1 general they suggest that there will be movement
2 downwards within the system and that there is not this
3 clearly defined discharge zone. There are, and we will
4 see as we look at them, obviously local variations
5 within the overall pattern. I want to be careful, I
6 should say at this point that through this we will
7 found that there is not a complete conclusive fit of
8 the data to any of the models, but I am looking at the
9 general overall picture.

10 Q. What work did you do to examine
11 these hydraulic gradients? I understand that you did
12 produce two new cross-sections among other things?

13 A. To examine these gradients we
14 looked at the Trow cross-sections, specifically at the
15 ones they prepared on a regional scale. I think in
16 their report these are A-A and B-B. We also prepared
17 two cross-sections of our own. One which more or less
18 passes down through the centre of proposed Site F and
19 one which runs south, I am using south in the sort of
20 local context there, from Bayview Park.

21 We used data, in our own cross-sections
22 we used data supplied by Trow, given in the Trow report
23 and just produced additional cross-sections. On Trow's
24 cross-sections they show themselves locations of the
25 piezometer tips and the water levels recorded in those



1 in 1986. We did the same thing on the cross-sections
2 we ourselves produced.

3 Q. I think this would be the
4 appropriate occasion to get up the cross-sections and
5 show the Board how you proceeded and perhaps illustrate
6 how you arrived at these conclusions.

7 DR. KINGHAM: Are these the cross-
8 sections we have?

9 MR. ESTRIN: Except we have some
10 coloured which I think will be more ...

11 DR. CHARLESWORTH: The first two
12 sections we were going to look at are actually cross-
13 sections from the Trow site F report which are drawing
14 six of Site F report.

15 MR. ESTRIN: Q. Do you want to put that
16 up? I think this should receive -- I think this should
17 be marked with a separate number because it has been
18 marked by you with different information or interpreted
19 differently.

20 First of all I think we should put up
21 your site plan.

22 A. I will just put up for a moment,
23 Mr. Chairman, the site plan which is in our report
24 which just shows the proposed Site F and the locations
25 of the boreholes. We have marked on there the



1 locations of our two cross-sections which we labelled G
2 and H.

3 DR. KINGHAM: Is that the same as the
4 diagram we have been using earlier for Site F, from
5 Halton, the same aerial photograph?

6 DR. CHARLESWORTH: I am not sure it is
7 the same aerial photograph. It is a drawing we drew up
8 so it is different from the Trow one.

9 DR. KINGHAM: The background, you are
10 working from the same basic aerial photograph?

11 DR. CHARLESWORTH: It probably is, I
12 think it is, yes, it is the same photograph.

13 I would just like to draw your
14 attention, Mr. Chairman, just to simplify this, I also
15 marked on here the location of Trow's cross-sections
16 A-A and B-B, although they do continue down to the lake
17 or to Hamilton Harbour. You will also note that
18 these two sections coincide in the northern part of the
19 site.

20 So first I am going to look at the Trow
21 cross-sections and discuss those.

22 MR. ESTRIN: Can we mark your site plan
23 as the next exhibit?

24 MR. LANCASTER: M-446.

25 MR. ESTRIN: Q. Which is the first



1 cross-section there?

2 MR. HODGSON: Perhaps, Mr. Chairman, if
3 I could suggest if we kept to the old system where
4 something has been taken out of a report. I think that
5 site plan is from Exhibit M-437. Why not just make it
6 M-437-D1. Am I right that that is what it is?

7 MR. ESTRIN: Sure.

8 MR. LANCASTER: What was the number.

9 MR. HODGSON: I am trying to get clear.
10 It is the site plan from M-437.

11 MR. ESTRIN: The witness has indicated
12 he has added two lines to it which are not on yours.

13 MR. HODGSON: I don't think that the
14 fact the witness has added something to it matters. We
15 should mark it as a separate exhibit anyway. How do
16 you keep track of it. If we are reading our reports
17 and we want to know something has been an exhibit and
18 marked up it is easier if it references the document it
19 originally came from and this came from Exhibit M-437.
20 I am just suggesting it be marked as part of the
21 exhibit.

22 MR. LANCASTER: Which drawing is it?

23 MR. HODGSON: I have it as Figure 1.

24 DR. CHARLESWORTH: Figure 1.

25 MR. ESTRIN: That is fine certainly.



1 MR. LANCASTER: We will call it M-437-
2 D1.

3 ---EXHIBIT NO.M-437-D1: Amended Site Plan, Site F

4 MR. ESTRIN: Q. Dr. Charlesworth which
5 cross-section are you going to discuss?

6 DR. CHARLESWORTH: A. This is Figure 6
7 from the Trow Site F volume 1 report which is cross-
8 section A-A.

9 Q. That is not found in your report?

10 A. That is not found in our report
11 and we have added some colour to it.

12 MR. ESTRIN: I think that properly
13 deserves a separate number.

14 MR. LANCASTER: It is in your exhibit I
15 would think?

16 MR. HODGSON: Is it Figure 6?

17 MR. ESTRIN: Yes.

18 MR. HODGSON: We have got a Figure 6
19 marked already, Mr. Chairman, as H-40-6. If this is a
20 different one...

21 MR. ESTRIN: I think it would be
22 appropriate to put a Milton number on it because the
23 new information is being provided by Milton and let us
24 not get it confused with whatever Trow has provided.

25 MR. LANCASTER: That would make it M-



1 446.

2 ---EXHIBIT NO. M-446: Figure 6 from Trow Site F Report

3 MR. ESTRIN: Q. Dr. Charlesworth I know
4 you don't have a terribly good pointer then but anyway
5 do your best. What have you done there, there are some
6 pink lines I can see from here. There are some other
7 colours.

8 DR. CHARLESWORTH: A. Mr. Chairman, all
9 we have done is to add some colour to it. We have
10 taken the Trow piezometers and the vertical gradient
11 reported by Trow and these are actually marked, at
12 least the water level is marked on the map, on the
13 cross-section. For example, here.

14 Q. Where is here?

15 A. At HC-4 we see piezometer one and
16 up towards the top of the borehole is an inverted
17 triangle halfway up marking the water level for that
18 piezometer. We do that for each of the piezometers so
19 you can see whether there is an upward or downward
20 gradient at that site, at that location. All we have
21 done here is where there is a downward gradient between
22 two piezometers we have marked it in red. Where there
23 is an upward gradient we have marked it in green and
24 where they reported a horizontal gradient, that the
25 water level was the same in these two piezometers, we



1 have marked it in yellow.

2 Q. Dr. Charlesworth, first of all, I
3 don't know -- they are having some difficulty at the
4 back of the room seeing that. I don't know if we can
5 elevate that in any way -- has anyone got some
6 paperclips?

7 Even from where I am standing I am
8 having a little bit of trouble distinguishing between
9 yellow and green. Perhaps just review that so we
10 clearly understand how your coding works. Start at the
11 left-hand side.

12 A. At the left-hand side we have
13 borehole HC-1 which has three piezometers in it and I
14 am using the word piezometer which sometimes a
15 shallow one is referred to as a standpipe but it
16 measures that water level in the surficial deposits.
17 We had three measuring points and between the upper
18 most one and the middle one, the upper one is in a
19 surficial deposit till, the middle one is at the top of
20 the shale and the lower one is down into the shale. We
21 have a downward gradient so the whole of that borehole
22 is marked red to show that there are downward gradients
23 as recorded by those piezometers.

24 In HC-4 we have a similar situation
25 across. Here we have four piezometers and we have



1 downward gradients. HC-6 has downward gradients.
2 Coming south MB-13 just close to Highway 403 has
3 downward gradients. When we come to HC-9 we do in fact
4 show on this occasion essentially horizontal gradients
5 within -- and I will talk a little more about this --
6 but we have essentially horizontal gradients within the
7 surficial deposits between the piezometer at the bottom
8 of the surficial deposits and the next one down in the
9 shale and the lower one we should see a downward
10 gradient.

11 As we start to move down towards the
12 lake we do in fact, at HC-10 have an upward gradient in
13 the till. There are two piezometers set within the
14 till but between the lower of those two and the ones
15 set near the top of the shale, according to this data
16 there was essentially a horizontal gradient. As you
17 move further towards the lake we have an interesting
18 situation. We do have an upward gradient showing here.

19 Q. Where is that one?

20 A. This is at borehole HC-12 which is
21 about halfway down towards Hamilton Harbour. The top
22 section at this time and here we have a piezometer set
23 within the surficial deposit and the one set down
24 within the shale we actually have a horizontal gradient
25 showing there so there seemed to be an upward gradient



1 within the shale, but a horizontal gradient around the
2 shale overburden contact.

3 DR. KINGHAM: What well number is that
4 again?

5 DR. CHARLESWORTH: That is HC-12. Down
6 to HC-13, just down to the lake we actually have a
7 downward gradient in the lower part of the shale, but
8 an upward but almost horizontal gradient just above
9 that.

10 So in this cross-section we definitely
11 have a pattern of downward gradients in the vicinity of
12 the site. We seem to have horizontal gradients within
13 the shale around south of the 403 and we have a
14 combination of horizontal and some upward gradients as
15 you move down towards the lake.

16 I will now refer to the next section
17 which is Trow's section B-B.

18 MR. ESTRIN: Q. Burlington have
19 provided you with a pointer.

20 DR. CHARLESWORTH: A. Here we are
21 looking at cross-section B-B. I guess we should give
22 this one an exhibit number too?

23 MR. LANCASTER: M-447.

24 ---EXHIBIT NO. M-447: Cross-section B-B

25 MR. ESTRIN: Q. If it is possible,



1 Dr. Charlesworth, with the pointer's assistance could
2 you stand either at one side or the other if possible.

3 DR. CHARLESWORTH: A. This section in
4 the upper part I won't go over that, they coincide. As
5 you may recall from this exhibit the top three
6 boreholes are the same and then the section, the
7 sections diverge. That is B-B runs southward and here
8 we have...

9 Q. Here is where?

10 A. At the north end of Site F,
11 downward gradient through the till and into the rock.
12 At HC-4 we have downward gradients throughout the
13 section of the borehole. At HC-5 we have downward
14 gradients. At HC-8 we have very, very slightly upward
15 gradient at the top but essentially horizontal and that
16 is probably why you can't see it from there,
17 Mr. Chairman, but we have a mixture of green and yellow
18 shading there and then downward gradients beneath that.

19 At HC-14 which is south of Highway 403
20 between the overburden and the upper part of the shale
21 and down to the next piezometer in the shale, the water
22 levels here show a downward gradient. We are into the
23 area south of the 403, north of the CN tracks which is
24 proposed as a discharge zone. We have a downward
25 gradient. At the bottom part of that hole we have



1 coloured it yellow with pink marks in it. It is almost
2 horizontal but very slightly downwards.

3 Here at HC-11 we do show an upward
4 gradient although we don't have a measurement within
5 the till. We have a shallow piezometer -- sorry, we
6 don't have more than one piezometer in the shale and we
7 only have one piezometer in the till or just at the top
8 of the till, so I have crossed quite a large distance
9 there, it does show an upward gradient. It seems to be
10 a shallow sort of perched system within the surficial
11 deposits. Down at HC-16 we are actually showing a
12 downward gradient in the vicinity of Hamilton Harbour.

13 So, those were the two Trow cross-
14 sections.

15 Q. That data is all taken from what
16 period of time in both of those exhibits, M-447 and M-
17 446?

18 A. These were taken April, 1986.

19 I then go to the figures that we have in
20 our report. The first one is our cross-section G-G
21 which if you refer to the site plan, runs from the
22 upper part of the Burlington landfill down the western
23 side of Site F and cuts across borehole 8 and borehole
24 14. So the lower part of this correlates.

25 We have a different vertical scale on



1 these, on our cross-sections, just so that we could fit
2 more data in.

3 Q. Perhaps, Dr. Charlesworth, we
4 should exhibit this with regard to Exhibit M-437 so
5 this would be M-437-D4.

6 ---EXHIBIT NO. M-437-D4: Cross-section G-G

7 MR. ESTRIN: Q. Mr. Hodgson, and my
8 associate, points out that we should mark it 4 on the
9 assumption we get 2 and 3. I am sorry, Dr.
10 Charlesworth would you change that to D4 which is
11 drawing 4 in your report.

12 DR. CHARLESWORTH: A. Here again
13 starting at the northern end which is a Gartner Lee
14 borehole we see once again downward gradients. This is
15 in the vicinity of the existing Burlington landfill.
16 Moving south we come to Gartner Lee GL-18 and we see
17 downward gradients. HC-3 we see downward gradients.
18 HC-8 we looked at it, it coincides with the previous
19 cross-section. We do have this slightly upward zone,
20 upward gradient, almost horizontal and I have a note
21 here to announce that there is a correction to be made
22 on your figure here that we have added a dotted line.
23 This was just a graphic error. Where it says weathered
24 shale between MB-5 and HC-8, that weathered shale
25 should be deleted.



1 That is in this vicinity here. There
2 should be a dotted line.

3 DR. KINGHAM: A dotted line to where?

4 DR. CHARLESWORTH: It separates the clay
5 silt and till from the till and weathered shale. It
6 runs through the upper horizon there.

7 MR. ESTRIN: Q. Could you just point
8 again to that?

9 DR. KINGHAM: You are deleting the words
10 weathered shale?

11 DR. CHARLESWORTH: Striking out the
12 words "weathered shale."

13 DR. KINGHAM: You are putting a dotted
14 line and I can see it and that really demarcates the
15 separation between till in the northern portion, and
16 weathered shale and clay silt to silt till in the
17 souther portion; is that right?

18 DR. CHARLESWORTH: Right.

19 We are seeing downward gradient. HC-8
20 was the borehole and 14 we had on the other sections.
21 So HC-14 as I pointed out before has a downward
22 gradient in the upper part and the horizontal, slightly
23 upward gradient in HC-18 which is just north -- HC-8
24 which is just north of Highway 403. So a predominance
25 of downward gradients.



1 Also in HC-5 which is to the west of the
2 cross-section, has downward gradients.

3 MR. ESTRIN: Q. So, again, what is the
4 overall conclusion with regard to gradients on that
5 cross-section?

6 DR. CHARLESWORTH: A. The conclusion
7 with regard to downward gradients on the site and even,
8 I am repeating myself when I mention HC-14, because we
9 have had it on a previous section, but south of Highway
10 403 a downward gradient in the upper part.

11 Q. Now subsequent to working with
12 that data which was from ...

13 A. We have another section.

14 Q. Sorry. The next one is which
15 figure from your report?

16 A. It is Figure 5, cross-section H-H.

17 Q. Could you mark that M-437-D5.

18 ---EXHIBIT NO. M-437-D5: Cross-section H-H

19 DR. CHARLESWORTH: I see there were a
20 few asterisks missed from borehole MB-11. It was a
21 correction on MB-11 that there is some information at
22 the bottom and there should be asterisks added to refer
23 to it.

24 MR. ESTRIN: Q. Dr. Charlesworth tells
25 me he can convey this information more usefully at the



1 break to anyone who is interested.

2 DR. CHARLESWORTH: A. It is just the
3 dates when water level measurements were taken because
4 it is a Morrison Beatty borehole and measurements were
5 not taken by Trow on the same occasion they were taken
6 elsewhere and so we added that information in.

7 DR. KINGHAM: Maybe you can add it in to
8 the Board's copy.

9 MR. ESTRIN: We will do that.

10 DR. CHARLESWORTH: This is the section
11 that runs down from the Bayview Park landfill down to
12 borehole nine, as we saw. We see north of the refuse,
13 the Bayview Park landfill and MB-6, there are downward
14 gradients at the surface. We have an interesting
15 pattern of some upward gradients happening at depth in
16 that borehole.

17 MR. ESTRIN: Q. Do the downward
18 gradients go to above what elevation relevant to the
19 surface?

20 DR. CHARLESWORTH: A. About 135 metres
21 elevation.

22 Q. What is the surface there?

23 A. The surface there is about 152 and
24 then we come to a series of, the WAT boreholes, these
25 are the Waterloo boreholes referred to in Ms. Hewetson's



1 thesis. These were the bundles of piezometers that were
2 installed and these have a large number of piezometers
3 in each borehole. It is interesting that we get a
4 somewhat more complex pattern which may be because we
5 are measuring it at more points and are picking up
6 greater variations that are not apparent when you have
7 less piezometers.

8 There are also some complications in
9 these boreholes as to how well these small diameter
10 piezometers are functioning or were functioning at that
11 time. Generally we have patterns of downward gradients
12 with a downward gradient in the upper most piezometer.

13 Q. Which borehole are you referring
14 to?

15 A. WAT-3 and an upward gradient below
16 that, downward gradients below that and between
17 piezometer 6 and 7 we have an upward gradient and
18 downward gradients below that. Moving slightly
19 downgradient in terms of downgrade I guess in terms of
20 topography, WAT-7 has predominantly downward gradients
21 with a horizontal gradient in the centre. I will be
22 talking some more about water levels here, but there
23 appeared to be a zone of horizontal gradients. Beneath
24 that downward gradient is downwards and upwards so a
25 fairly complex pattern.



1 MB-11 is an interesting hole. We
2 actually see upward gradients between the shallow
3 piezometer and the deep piezometer or the next deepest
4 piezometer MB-11. Then a downward gradient below that.
5 Actually when we were out there in the spring we
6 observed, that was in April of this year, we observed
7 this intermediate piezometer flowing at this location.
8 This is sort of confined conditions and water was
9 coming up to the surface and discharging out of the
10 top.

11 DR. KINGHAM: Can I just ask you to
12 explain something to us. Obviously these things are
13 going to be in play for a while. If you look at your
14 well on the most left side of diagram D5 where you have
15 got an upward gradient below and a downward gradient
16 above. Are we to understand by that that there is a
17 confluence of water, as it were, and it goes out
18 sideways at the point where the two meet?

19 DR. CHARLESWORTH: There are a number of
20 arguments that can be advanced on that. That is a
21 possibility. There could be a zone there and the flow
22 is taking place into it. It could be we are getting
23 the gradients because virtually there is no flow taking
24 place and we have got low permeability and therefore,
25 high gradients. We assume we have got some movement



1 and there would be movement towards a point of
2 confluence.

3 DR. KINGHAM: Conversely the last well
4 you mentioned, the Morrison Beatty well, you have got
5 an upward gradient above and a downward gradient below
6 a different point. Are we to understand by that kind
7 of information that would be a point where
8 hypothetically a lateral flow of water splits and some
9 goes up and some goes down?

10 DR. CHARLESWORTH: I suppose it is
11 conceivable that is taking place. It may also be that
12 given the spacing of the piezometers, it would be
13 unreasonable to suppose that only putting in three
14 piezometers you had the point -- not reasonable -- but
15 you may not hit the actual point. It is improbable I
16 would say unless you had a specific reason for them
17 placing the piezometer at that point. That's
18 conceivable, they may have seen a zone there. It is
19 possible that the flow from that zone and it is also a
20 possibility -- it is just a complex pattern that
21 manifests itself that way in the sampling we have got.
22 Certainly we know there is a confining layer above
23 which keeps that water down but when you put the
24 piezometer down it flows, at least in the spring. It
25 wasn't flowing later in the summer.



1 MR. ESTRIN: Q. Dr. Charlesworth, where
2 approximately is that hole you have just been referring
3 to relative to 403 and the North Service Road?

4 DR. CHARLESWORTH: A. 403 and the North
5 Service Road are located here. It is about halfway up
6 the valley towards the foot of the Bayview landfill.

7 WAT-7 also has predominantly downward
8 gradients but some upward gradients and I will refer to
9 those water levels again. MB-13 was moving south, it
10 is just north of the North Service Road showing
11 downward gradient and we had these on one of the
12 earlier sections. Nine has downward gradients in the
13 shale almost horizontal but slightly upwards in the
14 upper part.

15 This was just an attempt to get a feel
16 for what was happening at least in the terms of
17 vertical gradients. We drew up and coloured up these
18 sections.

19 Q. Having done that, that was the
20 Trow data essentially you illustrated?

21 A. That was the Trow data, yes.

22 Q. Did you do any further water level
23 measurements yourself?

24 A. Yes, we undertook monitoring after
25 notifying Trow and receiving their co-operation. We



1 monitored eight piezometer or eight borehole
2 installations for several weeks during the summer in
3 order to see if we were still getting the same pattern
4 that was obtained at the time these measurements were
5 taken and to see if there was any significant change
6 either between the measurements or during the
7 monitoring period.

8 Q. You report the results in your
9 report?

10 A. The graphs of the measurements are
11 given in Appendix A of our report.

12 Q. Are those hydrographs?

13 A. Those are hydrographs prepared
14 from the measurements taken.

15 Q. Have you then translated that into
16 borehole information?

17 A. We have discussed following page
18 4-5, 4-6, the patterns we observed in those boreholes.
19 It might be worth going through those and looking at
20 each of those graphs.

21 Q. At the bottom of page 4-5 you say:
22 "The pattern of vertical gradients
23 required in HC-3, HC-5 and HC-8 during
24 the present study was similar to those
25 given by Trow."



1 A. That is correct.

2 Q. You go ahead.

3 A. I have put it on the wall. You
4 have this in your report in Appendix A. This is HC-3
5 and here you can see we have numbered...

6 Q. HC-3 is the west side of the
7 proposed Site F about halfway up?

8 A. HC-3 is at this location here.

9 MS. CRONK: He keeps referring to there
10 and here.

11 DR. CHARLESWORTH: That's a shortcoming
12 of mine. HC-3 is located maybe a third of the way up
13 the western side of Site F, and this was a borehole
14 that we observed, that we looked at on cross-section
15 G-G a few moments ago. We have actually added colour
16 to the overhead to make it a little easier. You will
17 see here we are getting a pattern, something similar to
18 the pattern which we had with the measurements taken by
19 Trow. Piezometers 2 and 3 are within the shale and we
20 are showing very little gradient between 2 and 3.
21 Borehole 4 is also in the shale so there is a downward
22 gradient. Five is in overburden so throughout the
23 period we were taking the measurements a slight
24 downward gradient to 4 and a stronger downward gradient
25 to boreholes 2 and 3. Much more, to piezometers 2 and



1 3, and then a much more pronounced downward gradient to
2 piezometer No. 1. That corresponded to the kind of
3 pattern that was obtained by Trow at the time they took
4 their measurements.

5 HC-5 which wasn't on the sections that
6 we looked at, this is on Trow's section E-E which is
7 one of the holes we chose to monitor. HC-5 is in the
8 southwest corner of Site F, the location of that point
9 and we got a similar pattern to that recorded by Trow
10 if you refer to the water level measurements in their
11 report or look at their cross-section E-E. We have a
12 downward gradient between all the piezometers, that is
13 between 4 and 3. Four is in the overburden and 3 is
14 situated just in the upper part of the shale and then 2
15 and 1 are at depth in the shale.

16 So, the same pattern has been maintained
17 since the time Trow took the measurements, a downward
18 gradient throughout the section. This is HC-6 which is
19 on Trow's section A-A. All these piezometers were in
20 the shale and here we got a pattern similar to Trow's.
21 Initially something strange happened towards the end of
22 the time these measurements were being taken which is a
23 little difficult to explain. A rising water level in
24 the deepest piezometer. Otherwise very little gradient
25 between 4 and 3 and then generally a downward gradient



1 to piezometer 2 to in a more pronounced downward
2 gradient to piezometer 1.

3 DR. KINGHAM: I am sorry, if you could
4 just put that back up, that was HC-6. Where is HC-6
5 relative to HC-5?

6 DR. CHARLESWORTH: HC-6 is southeast of
7 HC-5. I suppose almost due east using the local
8 convention that the site is north-south. Sort of
9 midway towards ...

10 This was on our section G-G and using
11 the Trow data this is borehole HC-8. Using the Trow
12 data we showed slightly up. I guess I should locate
13 HC-8. HC-8 is at the southern end of the landfill in
14 about roughly the mid-point. The data we had on our
15 section G-G from the time that Trow took the
16 measurements showed a slightly upward gradient between
17 3 and 4. All these piezometers are set in the shale at
18 this location. Four is right at the top of the shale.
19 We are getting virtually no gradient as opposed to the
20 slightly upward gradient that Trow had.

21 So, a similar pattern and downward to
22 piezometer 2 and downward to piezometer 1. So
23 horizontal and then downward at HC-8.

24 Borehole HC-9 which showed up in a
25 couple of cross-sections, Trow's A-A and our H-H is



1 south of the 403 to the east end of the so-called
2 discharge zone. Here we are seeing that piezometers 2,
3 3 and 4, piezometer 4 is at the top of the till.
4 Piezometer 3 was in the shale till contact and, here,
5 as we saw in the cross-section, we get horizontal to
6 sometimes slightly upward gradients within the upper
7 part of the hole.

8 We have downward gradients to the lower
9 piezometer and what happens here, obviously someone
10 collected a water sample, and I believe this is one of
11 the holes that CRA monitored as part of their work on
12 the Bayview landfill. What you see here is a very slow
13 recovery in a matter of weeks once water had been taken
14 out of the borehole. The water level drops and by the
15 time we finish monitoring it it had improved, recovered
16 to its original level. That suggests that you have got
17 low hydraulic conductivity at that horizon.

18 We also monitored HC-14 which is moving
19 west through the area that Trow originally defined as a
20 discharge zone. It was on our section G-G and the
21 pattern that we see here is, piezometer No. 4 is at the
22 top of the shale, the highest point in the shale. The
23 rest of them are all in the shale. We have a
24 downward gradient from 4 to 3, generally a pattern of
25 downward gradients but some fluctuation between 2 and 3



1 with time.

2 The next borehole is one which is of
3 interest because we didn't have this on our cross-
4 sections. This is a cross-section that Trow drew
5 running east-west through the area south of 403. It is
6 borehole HC-15. There are four piezometers and they
7 are all set in the shale. We have a very pronounced
8 downward gradient. It is at this location, you can see
9 it here, HC-15 and HC-16 south of 403, south of Bayview
10 Park. We have very pronounced downward gradients in
11 the four piezometers set in that location.

12 Here again it appears as if a water
13 sample was taken. It is obviously on a monitoring
14 program. So that is downward gradients in the area
15 south of the 403.

16 We also wanted to -- WAT-7 which is one
17 with all the piezometers and we generally got a similar
18 pattern to that based on the Trow data. You remember
19 these are multi-levels. They are all in the shale,
20 downward gradient. We have a downward gradient. The
21 number is reversed in the WAT hole so 1, 2, 3, 4. The
22 downward gradient in the upper piezometers and then we
23 get into one of these areas of complexity where we have
24 between 5 and 6, a change here between 5 and 6.

25 Trow data showed a downward gradient.



1 This now seems to show an upward gradient and between 6
2 and 7 is the same pattern that Trow had. We have an
3 upward gradient and then from 7 to 8 a downward
4 gradient. It is in the next one, if I can find it, the
5 point I was going to make, one of the anomalies we seem
6 to be getting and we tested two of these piezometers by
7 adding water to them. Either it is extremely
8 impermeable or the piezometer is blocked. I believe
9 there was evidence that we went through when
10 Mr. Feenstra was on the stand that in fact these two
11 piezometers were not functioning and our tests seem to
12 indicate that too.

13 MR. ESTRIN: Q. Which piezometers are
14 these?

15 DR. CHARLESWORTH: A. These are
16 piezometers 10 and 11 in WAT-7.

17 Q. You say you introduced distilled
18 water in 9 and 10?

19 A. Sorry, 9 and 10. I apologize.

20 Q. So, in your having tried to find
21 out whether or not those piezometers were working --
22 what value is the order of the gradient?

23 A. I would say it is in the order of
24 no value at this time anyway. They may have worked at
25 one point in the past. I would say in summary we found



1 some changes.

2 Q. Just try and articulate the
3 changes, if you could, or the general conclusions?

4 A. My general conclusion is that the
5 patterns were similar to the patterns that we obtained
6 from the Trow data. In monitoring an additional hole
7 south of the 403 we had, which was borehole 15, we had
8 pronounced downward gradients at that location which
9 gave us some information which wasn't available from
10 the cross-sections, but was available from -- I guess--
11 was available from the Trow data but not presented in
12 the cross-sections.

13 Q. So if you look at the top of page
14 4-7 you have a paragraph there which you talk about
15 initially. Is that paragraph still appropriate having
16 done all of this work, that is having reviewed the Trow
17 data and then your own. The first paragraph begins in
18 your own summary:

19 "This review of the water level data
20 suggested that downward gradient
21 predominated at Site F and even to the
22 south of the site though there are local
23 complexities which probably vary on a
24 seasonal basis in the case of the
25 shallow flow system."



1 at HC-11, that from the two piezometers in that hole,
2 there is an upward gradient in this location from the
3 shale into the surficial deposits. It may be that it
4 is not representative of flow across that interface
5 because we see when we have more detailed monitoring
6 installations there is a different pattern but without
7 any other information that does suggest that there is
8 an upward gradient. I don't believe there is flow
9 taking place out there from the shale into the shallow
10 sands there because we see no evidence of salinity in
11 this general area. None has been reported although I
12 think there is indication of an upward gradient. I
13 don't think there are significant quantities of water,
14 if anything at all, of saline water getting up into
15 that area.

16 Q. Now, the other conclusion that I
17 think -- there was one other conclusion that I think
18 all of this review led you to and that was, had to do
19 with the existence or lack of existence of Trow's
20 discharge zone?

21 A. That was the major conclusion. I
22 felt that the data we got from the area that they
23 defined as the discharge zone or the nearest
24 piezometers which they had to that which was 9, 14 and
25 15, did not support a picture which they gave in their



1 model and their cross-section of flow coming up in the
2 shale at that location.

3 Q. You told us earlier that you
4 installed some mini-piezometers in this area. Are
5 those results reported in your report?

6 A. Yes, Mr. Chairman, you will find
7 the result from the mini-piezometers in Appendix B of
8 our report.

9 Q. What do these results show or
10 indicate with regard to this issue of whether or not a
11 discharge zone seems to exist there?

12 A. I would just refer to the
13 locations of the mini-piezometers. We put one at
14 location A which is close to, sort of south of HC-3 and
15 north of HC-5. We picked that location because there
16 seems to be a spring or seepage. There was a stream
17 flowing there that appeared to arise at that location
18 in the spring. We installed one of these mini-
19 piezometer installations there to try and see if there
20 was any upward gradient in the upper few inches
21 basically of the surface that would indicate that there
22 was seepage taking place.

23 We also installed -- yes, seepage from
24 the groundwater to the surface. We also installed one
25 at the bottom of the creek that drains down from



1 Bayview Park just north of the North Service Road. The
2 ones which we were particularly interested in, we felt
3 that at either of these locations there would probably
4 be upward flow. We were particularly interested in the
5 discharge area and we installed three piezometers,
6 mini-piezometer installations in the general sort of
7 area defined or that we understood to be Trow's idea of
8 the discharge zone.

9 C and D we installed, there was in fact
10 standing water, there was a wet area in April around
11 here.

12 Q. Around here being?

13 A. The area which I am referring to
14 which is south, just north of the railroad track, so
15 midway between 403 and the railroad tracks. We
16 installed piezometers, mini-piezometers at C and D
17 locations where were on the edge of the wet area that
18 looked like it may be the discharge zone. We
19 installed a third one E just to the east in the creek
20 bed to see if there was flow coming up into the creek,
21 groundwater contributing to the creek flow.

22 Now, these mini-piezometers are, it was
23 just one piece of an overall picture. I don't want to
24 put a lot of weight on to them. I think there are,
25 they can be a useful tool but I wouldn't draw a



1 conclusion based solely on these. We did get some sort
2 of variations. The May reading should be ignored
3 because the mini-piezometer had only been installed a
4 day or two before that, two days before that, but by
5 June, June 5th and June 26th they seem to have reached
6 some equilibrium. We got, I will address C, D and E
7 there, the more important ones.

8 We did not get evidence at C, D and E in
9 the discharge zone of upward gradients within the upper
10 zone, just below the ground surface. You can see that
11 the shallow piezometer is at water levels above or
12 below ground surface and you can see that the shallow
13 piezometers usually have a water level, a static head
14 higher, a foot above the ground surface than the deeper
15 piezometers. That suggests, if anything, that the
16 water is collecting in this zone and was actually
17 evaporating and probably even moving down, but I don't
18 want to put too much weight on that.

19 Certainly no evidence of an upwelling of
20 groundwater in the area based on these gradients.

21 Q. Now, dealing with that specific
22 point, other evidence or lack of evidence with respect
23 to this discharge zone, did you walk the area, take any
24 pictures of that particular one? I think you have one
25 picture have you not?



1 A. We have one picture at that
2 location.

3 Q. Mr. Chairman, this is contained on
4 a panel of pictures Dr. Charlesworth will be
5 discussing. I am wondering if we can have this panel of
6 photographs marked now?

7 MR. LANCASTER: M-448.

8 ---EXHIBIT NO. M-448: Panel of photographs

9 MR. ESTRIN: Q. Which picture on that
10 panel is relative here?

11 DR. CHARLESWORTH: A. It is the lower
12 right-hand picture.

13 Q. Has it got a number?

14 A. It is photo No. 5 which was taken
15 in the dry stream bed, September 27th. By September,
16 as I said, when we installed the mini-piezometers in
17 this possible discharge area, there was definitely
18 water standing around and cattails are growing there.
19 It is reasonable when you first look at it to think
20 maybe this is a discharge area. However, by September
21 it was, the area was quite dry and here we have a creek
22 that drains through the area and you would expect that
23 you would get some seepage into the creek and we have a
24 photograph showing that the creek is completely dry at
25 this time.



1 Q. Just so we are clear. Photograph
2 No. what is it, two?

3 A. Five.

4 Q. Taken in the creek bed?

5 A. Taken in the creek bed, yes.

6 Q. There is a round circle there,
7 what is that?

8 A. That is a tire.

9 Q. It is not a piezometer. It is dry
10 at that time?

11 A. That is correct.

12 Q. What is the significance again of
13 that observation, as far as you are concerned?

14 A. As far as I am concerned there is
15 no groundwater discharge taking place in this area or
16 else I would expect to see some flow in the stream out
17 of and draining the area. I should say that we also
18 visited this area about two weeks ago which we thought
19 would be a good time to look for groundwater seeps in
20 that there was virtually no snow cover at the time but
21 everything was at the end of the hard cold spell that
22 we had before things warmed up, and it is a good time
23 to look for groundwater seeps or springs, because the
24 surface water is all frozen but you tend to see moist
25 patches.



1 We walked this area quite extensively.
2 We walked up the valley to Bayview Park. We walked
3 over to Site F and back down Site F and we walked all
4 around the area of the discharge area. We saw no
5 evidence of seepage taking place at all in the
6 discharge area again at this time of year, which did
7 not surprise me given that we didn't see it in the
8 fall.

9 Interestingly there was no seepage
10 taking place around mini-piezometer location A. It was
11 completely dry and frozen. The valleys leading up to
12 Bayview Park, there was no flow at the southern end
13 where we also have mini-piezometer B. The only place
14 we saw anything, seepage there, was sort of soft slushy
15 ice between MB-7 and MB 12, in that general area
16 suggesting there probably is some seepage of the
17 shallow flow system coming to the surface in that area.
18 We also saw, we went cross to where Falcon Creek comes
19 out, goes up to the North Service Road from Bayview
20 Park and there was flow in the stream there.

21 So, certainly conditions were such that
22 if there were springs or seepages one would have
23 expected to see them where we were over on Falcon
24 Creek, but nothing in the discharge area.

25 Q. Just perhaps one last -- perhaps



1 if this is an appropriate time to take a break, we
2 could do that? I am not sure when we normally break
3 for the afternoon.

4 MR. LANCASTER: Anytime now, between now
5 and a quarter after, but it is up to you.

6 MR. ESTRIN: I think this would be
7 appropriate.

8 ---Recess

9 MR. LANCASTER: Please be seated.

10 MR. ESTRIN: Q. Before coffee then,
11 Dr. Charlesworth, we were discussing your views and
12 conclusions with regard to gradients and there is
13 something that you discussed at page 6-2 of Exhibit M-
14 437 that relates to measurements of electrical
15 conductivity of waters in Indian and Falcon Creek.
16 With regard to that do measurements of electrical
17 conductivity have relevance to this topic of using the
18 gradients to try and indicate the potential impact of
19 the site?

20 DR. CHARLESWORTH: A. Yes, it does.
21 If in fact in the area downgradient of the site, the
22 area say between 403 and Hamilton Harbour, if where we
23 have seen sometimes there are upward gradients in the
24 shale, horizontal gradients at the interface, if there
25 was any significant upward movement of the saline



1 water, then you might reasonably expect to get saline
2 seepages, or elevated salinities in the creeks as they
3 flow across that section and take in groundwater.

4 Q. And ...

5 DR. KINGHAM: Just so we are clear on
6 that, you are telling us that the electrical
7 conductance of these waters will tell us about ionic
8 constituents, not organic constituents?

9 DR. CHARLESWORTH: I am referring to the
10 high chlorides in the Queenston shale that manifest
11 themselves.

12 DR. KINGHAM: So there would be an
13 indicator for us of saline movements, not organics?

14 DR. CHARLESWORTH: It would tell us
15 regardless of the landfills, whether the saline water
16 in the shale reappears, gives an indication whether it
17 reappears at the surface. Trow in fact did a series of
18 conductivity measurements on Indian Creek. They took
19 some chemical analyses on Falcon Creek and they did not
20 pick any indication of what I would construe as
21 indication of this highly saline water manifesting
22 itself at the surface.

23 MR. ESTRIN: Q. Did you do any spot
24 checks of your own?

25 DR. CHARLESWORTH: A. We ran some spot



1 checks down Falcon Creek to see if maybe there was
2 maybe a big gap in the data there and we ran a number
3 of spot checks as field conductivity measurements and
4 we got values, I would say, comparable to the values
5 that Trow had got at Indian Creek. Maybe a little
6 lower but it might be a variation on the field
7 conductivity meter that we were using. Certainly
8 nothing that suggested major upwelling of saline
9 waters.

10 Q. Therefore, how does that, those
11 measurements of electrical conductivity fit or not fit
12 with your overall valuation of gradients?

13 A. I think that they fit, it fits
14 with this sort of simple concept that I proposed for
15 groundwater flow. There is downward movement on the
16 site, lateral movement and there is no significant
17 discharge south, say, of the 403, other than when it
18 reaches the lake. We don't really know what happens
19 there.

20 Q. Now, I want to turn on this
21 general issue to your witness statement to look at
22 paragraph 78. This is Exhibit M-444 where it says:
23 "Dr. Charlesworth will comment with
24 respect to Exhibit E-109, the review
25 under the Environmental Assessment Act



1 prepared by various Ministries and, in
2 particular will address the comment that
3 the Ministry of the Environment would
4 only accept Site F from a
5 hydrogeological perspective if the
6 consultant can reasonably demonstrate
7 that the leachate infiltrating into the
8 shale will go to depth and will not come
9 to the surface between the site and the
10 lake."

11 Will you give us please, have you reviewed the data
12 thus far discussed, the gradients and the
13 conductivities and anything else you reviewed now in
14 evidence, what opinion you can offer about that?

15 A. I don't see any evidence that
16 suggests any leachate infiltration would come out of
17 the site south to the lake. If it were going to
18 reappear we would see evidence of this saline
19 groundwater with all of its salinity appearing at the
20 surface. I don't see any evidence of that. I think
21 the two areas of concern were the discharge area as
22 postulated by Trow and I see little evidence, as I have
23 indicated, of that in fact being a discharge area.

24 I haven't seen evidence of saline waters
25 appearing at the surface anywhere between the CN tracks



1 and the Lakeshore.

2 Q. So, if what is suggested in this
3 quotation is somehow accepted as an appropriate test of
4 the safety of Site F, your opinion is what? Has it or
5 has it not been reasonably demonstrated that leachate
6 infiltrating in the shale will not come to the surface
7 between the site and the lake?

8 A. I would say that the combination
9 of the Trow data plus our own observations and our own
10 measurements, our field observations, our examination
11 of lack of evidence of seepage, yes, it has been
12 reasonably demonstrated.

13 Q. Thank you.

14 The next topic I want to turn to in your
15 report is the topic of hydraulic conductivities. That
16 begins at page 4-7. First of all, for what reason did
17 you review the data with respect to hydraulic
18 conductivity?

19 A. I initially reviewed the data in
20 connection or related to hydraulic conductivity because
21 it is one of the fundamental parameters that you are
22 concerned with in hydrogeology. When you start to look
23 at a landfill site you want to have some indication of
24 the nature of the material, the hydraulic properties of
25 the material that the waste will be placed on or in.



1 You, also in this case we were doing
2 this work parallel with Dr. Rowe who is going to be
3 doing his modelling and this was one of the parameters
4 which he needed as input to his model.

5 Q. Now, can you tell us, please, what
6 you did to review this data? Whose data did you
7 review?

8 A. We reviewed all the data that was
9 presented in the various reports that we referred to
10 earlier, the Trow report, Gartner Lee, Hewetson.
11 Essentially all the available data for these sites.

12 Q. Including Morrison Beatty?

13 A. Including Morrison Beatty.

14 Q. What did you do with respect to
15 that data?

16 A. Well, after looking at it, it
17 seemed that with the concept that I proposed, that we
18 should really be concentrating on this shallow system
19 where more activity, the activity seemed to be taking
20 place. We concentrated on that zone. Maybe this is a
21 good point to say that although this morning I referred
22 to looking, say, at the 5000 parts per million contour
23 as an indicator of where this zone is, that was not
24 carved in stone.

25 I think it would be wrong to imply that



1 there is something magical about that line. Our first
2 step had been to say, yes, there seems to be this more
3 active zone and it seems to vary 10 metres, 20 metres.

4 We felt that it would be reasonable to postulate a
5 zone in the order of 20-25 metres. We actually settled
6 on a zone of 25 metres as sort of the maximum active
7 zone.

8 In terms of assessing the hydraulic
9 conductivity, we then looked at all the data that was
10 available from the reports that I have referred to,
11 that applied to this other 25 metres of the shale.

12 Q. This is 25 metres from the top of
13 the shale, downwards from the top of the shale?

14 A. That is correct.

15 Q. What did you do with respect to
16 each borehole, looking at the data?

17 A. Well, I felt we needed to arrive
18 at, certainly for the purposes of either doing a simple
19 calculation if we wanted to get a handle on flow, but
20 also for the input to Dr. Rowe's model. He was going
21 to model this zone as 25 metres and he needed a
22 hydraulic conductivity value, a mean value.

23 So, we looked at each borehole and we
24 took the geometric means of the values for that
25 borehole across the upper 25 metres for each borehole.



1 We felt it was important to do this because there was
2 overlapping sections and some boreholes with more tests
3 than others, so we did want more tests performed in
4 them. We didn't want to give undue weight to one
5 particular location, one may have had 5 tests and
6 another had 2.

7 First we took the geometric means of the
8 values for that borehole and having arrived at that we
9 then took a geometric mean of the mean value for the
10 boreholes to come up with a mean value for this upper
11 25 metre zone that Dr. Rowe was going to model.

12 Q. It sounds like a mean test. The
13 point is you say you calculated the geometric mean of
14 the mean values derived for the individual boreholes,
15 is that what you just said?

16 A. That is correct, yes.

17 Q. Then if you turn to page 4-8 of
18 your report, there is some discussion of this area and
19 in the last paragraph before the heading "Porosity" you
20 say:

21 "In our opinion 4.5×10^{-6} cm/sec as
22 used by Dr. Rowe in his modelling is a
23 reasonable value in light of the data
24 quoted above."

25 That number 4.5×10^{-6} cm/sec, does that refer to the



1 25 metre zone?

2 A. That refers to the 25 metre zone,
3 yes.

4 Q. Is that the exact number you gave
5 to Dr. Rowe?

6 A. Our number was actually 4.7×10^{-6}
7 from going through the process I have just described.
8 I think we may have done a preliminary estimate. I am
9 not sure about this now, it may have been 4.5, but the
10 exact number we arrived at was 4.7. Dr. Rowe at that
11 time was modelling 4.5 and he felt and we felt that
12 there was no significant difference between 4.7 and 4.5
13 in terms of his model, and I understand that he tested
14 out the sensitivity of the model.

15 Q. We will be hearing more about that
16 I take it from Dr. Rowe, what you modelled around that
17 number?

18 DR. ROWE: A. That is correct.

19 Q. Also, with respect to this general
20 issue of hydraulic conductivities, you say in the
21 middle part of the second paragraph on page 4-8:

22 "Our examination of the Trow data
23 suggests that the argument for
24 redefining the hydrostratigraphic units
25 on the basis of the hydraulic



1 conductivities is somewhat tenuous. In
2 addition, the value which they derived
3 from the pumping test for the highly
4 fractured unit could be at least an
5 order of magnitude too high because of
6 the value they assumed for the saturated
7 thickness of the water bearing
8 formation."

9 Now, can you just discuss that for a moment. I think
10 there is some reference also to this topic in paragraph
11 21 of your witness statement?

12 DR. CHARLESWORTH: A. Yes. The first
13 item was this matter of how from their pumping test
14 data Trow -- the pumping test calculates a parameter
15 known as transmissivity which I think may have been
16 explained earlier to the Board which is really the
17 hydraulic conductivity applied to the saturated
18 thickness of the aquifer. Trow, therefore, the pumping
19 tests, the analysis of the pumping test gives you a
20 transmissivity value. You then have to divide by the
21 thickness, the saturated thickness of the aquifer to
22 arrive at the hydraulic conductivity.

23 Trow had used a very low value. I think
24 0.3 metres. I felt that their rationale for doing that
25 in that they said they felt although the aquifer was



1 thicker than that and I believe the thickness of the
2 case structure of the borehole I think was 11 metres.
3 They were just dealing with fractures and therefore the
4 effective thickness was 0.3 of a metre, and they
5 divided by that which as you are dividing by it gives
6 you a higher hydraulic conductivity.

7 I just -- I don't think I would argue
8 with them as to whether that is the right technique.
9 You are dealing with the aquifer. The flow is coming
10 through the fracture, but to try and reduce it down to
11 this spacing of the fractures, I just think is not
12 technically correct.

13 I gather that Mr. Feenstra commented to
14 that effect too.

15 Q. In your witness statement at
16 paragraph 21 you refer to his testimony to the effect,
17 and this is his opinion at volume 46, that to the
18 effect that Trow's method of calculating hydraulic
19 conductivity is incorrect and the value derived from
20 the pumping test should be at least one order of
21 magnitude lower than that given by Trow; do you agree
22 or disagree with that?

23 A. I agree with that statement.

24 Q. Subsequently, in the better fit
25 model, Trow came up with another value?



1 A. I think instead of 10^{-2} cm/sec, I
2 believe in the better fit for the horizontal hydraulic
3 conductivity, they were using 10^{-4} for that zone which
4 I think was a more reasonable value for them to have
5 obtained from the pump test, the kind of number they
6 would come up with from a pump test.

7 Q. This value that essentially is
8 reported at 4-8 of your report, or is referred to, the
9 value of 4.5×10^{-6} cm/sec as used by Dr. Rowe in his
10 modelling, how and when did you use that approximate
11 value with regard to your work?

12 A. Well, I used it just to get --
13 well, we had reviewed the groundwater velocities that
14 other people had derived for this general area, whether
15 they were working on Bayview or Burlington. I used
16 that to calculate a groundwater velocity to compare
17 with the values that other people, other workers in the
18 area had come up with.

19 It is also of relevance if you start to
20 look at the likely extent to which a leachate plume may
21 have moved from the existing sites.

22 Q. Well then, you are saying I think,
23 we have to plug this value back in to some overall
24 calculation later on, we have some other values?

25 A. That is correct.



1 Q. Let us turn to porosity which is
2 dealt with in section 4.3 of Exhibit M-437. Again, you
3 looked at this I take it in respect of groundwater
4 velocity in arriving at a groundwater velocity?

5 A. Yes, and it was also needed by
6 Dr. Rowe. We reviewed the values presented by the
7 other people who had already worked in that area. The
8 problem with porosity and I think this probably came up
9 earlier in the hearings, is that it is a difficult
10 parameter, number to get a handle on. People would
11 argue about what is a realistic value. So, we looked
12 at the values that other people proposed, and suggested
13 a range, or came up with a range that we thought was
14 reasonable in the light of work that other people had
15 done.

16 Q. What range did you suggest to Dr.
17 Rowe for his modelling purposes?

18 A. We suggested a range from 0.001 up
19 to 0.01, so two zeros and one zero.

20 Q. Your report at page 4-9, that in
21 fact, Dr. Rowe, looking just before the heading
22 "Groundwater Velocity" you say, Dr. Rowe in his
23 modelling performed a series of analysis for porosities
24 ranging from .0001 to .01?

25 A. That's right, the lower the



1 porosity the higher the velocity and Dr. Rowe was
2 taking a conservative approach as I understand it and
3 tested out his model with yet an order of magnitude
4 lower than the range we had given him.

5 DR. KINGHAM: When you say the lower the
6 porosity the higher the velocity, you mean for a given
7 hydraulic conductivity?

8 DR. CHARLESWORTH: Yes.

9 MR. ESTRIN: Q. Presuming we are
10 talking about the average linearalized groundwater
11 velocity?

12 DR. CHARLESWORTH: A. Yes.

13 Q. As opposed to another velocity
14 that Dr. Rowe is going to be talking about?

15 A. The Darcy velocity.

16 Q. Which we don't need to be thinking
17 about today. If you plug in all these parameters with
18 respect to porosity and hydraulic conductivity
19 gradients, what linear groundwater velocity range did
20 your review of the data indicate?

21 A. It suggested something in the
22 order of, using those values, gave us a range of 5 to
23 50 metres per year.

24 Q. Is that horizontal or vertical?

25 A. That was horizontal velocity or



1 actually inclined velocity, flowing down, lateral
2 velocity.

3 Q. Now, the next section in your
4 report deals with groundwater chemistry. That is at
5 page 4-9 and this discussion, there is a substantial
6 amount of discussion under the topic?

7 A. 5-1.

8 Q. I am sorry, I am looking at the
9 wrong page. We are now up to groundwater chemistry,
10 page 5-1. The first sub-heading describes background
11 patterns. Is a summary of this section, this sub-
12 section really towards the bottom of page 5-2, the last
13 paragraph there that begins: "In summary"?

14 A. Yes.

15 Q. Could you read that please?

16 A. "In summary it can be said that
17 there is a pattern of increasing
18 mineralization of the groundwater with
19 depth in the shale and that the less
20 mineralized water which occurs in the
21 shallow zones represent the effects of
22 recharge from precipitation in recent
23 years."

24 Q. And what data did you review to
25 reach that conclusion, is that discussed on the page



1 preceding?

2 A. Yes. We reviewed the chemical
3 data that the various workers had presented. We also
4 looked at the tritium data that Trow presented,
5 Morrison Beatty. Also Hewetson, although there were
6 some anomalies in the Hewetson data.

7 Q. We see if we turn back to page 5-
8 1, the second full paragraph. Perhaps if you would
9 read that?

10 A. The second paragraph?

11 Q. Yes, on page 5-1:

12 A. "There is a distinct pattern of
13 increasing chloride with depth within
14 the rock at this location, indicating
15 that in the shallow zone, there has been
16 some flushing of the original water by
17 the recharge from modern precipitation.
18 However, this effect does not seem to
19 extend to any great depth."

20 Q. Does that reflect what you were
21 saying to the Board during the beginning of your
22 discussions earlier today?

23 A. Yes, it does.

24 DR. KINGHAM: Where were you reading
25 that from, please?



1 DR. CHARLESWORTH: Page 5-1, second
2 paragraph.

3 MR. ESTRIN: Q. Now, the next topic
4 that you discuss in your report is at the bottom of
5 that page, the bottom of page 5-2 under the heading
6 "Leachate Contamination"?

7 DR. CHARLESWORTH: A. That is correct.

8 Q. What was it you were trying to
9 assess or review in this discussion which continues
10 from 5-2 to essentially 5-6?

11 A. I was reviewing the data to see --
12 obviously if Site F, if you consider whether Site F
13 should go ahead or not, one of the key factors, one of
14 the major factors in my opinion is how the Burlington
15 site and the Bayview site have performed in terms of
16 their impact on the environment, on the groundwater
17 environment. It was with that in mind I was looking at
18 this data.

19 Q. You discussed, you reviewed the
20 Hewetson report, for example, and looked at her data?

21 A. That is correct.

22 Q. You reviewed Mr. Feenstra's
23 reports and witness statement on this topic?

24 A. Yes, I have reviewed that. I am
25 just trying to remember the timing of this report. But



1 I have reviewed his.

2 Q. If I refer you to the second
3 paragraph on page 5-3, for example, about the middle of
4 that paragraph it says, "as discussed by Feenstra in
5 his witness statement"?

6 A. That answers my question. I don't
7 see that. I see that. I wasn't sure of the timing. I
8 read his witness statement before I wrote the report.

9 Q. Did you review Conestoga-Rovers
10 monitoring report, 1986 that is referred to there?

11 A. Yes, I did.

12 Q. In that paragraph you comment
13 specifically with regard to organic nitrogen. Do you
14 want to just elaborate on that?

15 A. It seemed to me reviewing the
16 Conestoga-Rovers report that one of their main, the
17 main pillars of their argument indicating that there
18 may have been movement of leachate from the landfill
19 was the organic nitrogen concentrations. In reviewing
20 that I had some concerns. One of the things that
21 struck me was, organic nitrogen is essentially
22 calculated by taking the difference between total
23 Kjeldahl nitrogen and free ammonia. I notice that in
24 many cases they had quite high Kjeldahl and free
25 ammonia concentrations. There is a relatively small



1 difference between them. In fact I think they define
2 the background level as 0.3 and were using values not
3 much greater than that in suggesting that this may be
4 due to leachate or this was due to leachate.

5 I felt that possibly errors in the
6 analysis in the first place, whether laboratory errors
7 or sampling errors or this kind of thing, would
8 probably be greater than the value of organic nitrogen
9 that you obtain from that simple calculation.

10 Q. Therefore, what value, if any, did
11 you conclude that these numbers, at least reported by
12 Conestoga-Rovers, had in coming to some conclusion
13 there?

14 A. I felt that they had very little,
15 if any, value. Another factor was some of the data
16 which they did present in their report was that they
17 averaged or took all three analyses, I can't remember
18 the exact figures now, but they were averaging values
19 which I think in one case were zero point something,
20 two point something and 12 point something and stating
21 there was a value in the order of 6 milligrams per
22 litre. I felt that to take an average in that kind of
23 range where you have two low values and one high was
24 probably stretching things a little.

25 Q. You also say, referring to Gartner



1 Lee at the top of page 5-4, pointing out that there are
2 potential problems of the accuracy of the Kjeldahl
3 nitrogen and ammonia analysis in highly mineralized
4 water. What were you referring to there?

5 A. Gartner Lee made the statement, I
6 am not a chemist but I did ask colleagues, a chemist,
7 about this. There seems to be some feeling that when
8 you are into such a highly mineralized situation there
9 are problems with actually determining those
10 parameters.

11 Q. Right. So your conclusion with
12 respect to organic nitrogen, there is that statement
13 about that in the fourth paragraph on page 5-4.
14 Perhaps you can just read that paragraph.

15 A. The one that starts "In the light
16 of..."?

17 Q. Yes.

18 A. "In light of the above facts and
19 given that little is known about the of
20 occurrence of organic nitrogen either at
21 this site in particular or with regards
22 to groundwater in general, it seems
23 unreasonable to use the organic nitrogen
24 concentrations to conclude that a plume
25 extends downgradient (to) the Bayview



1 landfill."

2 Downgradient from the Bayview landfill.

3 Q. You continue on page 5-6 to
4 discuss other data, for example, the Gartner Lee plume
5 delineation study and report that there seems to be
6 some divergence of opinion as between certain people as
7 to how they interpret this data. I wanted to refer you
8 on this general topic, first of all, to your witness
9 statement at paragraph 74. Perhaps really 73 to begin
10 with. Paragraph 73 refers to some testimony of
11 Mr. Feenstra which is quoted from the transcript which
12 talks to the issue, the fact that there are chemical
13 concentrations in background wells particular WAT-2 and
14 MB-14.

15 "The relatively low concentrations of
16 contaminants detected in Waterloo and
17 Morrison Beatty wells over a large area
18 up to a very great distance from the
19 landfill, combined with the fact that we
20 regard the data to truly reflect
21 groundwater concentrations, I think we
22 would be hard pressed to come up with a
23 scenario of attenuation mechanisms that
24 would allow the movement of trace
25 concentrations those great distances



1 with very little change in
2 concentrations. I would believe that the
3 conclusion or interpretation is quite
4 conclusive."
5 I think we should look at paragraph 74:
6 "Similarly Drs. Rowe and Charlesworth
7 will agree with Mr. Feenstra's evidence
8 with respect to the fact that there is
9 no particular pattern to the level of
10 concentrations in the monitoring wells
11 downgradient of the Burlington landfill;
12 that the concentration of wells nearest
13 the landfill are not higher than the
14 concentrations detected 300, 600 or 700
15 metres downgradient, which would not be
16 expected if in fact these chemicals were
17 landfilled derived."

18 I wonder if you and Dr. Rowe could comment on those two
19 paragraphs? First of all with regard to Mr. Feenstra's
20 quoted response there? Paragraph 73.

21 DR. ROWE: A. Just to give
22 Dr. Charlesworth a break for a moment, I would
23 generally agree with Mr. Feenstra's statement in
24 paragraph 73. I don't see any evidence of contaminant
25 migration having moved through the rock from the



1 Bayview Park to the monitoring wells. I think one can
2 debate how the contaminants at those wells got there,
3 if they are real, first of all, which I think
4 Mr. Feenstra addressed that question.

5 The other issue that needs to be
6 addressed, and I suspect Dr. Charlesworth can do that,
7 is whether contaminants could have gotten there in some
8 cases by being carried in the surface water primarily
9 from the landfill and then perhaps moved down a short
10 distance through the rock. I see no evidence based on
11 the information that I have reviewed that would lead me
12 to believe that the contaminant has moved from the
13 Bayview Park landfill through the rock, the significant
14 distances that have been suggested.

15 Would you like me to comment on 74 as
16 well?

17 Q. Yes, please, while you are there.

18 A. With regard to item 74 which
19 relates to the Burlington landfill, based on the
20 information I have reviewed I would say that there is
21 room for some debate that conservative-like
22 contaminants may have moved 25 metres. I think that is
23 referred to in Dr. Charlesworth's report. However, I
24 see no evidence that conservative species have
25 travelled significantly further than that. I saw no



1 evidence that benzenes or 1-1-1, trichloroethane or
2 others that we have checked have moved even 25 metres.

3 Q. What about Mr. Feenstra's evidence
4 that if contaminant was escaping he would expect there
5 to be higher concentrations closer to the landfill?

6 A. So would I.

7 Q. Is that based on some physical
8 phenomenon?

9 A. That is.

10 Q. Is that something in the area of
11 your consideration in this and other studies?

12 A. I think that is true.

13 Q. Dr. Charlesworth, can you comment?

14 DR. CHARLESWORTH: A. I can agree with
15 those statements, particularly the last point. What I
16 think Mr. Feenstra was getting at in his response was
17 it is difficult to conceive of a mechanism where you
18 would have concentrations at the same level close to
19 the landfill and at some distance away, it is as if it
20 has been attenuated very rapidly and then remains at a
21 similar concentration. I would find it difficult to
22 conceive of that mechanism.

23 Q. I think that might logically bring
24 us to paragraph 75 of your statement. You have
25 reviewed the Hewetson thesis, you have been out on the



1 site several times; do you know how many actually?

2 A. I think it is six or seven.

3 Q. You have walked the site in
4 various seasons of the year?

5 A. Yes, all seasons of the year.

6 Q. All seasons of the year, right.

7 Now what about the issue discussed in paragraph 75.

8 There is a suggestion in the witness statement that a
9 number of monitoring holes are in a location such that
10 surface transport at such toe discharge could take such
11 leachate proximate to the locations of the monitors?

12 A. I think that is something that
13 shouldn't be ruled out in the case of the study at the
14 Bayview Landfill. The rest of these photographs here
15 on Exhibit M-448 will hopefully give some indication of
16 that. A number. Actually I think there is an error
17 here. I think that it is WAT-5, WAT-7 should be WAT-5.
18 This is in the witness statement, paragraph 75 at the
19 bottom of page 42. We refer to WAT-3, MB-11 and MB-12
20 and it says WAT-7. In fact WAT-7 would not fall into
21 this category. WAT-7 is somewhat out of the valley
22 bottom which is the point I am making here. These
23 piezometers were installed down the line of the valley
24 and you can get some idea of that from looking at the
25 photographs on Exhibit M-448. For example, here we



1 have WAT-3.

2 Q. Which picture are you referring
3 to?

4 A. I am referring to photo No. 1.

5 Q. What does the title say?

6 A. Photo 1 is "Installation WAT-3,
7 Bayview Park landfill visible behind." It says this
8 photograph was taken on September 27th, looking up the
9 valley. So you can see if you have flood flow. In the
10 early days when there was overland transportation of
11 contaminants then this general area could become
12 contaminated.

13 Q. Dr. Charlesworth just a second.
14 Come on over here. I want to be sure the Board sees
15 this. Have you got the pointer there?

16 Looking at photograph No. 1, if I can do
17 this in a more convenient manner for everyone, let me
18 know.

19 In the background of this photograph
20 what are you looking at?

21 A. We are looking at the old Bayview
22 landfill. The valley comes towards us.

23 Q. Does the topography rise toward
24 the landfill in the background?

25 A. In general the topography rises



1 towards the landfill through the whole valley.

2 Q. There are some green arrows on
3 Exhibit M-448, what do they indicate?

4 A. That is the view, it is the
5 orientation.

6 MS. CRONK: I am sorry, but your voice
7 is not carrying.

8 DR. CHARLESWORTH: The arrows indicate
9 the orientation of the photograph, the direction the
10 photograph was taken. Photo No. 2 is an installation of
11 WAT-5 and in that case we are looking downstream, but
12 you can see, it is harder to see in that particular
13 photograph except that the vegetation was, I suggest,
14 the vegetation indicates to you we are in a low area
15 there.

16 Photo No. 3 is at MB-11 and once again
17 the Bayview Park landfill is visible in the background.
18 We are looking up the valley. The caption says that
19 this was a piezometer which was discharging in the
20 spring of '87. The one on which the camera is hanging,
21 the one which I am peering down.

22 Photo No. 4 is MB-12. We are looking
23 across the valley and you can see the sides of the
24 valley behind there.

25 The remaining photograph here is the one



1 I discussed earlier which is in the postulated
2 discharge area.

3 MR. ESTRIN: Q. Therefore, what effect,
4 if any, would the location of those locations for the
5 measurement of leachate, assuming it was leachate, have
6 with respect to that leachate being derived from
7 surface flow possibly rather than from groundwater
8 transport?

9 DR. CHARLESWORTH: A. I think that is
10 what you can say that it could possibly be derived from
11 overland flow at those locations.

12 Q. You have heard Mr. Feenstra talk
13 about a number of problems with some of the data that
14 does purport to establish contamination. You have just
15 referred to this factor. Overall what conclusion have
16 you reached with regard to whether or not there is
17 concrete evidence of off-site, if you like,
18 contamination?

19 A. I feel that the investigators have
20 taken the right approach in looking at the organic
21 parameters given the natural quality of the groundwater
22 here. I feel there is no concrete evidence of leachate
23 plumes from these sites.

24 Q. Now, there is two more paragraphs
25 of the witness statement that generally relate to this



1 issue and I would like to draw you and -- I think it is
2 you -- your attention, Dr. Charlesworth, to paragraph
3 76 and 77.

4 There were various measurements put in
5 for organics. Mr. Feenstra discussed these to the
6 effect that these were not necessarily related to
7 contaminants originating in the landfill. The issue
8 arose as to whether measurements at locations or
9 horizons that are suggested to be at the same depth or
10 otherwise related, but which are not of the same value
11 provides a basis for concluding that the two landfill
12 sites are behaving in a substantially different manner.

13 I wanted to ask you to provide the Board
14 with your view whether it is or not reasonable to
15 predict the impact of a landfill even if there may be
16 variations of various kinds at a localized level in the
17 data?

18 A. I feel that it is certainly
19 reasonable to, and in fact I think it is incumbent on
20 anyone proposing a landfill at Site F, to use the
21 behaviour of the existing landfills as a means of
22 predicting what may happen at Site F.

23 Q. Well, does -- put it in context,
24 if you can. Do local variations occur in other
25 hydrogeologic environments?



1 A. Yes, local variations occur in all
2 hydrogeological environments.

3 Q. Do those local variations stop you
4 or other hydrogeologists from coming to some opinion, I
5 guess it is all a question of relativity, but to what
6 extent does the fact that some local variations exist
7 prohibit you in other situations from coming to some
8 opinion?

9 A. They don't. We make predictions
10 all the time in which there are these local variations
11 in groundwater regimes.

12 Q. Dr. Charlesworth, help us. We are
13 looking at this geographic area called Site F which has
14 been bounded by the present Burlington landfill site
15 and the Bayview Park old landfill site. The local
16 variations that have been suggested in the data range
17 over, can occur over this distance of, what is it,
18 several hundred metres I suppose. Give us your views?

19 A. I just feel on the grand scale of
20 things, if you put a large amount of garbage in here,
21 that being the Bayview landfill, the Burlington
22 landfill and you monitor what is happening there and
23 you have got the same thing at Bayview where you have
24 had garbage put in there and you are able, there being
25 Bayview, and you are able to monitor the impact, if



1 any, it is perfectly reasonable to use those
2 conclusions to predict what may happen in the proposed
3 Site F located between those two sites even though on a
4 very localized or a localized scale there will be some
5 variations in three areas.

6 Q. Now, in your next -- in paragraph
7 77 of your witness statement, you have, I believe, you
8 continue to address this general issue. The issue arose
9 that there seems to be differences in values of
10 sulphates and chlorides in various exhibits. Just hold
11 on a moment.

12 In paragraph 77 reference is made to
13 data contained in Exhibits N-191 and N-192 and the
14 differences in values of sulphates and chlorides. That
15 issue was raised indeed by Dr. Kingham at one point. I
16 wanted you to discuss the variations that you may or
17 may not expect in soluble minerals within rocks?

18 A. I understand Dr. Kingham's
19 question in the first place that you do have these
20 variations but the situation we have here I feel is
21 not, I don't find it surprising. For example, soluble
22 minerals within rocks will lead to variations in the
23 groundwater chemistry. You always find some variations
24 in the chemistry at pretty well any site or any
25 groundwater regime that you choose to study.



1 Often these are more subtle, less
2 pronounced than the variations that exist in this area.
3 I think that is only because the mineralization of the
4 water is so much more dramatic here that the ranges we
5 are looking at are quite dramatic and, therefore, any
6 variations, localized variations because of change in
7 the flow system, localized mineralization et cetera
8 will be magnified that much more. It doesn't surprise
9 me, given that we have this dramatic increase in
10 salinity, for example, chlorides content, that you get
11 more extreme variations than you would have in another
12 hydrogeological environment.

13 Q. Right. Well, another aspect of
14 the topic discussed in paragraph 77, differences in
15 chlorides could be due to higher concentrations of
16 water trapped in the matrix of the rock. We are going
17 to be hearing some evidence about chlorides in the
18 matrix of the rock at Site F from Dr. Rowe I guess, but
19 do you want to comment on that?

20 A. Yes. As you said Dr. Rowe will be
21 addressing the whole issue of matrix diffusion. Just
22 as diffusion can be a two-way process it follows
23 concentration gradients. So it is quite possible that
24 where you have saline waters trapped in the rock you
25 will get movement of the salinity from either out of



1 the matrix or into it and this can lead to variations
2 between two points within the system.

3 Q. What about the issue of whether or
4 not the variability and data does indicate some
5 underlying geological irregularity?

6 A. I think, as a geologist and a
7 hydrogeologist, to me it doesn't indicate any sort of
8 unusual irregularity. It sort of goes back to my point
9 of scale. There are irregularities, I guess you would
10 call them irregularities. You will find them in any
11 system you are trying to classify and study.

12 Here because of the extremes in the
13 chemistry the effects will be that much greater. It is
14 due to that, it is not due to geological
15 irregularities, such as major changes in the flow
16 system.

17 DR. KINGHAM: I think,
18 Dr. Charlesworth, what the Board was looking at at that
19 time when we put those questions to either Mr. Sobanski
20 or Mr. Beechinor, was some appreciation of the
21 complexity of the situation. Here you have a situation
22 which, as you have described to us just a moment ago,
23 gives you a variability of hydraulic conductivity of as
24 much as 8 orders of magnitude between different
25 observers. It gives you, as you have described in your



1 Exhibit M-437, great variability in the tritium data
2 which you explain in different ways. It gives you this
3 variability in sulphates and chlorides from one well to
4 another.

5 I believe the Board was looking for
6 their appreciation and I understand you are now giving
7 us your appreciation of the extent to which that does
8 represent a more irregular, a more highly variable
9 geology than might exist elsewhere in the region. We
10 were seeking that kind of clarification. I gather that
11 is precisely the reason Mr. Estrin is bringing this to
12 the fore now?

13 DR. CHARLESWORTH: Thank you. I
14 appreciate that clarification.

15 Without doubt there are complexities
16 within this science. I think this goes back to the
17 point I started out this morning. It would be quite
18 difficult to get a complete handle on all the
19 complexities but in the broad general picture, we can
20 see what is happening in the general picture at the
21 existing sites. That gives me comfort in terms of
22 using this as a future site. Sure I recognize the
23 local complexities, but I still feel you can look at
24 the thing on an overall simplified scale because you
25 have the existing landfills there. I really feel that



1 is the big part of the case at this site.

2 MR. ESTRIN: Mr. Chairman, that really
3 brings us to the final chapter, if you like, of
4 Dr. Charlesworth's report. I wonder, we have had a
5 relatively long day, if we could -- I think I will be
6 able to fairly quickly tomorrow morning finish
7 Dr. Charlesworth's Site F report and swing in to
8 Dr. Rowe's. With the Board's indulgence if we could
9 perhaps stop at this point.

10 MR. LANCASTER: Fine. 9:30 tomorrow
11 morning.

12 ---Adjournment at 4:18 p.m.

13
14
15 Certified Correct
16 (Page No. 18850 follows)

P.D. McQueen

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