CONSOLIDATED HEARINGS BOARD

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

— and —

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

— and —

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

— and —

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

— and —

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

— and —

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

— and —

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

— and —

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

— and —

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

— and —

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

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

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

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

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

— and —

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

— and —

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

— and —

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

VOLUME: 21

HELD AT: Oakville, Ontario.

DATE: June 15, 1987

OFFICIAL REPORTERS

NETHERCUT & COMPANY LTD.

185 RICHMOND ST. W.,

TORONTO, ONT. M5V 1V3

TEL: 593-4802

Nethercut & Co. Ltd.

Toronto, Ontario

CH-86-02

THE 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 Sections 12(2) of the Environmental Assessment Act, R.S.O. 1980, c.140;

- and -

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

- and -

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

- and -

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

- and -

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

- and -

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

- and -

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

- and -

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

\- and -

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

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

(i) landfilling at the site referred to in Halton's Environmental Assessment as Site F in the City of Burlington;

(ii) landfilling at the site commonly referred to in Halton's Environmental Assessment as Site D in the Town of Milton.

at an estimated cost of $12,775,000.00 and the borrowing of money be 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.

BEFORE:	H. H. Lancaster, Q.C.	-	Chairman
	Dr. D.J. Kingham	-	Member
	S. Tanner	-	Member

Hearing conducted at The Oakville Granary Commercial Centre, 105 Robinson Street, Oakville, Ontario, on June 15, 1987.

VOLUME 21

APPEARANCES:

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

Nethercut & Co. Ltd.
Toronto, Ontario

APPEARANCES (Cont'd):

C. Stevenson P. Hancock	for Framgard Holdings, Fosseri Investments Limited, Seriphos Investments Limited and Topic Investments
J.H. Olah	for the Halton Region Conservation Authority

* * * * * *

Nethercut & Co. Ltd.
Official Reporters
185 Richmond St. W.
Toronto, Ontario
M5V 1V3

Per: Cindy Littlemore, C.S.R.

Nethercut & Co. Ltd.
Toronto, Ontario

JUNE 15, 1987 OAKVILLE, ONTARIO

--- (UPON COMMENCING AT 9:30 A.M.)

ALFRED A. SOBANSKI, (Resumed)
JAMES BEECHINOR, (Resumed)

MR. LEDERER: Good morning, sir. Now, Mr. Chairman, you will recall that at the end of last day, we had completed the individual review of the work that was undertaken with respect to Site D, and that in the course of leading up to that, we had gone through the study process with respect to both sites. So, what I propose to do with Mr. Sobanski this morning is to now take you through the Site F study, Exhibit H-40, to indicate to you the results of the work undertaken in relation to that whole site. This will start us on page 29 of that exhibit.

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

Q. Now, Mr. Sobanski, as with Site D, sir, would you discuss with the Board, please, your findings with respect to the physiography and topography in the area around Site F?

A. Yes, in terms of the physiography, Mr. Chairman, we are located in a physiographic region defined by Chapman & Putnam as the South Slope. It's characterized as a narrow belt of undulating glacial till situated above the Iroquois shorecliff. The dominant physiographic feature found at Site F is the deeply eroded southern edge of the Halton Till Plain. South of the Lake Iroquois shoreline, the lacustrine sediments overlie the Halton Till Plain.

In general, the Iroquois shoreline occurs just south of Highway 403. It's a small bluff. Below that -- we talked about this in the 2C study. Below that, we have some sands and silty sands that have been laid down as a beach-type or lacustrine-type deposit from the Old Lake Iroquois, the glacial Lake Iroquois, which once filled this area. So, it extended up to about Highway 403, just south of Highway 403.

So, this is a gently sloping plain south of the highway that slopes down toward the Hamilton Harbour. On the site, itself, the topography is more severe. It's a steeper topography. It falls quite rapidly across the site. Unfortunately, this isn't too easy to see, but we have --

Q. All right. Now, just for the record,

Mr. Sobanski, if you could indicate for the Board, please, which of the drawings that pertain to this report you are now talking about?

A. Yes, we are referring to a report H-40, Drawing 12, Surficial Geology. In the clear areas, which I am out lining with my pointer, where are in the central region of Site F, that extend to the east of **Kings Harbour, we can see clear areas that don't have the heavy stippling on them. They extend down also southward across Site F. These are deeply eroded gullies that occur on the site that have incised this sloping till plain, and in these areas, we have exposed shale on the properties.

So, within this property, the topography is rather severe. It's extensively disected by these ravines cut into the shale and, therefore, we have modified the original terrain, and what we have are caps of till lying interspersed with these deeply eroded valleys into the shale. These features are in the order of -- in the valleys are 50 to 60 feet high and quite steep. They are used extensively by young people to race motorcycles and dune buggies and the like to test their equipment. So, it's really quite severe in those valleys.

Q. Now, can we then turn to page 30, and could you discuss with the Board, please, your findings with respect to Site F in relation to regional geology, and if we can do that again, first of all, with respect to the bedrock geology and then the overburden geology. All right. Now, Mr. Beechinor has put up what I believe is Drawing 2 to Exhibit H-40?

A. That's correct. It's entitled "Location of Exploratory Boreholes and Water Supply Wells". The purpose of this drawing is to show the Board that we are going to show two geologic cross-sections, A-A and B-B. Both cross the landfill area, the proposed landfill area, in approximately the same area running from north to south -- south from HC-1 roughly down to HC-8, and there they are going to diverge, one roughly parallel with the Queen Elizabeth Highway, and the other coming straight south from the site down to Hamilton Harbour going through HC-8 down through HC-16 located near the shore of Hamilton Harbour.

If I could refer now to Drawing No. 6, this is a cross-section A-A, which extends southward from the site and then down roughly parallel in the Queen Elizabeth Highway. This shows both overburden and bedrock, and we may as well discuss them together in the regional context. The bedrock is the red and mottled red and green shale of the Queenston formation as we found on Site D. You can see in the site area, which is shown at the top of the drawing -- and, perhaps, for the record, I might say that this is called Regional Stratigraphic Cross-Section A-A.

Q. Mr. Sobanski, before you get into the discussion of the substance of this, perhaps you could do two things. First of all, point out to the Board the location of Site F, and secondly, review with them the scale on which this is drawn?

A. Referring first to scale, we are dealing here with metres above mean sea level in terms of elevation starting at the north end of the site at an elevation of about 185 metres, and then coming down on the right-hand side to Hamilton Harbour at an elevation something of around 75 metres. So, we have about a little over a hundred metre drop from the north on the left-hand side of the drawing to the south on the right-hand side of the drawing.

Drilling sites on Site F, if we look at Site F, Site F would start somewhere in the vicinity of about HC-1 on the left-hand side of the drawing and would extend southward to about Lot 7 on this drawing, which is located somewhat to the south. Now, in terms of scale, using zero as a marker on the left-hand side, we are talking five kilometres in distance between the north end of the section and the south end of the section on the right-hand side of the drawing.

So, this is showing then -- across the top, we have drilling sites on Site F, and when we say on Site F, or near Site F, roughly down to Highway 403, and then going further south, we have drilling sites between Site F and Hamilton Harbour, of which there are four nests installed; HC-9, 10, 12 and 13.

DR. KINGHAM: Just for the record, Mr. Sobanski, would that be a 10 to 1 exaggeration of the vertical scale roughly?

THE WITNESS: Yes, roughly.

DR. KINGHAM: So, everything is about one-tenth as dramatic of it's vertical height as shown here?

THE WITNESS: That's correct. It's a geological trickster that you can see these things. If we were to drawing them to scale, there wouldn't be much to see without having quite a long, long roll of paper to look at.
So, normal geological scales are 10 to 1 exaggeration.

So, coming back to the bedrock, again it's the Queenston shale, as we found on Site D. It is a brick red shale with green interbeds. That is also mottled red and green in some areas. We can see that the shale has been -- or the overburden has been eroded off the shale over much of Site F.

Now, regionally, the area hasn't been tectonically disturbed; that is, it isn't subject to major earth movements, although there are earthquakes in the Hamilton area, very deep earthquakes,. but there has been some disturbance of the Queenston formation, we feel, due to the post-glacial stress relief. During glacial times, we had two miles of ice on the area and, in fact, the whole area was suppressed below sea level. As the ice withdrew, the earth surface has rebounded from that condition, and this, however, created some stress within the shales, we believe, and has created some of the features that we have discussed in hydrostratigraphy.

We have two major overburden units on a regional scale. These are the Halton Till, which is found above the site on the north end of the property and also south of the site, and on top of this unit, we have the lacustrines that ~~have~~ been laid down on top of the Halton Till. So, glacial Lake Iroquois came up to a point here at about Highway 403 at one time, above elevation a hundred metres or so.

Now, our grass mound, as I should point

out, has had a lit bit of poetic license. The overburden, as shown between the sand units between HC-9 and HC-10, isn't quite as thick as shown there, because they have tried to extract sands in that area and run into the till at a higher elevation. We can now look at the other regional section.

Q. Mr. Chairman this is Drawing 7 on Exhibit H-40?

A. This is called Regional Stratigraphic Cross-Section D-D. It runs from the north end of the site down to Hamilton Harbour in a fairly straight line running straight south. Site F, the location of Site F, is identified at the top of the drawing. Again, the elevation in metres above mean sea level is given on left-hand side of the drawing, on the right-hand side, from vertical to horizontal exaggeration.

Q. Mr. Sobanski, it might be better for us to wait for the paper symphony. All right. Could you tell us what you can see by examination of Drawing 7, Cross-Section D-D?

A. The distance scale along the bottom now runs from zero to a little over four kilometres at Hamilton Harbour. Again, the bricky configuration is the Queenston shale, and I point out again that over much of Site F it has been eroded away. Again, regionally we have the Halton Till on the north end of the site, and then extending roughly from Highway 403 and parts of the southern portion of the proposed site down to Hamilton Harbour. We also see, again, the remnants of the Iroquois deposits, the lacustrine deposits, which are sandy material deposits on top of the till. This is a little more representative of the area south of the site where we are now not showing any significant effects of sandy overburden between HC-14 and CNR.

Q. All right. Can we move now from the regional geology to the local geology. Again, could you review with the Board, please, your findings with respect to this aspect of your study. Again, perhaps, we could look at this first in the context of the bedrock, and secondly, the overburden?

A. You will be looking here at Drawings 8, 9 and 10. Mr. Lederer, we seem to be missing one drawing here. I would like to refer first to Figure 5, or Drawing 5, which is entitled "Location of Drilling Sites and Observation Wells", give the general flavour for where these sections are located, the ones we are going to be looking at.

We are looking at Section A-a, which is a blowup of part of the regional section that we looked at that went parallel to the QEW. That is Section A-a, which is located between HC-1 and HC-9 on the south, HC-1 on the north and HC-9 on the south.

Section B was one of the large sections that we looked at. Section C-C is shown on Drawing 5. That's at the north end of the property. D-D is further south on the property located between Gartner Lee 25 and University of Waterloo WAT-2. Section E-E is located between Gartner Lee 24 and Hydraulic Consultants 7 on the east. Finally, F-F is located between HC-15 and HC-9 located south of Highway 403.

If we look first at the blowup of the north/south section, we don't show the location of Site F on this drawing. It essentially extends from HC-1, which is on the left or north side of the drawing, and extends down to roughly a place call Tributary to Indian Creek between WAT-7 and MB-13 on the right-hand side of the drawing. The shale and its erosional features can be seen on this drawing where the overburden is absent through most of the site.

Now, the shale, again, is the Queenston formation of Upper Ordovician Age. It is a brick red shale, and it contains about 20 percent of green beds, either mottled or individual beds, interspersed with the red shale. We have gypsum nodules and seams within the shale, and we have some cavities within the shale, which can be attributed to dissolution of these futures. The gypsum generally comprises, we feel, less than one percent of the rock.

A review of the core logs taken over the site indicates that the shales have a complex fracture system near surface and at depth.

In Drawing 9, Cross-Section C-C and D-D, these are located toward the north end of the property, and here we can see the thick glacial till unit that overlies --

Q. Sorry, just to be clear, this is Drawing 9 when you say that?

A. This is Drawing 9.

Q. Thank you.

A. A little further south, you can see that the overburden is thinning, but again, we have the same shales.

Q. And Mr. Sobanski, maybe you could just wait for everybody to catch up to you. Just put the drawing down for the moment. All right. Now, if you could review with the Board, please, what you see in Cross-Section C-C and D-D on Drawing 9?

A. On C-C, we can see across the top of the figure, which is a distance of about .7 of a kilometre. On the left-hand side, the Burlington Landfill is identified and the materials on which it was founded. This was predisposal. On the right side, we have Site F, shown as running from Gartner Lee 23 roughly to King Road, keeping in mind that buffers would be involved.

These scales are the same as shown before. We have a vertical elevation on the left-hand side and distance in kilometres on the X-axis. You can see that the till is fairly thick in this area, being in excess. It's about 15 metres. As we come a little farther south, we now see that the till is thinning. The figure on Section D-D is set up the same way with the Burlington Landfill, and Site F being shown on the top of the drawing, and we can see that one of the tributaries here to Indian Creek is interpreted to have merely been sliced through the till down to the shale, this section being much thinner here.

Q. Now, you are taking us to Drawing 10?

A. This is now Drawing 10.

Q. If you can just give everybody a chance to catch up to you.

A. For the court reporter, it's Local Stratigraphic Cross-Section E-E and F-F. We haven't taken a section through the area that is essentially all shale. Section E-E is located toward the southern portion of the site running from Gartner Lee 24 on the west to HC-7 and King Road on the east. Section F-F is located south of Highway 403.

Now, the scale, horizontal scales, on these drawings are changed a bit, as are the vertical scales, still about 10 to 1. Now, here we can see where the tributaries to Indian Creek in the centre of the site have been sliced through the overburden, and shale is exposed in the valleys. On the south of the property, we can see that the overburden comprises both the till and then the overlying Iroquois sands. This is just south of 403.

Now, when we looked at all of our information, we reviewed the core logs, as we said, and we found what we felt was a complex fracture system. We took all of our available information that we had on the Queenston shale and from literature, from personal discussions with people who have worked with it, and most importantly, from our field data, and this resulted in our interpreting the four zones to occur within the shale, and I would like to refer to Figure 2 on page 35 of the report.

This is entitled "Local Categorization of the Queenston Formation Based On Distribution Of

Fractures". The upper most zone that we found was a weathered or fractured shale, weathered and moderately, moderately fractured and weathered shale identified from its consistency and from fractures within the unit.

This unit is underlain by a moderately fractured mass of shale, which is calcite cemented and is very evident in the cores as a fairly competent unit, but within it, there is still the odd fracture. Below the contact or below the base of the weakly fractured mass of shale, we have identified a highly fractured shale. This we have attributed to being a pressure relief zone possibility that the glacial ice, when it retreated, caused this material to shift and move and has created some additional fracture permeability.

Finally, we identified moderately fractured. This is calcite poor shale, which occurs below that, and this we interpret to be a part of the regional bedrock. All of the units do contain some fractures, but it's a question of degree, and in the cores, this weakly fractured mass of shales shows up very distinctly as a unit or a competent rock.

DR. KINGHAM: Mr. Sobanski, again, just for clarity, this is just the southern half of the site, is it, --

THE WITNESS: Yes.

DR. KINGHAM: -- from HC-4 down?

THE WITNESS: Yes. On the left-hand side, we were dealing with a scale again, and we start on this one at HC-4, which best depicts the section. HC-4 occurs -- I am now referring to Drawing 5, Location of Drilling Sites and Observation Wells. HC-4 occurs about in the middle of the property just opposite the south end of the Bayview Landfill, and it extends from there down to HC-14.

So, we are running straight south, just south of Highway 403, showing our interpretation of this area. There are other drawings that carry it a little father north later on, but this section demonstrates, we believe, what we feel the major units are on one section. To the north of that we have sparser data, because we get into the heavy tills.

BY MR. LEDERER:

Q. Now, just to be clear, what geology do you expect to find to the north in the bedrock?

A. To the north in the bedrock, we would expect to be into the moderately fractured and weathered shale. We would have the weakly fractured mass of shale. We believe that the highly fractured shale unit, which will be discussed in more detail, pinches out into the vicinity of HC-4. Somewhere about the middle of the site, we believe it pinches out. This is based on pumping tests that have been run and on modelling that we have done, and the moderately fractured shale, the major unit that we find, extends under the entire property.

If I could refer now -- this is sort of a schematic that may help show something we feel that would come up again. On the north end of the site, glacial till --

MR. ESTRIN: I am sorry, Mr. Chairman, could the witness refer to something specific that he is describing?

MR. LEDERER: Well, I think he has

MR. ESTRIN: Well, could we identify it?

MR. LEDERER: Typically, you identify it for exhibiting purposes after its been discussed. This doesn't appear anywhere in any of the reports. It's a schematic --

MR. ESTRIN: I am just trying to get the transcript clear, Mr. Chairman.

MR. LEDERER: It's a schematic that was prepared for presentation, and I am just trying to clarify what the last number was. I am not certain, Mr. Chairman, what it is, but clearly this should be exhibited separately as it is not contained, as I have said, in any of the reports.

THE WITNESS: This is entitled "Geology Site At Burlington".

THE CHAIRMAN: H-40-2.

MR. LEDERER: I am sorry, sir, I am having difficulty hearing you.

THE CHAIRMAN: H-40-2.

MR. LEDERER: All right, H-40-2.

THE WITNESS: This drawing shows the distribution of the bedrock units as well as the overburden in a schematic way. The upper portion of the site is underlain by the weathered and fractured shale, underlain by the weakly fractured mass of shale unit, and finally, the regional bedrock structure.

Now, about halfway down the site, we interpret that we have a wedge-shaped piece of highly fractured shale material with relatively good transmissiblity that extends southward beyond Highway 403, and at some point south of 403 contacts the glacial till overburden.

In terms of overburden, we have overburden glacial till at the north end of the property, and schematically, we are showing overburden south of Highway 403 and partially on the landfill site, and this compromising both the Halton Till and some overlying lacustrine sands from Lake Iroquois. Again, we show here about half of the site, more than half of the site, to be devoid of significant overburden covering.

I would like to discuss now briefly the overburden. I would like to refer to Drawing 12. Drawing 12 is "Surficial Geology". We have discussed this as well under -- the overburden on the site comprises entirely the Halton Till. Its texture, as at Site D, ranges from a silt to a clayey silt. So, it contains some stones. The overburden, as we mentioned before, has been modified by these deep erosional features that we see on the site where the overburden has been stripped off completely and shale bedrock had been left exposed in the valleys.

On the northern part of the site, as we can see extending from about Gartner Lee 18 to Morrison Beatty 4, and then from there eastward, we have a good capping of glacial till. The central portion of the site has little or no overburden covering, and then in the south end of the property, we come into the caps of glacial till in between the stream valleys, which are shown as dark globs on the maps. Although this isn't site specific, the Lake Iroquois shoreline can be seen just south of Highway 403 and below the point of about HC-14, and just north of HC-9, we start to come into the sandier sediments that overlie the till which now seeps beneath the sands.

Q. Now, Mr. Sobanski, I want to just see if I can summarize all of this for the Board, and Mr. Beechinor, perhaps, you could just put H-40-2 back up. All right. Now, would I be right in saying, that in the overburden on this site, there is overburden on the north, that in the southern part of the site in places, it has eroded, and that in the bedrock, there are essentially four separate geological units, one of which will have a fractured shale, pinches out about halfway up the site, and runs from there to the southern end of the site and off site?

A. That's correct.

Q. All right, and of those four units, we have then a moderately fractured and weathered shale, a weakly fractured mass of shale, then this highly fractured unit which pinches out, and finally, a moderately fractured shale, mass of shale, at the bottom?

A. That's correct.

Q. Thank you. Now then, can we move then to page 49 of this report, and following along the findings for Site D, can you indicate to the Board, with this geologic information in place, were you able to identify hydrostratigraphic units for Site F?

A. Yes, we were. We identified five major hydrostratigraphic units. The first we have lumped into one unit, which we are calling the glacial till on the north side of the site, and the discharge zone till on the south end of the site, which occurs over part of Site F and then extends downward through Hamilton Harbour. So, this is identified as a unit.

Q. All right. Now, when you are using Exhibit H-40-2, and you are referring to the till unit, first of all, at the north of the site, and secondly, at the south of the site, as two separate hydrostratigraphic units?

A. Yes.

Q. Thank you.

A. Now, we then identify the weakly fractured or the weathered and fractured shale unit as another hydrostratigraphic unit, a weakly fractured mass of unit as a hydrostratigraphic unit, the highly fractured shale as another hydrostratigraphic unit, and finally, the fairly massive weakly fractured zone at the -- beneath the site, the regional shale, as the final hydrostratigraphic unit.

Now, all of these units are important in that they -- when we talk about hydrostratigraphy, these zones exert and influence on how -- the way the ground water moves at the site.

Q. All right. Now, we are referring to Figure 4, which, Mr. Chairman, you will find on page 49 of the report, and using that figure, Mr. Sobanski, could you, first of all, identify again the six hydrostratigraphic units and indicate to the Board the hydraulic conductivity values assessed for each of these units?

A. The first unit is Unit 1A and 1B, 1A being the till unit on the north end of the property, and 1B being the discharge zone till. The unit, again, consists of a clayey silt, silty clay till. The hydraulic conductivities that we measured, based on Gartner Lee's information and our own information for Unit 1A, which is the till on the north side of the site, gave us a hydraulic conductivity of 1 x 10 -7 cm/s. They varied from about 5 x 10 -8 cm/s to 1.7 x 10 -7 cm/s.

We interpreted a weathered upper till zone in this area as well to a depth of four to five metres. We would consider that to have a hydraulic conductivity of 10 -5 cm/s, as we did in Site D. However, in this case, the glacial till will be extracted for cover material, so we will be dealing with the massive unit in terms of hydraulic conductivity.

The discharge zone till, we gave an average hydraulic conductivity of 3 x 10 -6 cm/s. This was done by averaging a glacial till hydraulic conductivity and the overlying silty sand hydraulic conductivity. For the fractured weathered upper shale unit, which is Unit 2, we used a hydraulic conductivity of 1 x 10 -5 cm/s. This hydraulic conductivity is based upon measured field data.

The weakly fractured massive shale unit gave us some problems in terms of hydraulic conductivity. We used the hydraulic conductivity of 1 x 10 -7 cm/s. In fact, there is a considerable variability within this unit. We have measured the odd local zone that can have hydraulic conductivities in the 10 -4 to 10 -5 range, whereas other investigators have found the hydraulic conductivity to be as low as 10 -10 in the extremely tight competent units.

So, where we do find the odd fracture, it does have a bit of permeability, but the generally massive unit is very tight, at about 10 -10. So, what we did, is we have used in this case 1 x 10 -7. We will see later that when we do the mathematical demodelling on the side, this value actually gives us our best fit to field data.

For the highly fractured shale unit, the hydraulic conductivity is based on pumping tests, and this is given as 1 x 10 -2 cm/s. So, in terms of hydraulics, we can take a look at the Unit 3, the weakly fractured unit, and Unit 4, the highly fractured unit, and we see five orders of magnitude in terms of hydraulic conductivity, a difference between the two. So, this obviously is going to have an influence on ground water flow system.

For the moderately fractured bulk shale unit, which underlies the entire site, we have used a hydraulic conductivity of 1 x 10 -6 cm/s.

DR. KINGHAM: Just to remove the mystique of negative exponents for all of us, 1 x 10 -6 cm/s, that's about a foot per year, and 10 -5 then would be about 10 feet per year, and 10 -7 would be a little less than an inch per year?

THE WITNESS: I will trust you on that. I haven't worked it out in my head. I just used the -- strangely enough, I don't use them that way, but I will take your word for it.

DR. KINGHAM: Well, maybe you will want to work it out. It's just a little easier for us to visualize. Not now. I am not suggesting you do that now, but just to keep it clear and comprehensible. If that's right, it might be worth everybody knowing.

MR. LEDERER: Dr. Kingham, perhaps you could just give us those figures again. We will double check
your ...

DR. KINGHAM: Well, thank you. I am basing my information on other information you have in here, where you talk about it in terms of metres per year, or working it from first principles. 1 x 10 -6 should be about a foot per year, so that we can understand; 10 -5 should be about 10 feet per year obviously then. It's an order of magnitude.

THE WITNESS: I am sort of caught in the middle now, Dr. Kingham, in between metrication and the old imperial units. Being a 1960s grad --

DR. KINGHAM: I think you are probably not alone in that.

THE WITNESS: -- I am rather confused at times by both systems now. I don't mean it quite that way, but -- maybe I do.

BY MR. LEDERER:

Q. It's called a quickly retrenching position. Perhaps, we could just pick up on Dr. Kingham's point and put it this way, in the sense this is a repeat of some answers you gave with respect to Site D, could you, perhaps, take us to these values and give the Board some relative idea, within.your discpline, as to which of these or what these values are considered to be in terms of the speed which water flows then? Are they moderate? Are they fast? Are they slow. How do they fit into the relative scales?

A. Well, in terms of relative scales, the movement of water through a 10 -7 material would be very slow. It doesn't move very quickly, whereas 10 -2 material is equivalent to sand and gravel and would move very quickly. When we talk to the 10 -2 under normal gradients, groundwater gradients of about .01, which is fairly common, we will be talking in the order of 300 feet per year or so in that type of a unit. So, velocity, of course -- it's, again, this problem we have with the Darcy velocity when we talk about these permeabilities, because then we have to consider both the gradient and the effective porosity, unfortunately which confuses the issue.

This why I normally don't think of --

when I talk about hydraulic conductivity, I normally don't think of it as a velocity, because into that you must again consider the gradient and the effective porosity. So, the values are very low, and we will go into a calculation in a bit in the report similar to what we did at Site D to give some indication just how fast things can move in these materials. A fractured medium hydraulic conductivity of 10 -2, they can move very fast indeed.

Q. All right. Now, as with Site D, did you do any work to establish porosity values for the hydrostratigraphic units at this site?

A. Yes. We have applied our judgment to what the effective porosity would be for these type of units, and a fractured medium again can vary over quite a wide change. We have to use some judgment on this, and also it's -- we have thought of other factors, such as the results of our tritium data and what they show, but for the till units, 1A and 1B, we are, again, considering the effective porosity of about 25 percent, as we ~~did~~ at Site D.

For Unit 2, the weathered and fractured shale unit, we are using a fracture porosity of about .001. For Unit 3, we are using very nearly a matrix permeability on this shale. Shale would have a matrix permeability of about .4 perhaps, 40 to 50 percent porosity. As we view that unit, it does have some fractures in this, but they are very few and far between. So, instead of taking a fracture porosity for that unit, we have used closer to the matrix porosity, because we don't feel that from the few fractures that we found within it that they would move very much water from Unit 2 down into Unit 5 or 4. So, we have used a value .1 as opposed to a probable value of about .4 if it were totally unfractured.

For the Unit 4, which is the -- we refer to as the highly fractured shale unit, we have used an effective porosity of .01. This is a little higher than just fracture porosity, because there are quite a few fractures within this unit. I shall point out to you in that unit, when you talk about distribution, you won't find it everywhere. It occurs over fairly large areas, but the odd well penetrates, and it doesn't seem to encounter any major fractures within it, but it does extend over a reasonable area.

Finally, for the Unit 5, we found that we did not have to apply a porosity, an effective porosity, to that unit at all. As we will see from modelling conditions, that unit moves very, very little water. Most of the activity of groundwater movement takes place within the upper units, being controlled by the massive unit and the highly permeable unit.

Q. Mr. Sobanski, did you undertake any pumping tests at this site?

A. Yes, we did.

Q. Would you indicate for the Board, please, why you did these tests, and what the purpose was behind it?

A. When we did the packer tests, on HC-3 and HC-4 --

Q. Mr. Chairman, I just might say, while Mr. Sobanski is getting Drawing 5 out, that you will find this discussed generally at pages 52 to 54 of the report.

A. HC-3 is located about -- well, not quite midway up the site, but roughly located to the west of the Bayview Landfill on the west side of Site F. HC-4 is located to the east of HC-3 near the property boundary with the -- of the Bayview Landfill, near the Bayview Landfill southwest corner. We found permeable zones within these wells, where we packed off a section of formation, injected water in a couple of these -- well, in both of these wells. We found zones that we were not able to keep up with the water. We could inject it as fast as we could put it in, and we weren't able to get an actual hydraulic conductivity value because of the rapidity of those tests.

So, we decided to determine the significance of these units by running pumping tests; that is, by installing small water wells and running pumping tests by observing drawdowns both in pump wells and in surrounding observation wells. We did this for several reasons. We want to use this data for a contaminant pathway analysis, because obviously we had zones of much higher permeability.
We wanted to obtain hydraulic conductivity values for the zones so that they could be applied to our considerations of groundwater flow, and finally, we wanted to gather data on the possibility of the installation of contingency control systems, such as purge wells, which could be considered -- were being considered at Site D and also we have it in mind for Site F. So, these were the main reasons for undertaking that work.

Q. Can you review with the Board again the results of the work?

A. Pumping Test 1 was run on Pump Well No. 1, which is located near the North Service Road down in the southeast corner of Site F. We recorded drawdowns in numerous observation wells. I am looking at my notes here. In a well called OW-1, which was an offset that we constructed to the Pump Well 1, we observed in Morrison Beatty 12, which is located some distance to the north and close to 200 metres, based on the scale of 200 metres north of the pump well; Morrison Beatty 16, which is located in the southeast corner of the property, and finally in WAT-7, which is located north about -- oh, 150 metres north of Pump Well 1.

We used the Tyson/Jacob methods standard techniques for analyzing pumping tests, and we came up a hydraulic conductivity of that zone as being 1.3 x 10 -2 cm/s. The distance versus drawdown diagram for that pumping test indicated, that at a pumping time of about a thousand minutes, which is just a little less than a day, the drawdown cone would have extended about a 180 metres or greater from the pumping well. We were seeing interferences out in these various wells that we were measuring. So, we had to spread a cone in the order of about 180 metres from that pumping well. In fact, HC-9, to the south of the 403, was also affected.

Q. Sorry, can we just be clear, what hydrostratigraphic unit are we talking about?

A. We are talking about a pumping test in the highly fractured shale unit. We ran some other pumping tests, two other pumping tests as well. A Pump Well 2 is located near HC-3. This was pumped for a period of time and showed good hydraulic communication between those wells. A relatively -- an extensive fracture zone is indicated apparently, but it wasn't as well-instrumented as Pump Well 1. So, we are unable to draw as much information from it. The results of those tests are shown in Appendix 10 of the report.

Pump Well 3 is located south of the Bayview Landfill near WAT-5. It's identified as PW-3 on Drawing 5. This was pumped at a very low rate. This well did not yield a lot of water. We did find a connection with Observation Well WAT-5 located to the south. We know that we threw the cone of influence out about 22 metres, but it was apparent to us that the test results indicated that the fractured zone, at this point, was limited in its lateral extent.

The major outcome of these pumping tests was that it lead us to realize that the fracture orientations of the permeable zones, the more permeable zones, were approximately horizontal. It then helped us to do this type of an interpretation that we have seen on Drawing H-40-2 and Figure 4 on page 49. So, this was important to realize that they are laid fracture systems and appear to be approximate horizontal.

Q. Now, Mr. Sobanski, before we leave this, we may have run into some terminology that we didn't hear in Site D, or we may have not explained it fully. Could you indicate to the Board, when you were referring to the first of these tests, and you refer to the "cone of influence", can you explain to the Board what that means, please?

A. It's the area in which we effect the hydraulic pressure in surrounding wells. If you like, we create a pumping cone of depression within the water table. We make a depression that looks like an inverted hill, and to move water to the well, we create a gradient to the well, the water level in the well drops, and this cone spreads out through the formation, through the unit that we are test pumping, and we can see drawdowns in the various wells.

So, this cone of depression is a cone of hydraulic pressure that slopes inward toward the centre of the cone, which is the pumping well. Indeed, it looks somewhat like a cone.

Q. The extent to which the pumping test affects the flow of groundwater, the physical extent?

A. It is measuring the physical extent by pumping as you are measuring the physical extent to which you are influencing pressure in the hydrogeological system. In other words, what is it connected to, where is the connection within the unit?

Q. All right, and secondly, I think you referred to "hydraulic communication". What does that refer to?

A. Simply put, it would be the communication of hydraulic pressures. In other words, certain zones are in communication if we effect them hydraulically. In other words, we change the head within them, then they are hydraulic connections.

Q. The connection between the various hydraulic zones?

A. Yes, there is.

MR. LEDERER: Now, Mr. Chairman, it's a little bit early for the break, but as the Board will recognize, from Site D events, this tends to be the point of these studies which is the most detailed, and people are being asked to take in the most amount of information in a hurry, and it might be wise if we could have a break and that will let everybody just assimilate all this evidence.

THE CHAIRMAN: Ten minutes.

--- SHORT RECESS

--- UPON RESUMING

THE WITNESS: Before we start, Mr. Lederer, Dr. Kingham's number is correct, 10 -6 centimetres per year is about one foot per year -- or 10 -6 cm/s is about one foot per year, and so on.

BY MR. LEDERER:

Q. All right. Now, just before the break, Mr. Sobanski, we had reviewed with the Board the geology, the hydrostratigraphy, as you have identified for Site F, reviewed with them some of the analysis done with respect to that hydrostratigraphy, the hydraulic conductivity values, the porosity values and the pumping tests results. With all of that identified, were you in a position to determine the groundwater flow systems in the bedrock beneath Site F?

A. Yes, we were.

Q. All right. Could you review with the Board, please, your findings with respect to that flow system, again as with the geology. First of all, in a regional context, and secondly, in a local context?

A. I would like to refer here to Drawings 13 and 15, please.

Q. I may say, Mr. Chairman, for those interested, generally this evidence is found at pages 54 and 55 of the report. Mr. Sobanski, now we have in front of us Drawing 13 from Exhibit H-40. Could you use that to indicate to the Board, please, the groundwater flow system in bedrock in a regional context?

A. Yes. Drawing 13 is entitled "Regional Bedrock Potentiometric Contour Map Shallow Bedrock". We are looking here at the flow in the bedrock near the overburden bedrock contact. Now, in terms of our drawings, we are going to look at it in two dimensions, as we usually do. So, we are looking down in a plan view to see which way groundwater flows within the shallow rock.

The information here is based on our numerous boreholes that were constructed on the site, as well as boreholes that have been constructed by others. For scale, we are dealing with a distance of about five kilometres from the north end of the flow system, which occurs to the south of the Niagara Escarpment, and then goes southward down to Hamilton Harbour. So, about five kilometre length.

We see that the movement in this case is southerly. In fact, southeasterly, but from the point of view of the map, southerly down toward Hamilton Harbour. The horizontal gradient buries from .009, a relatively small value, to a value of .03.

The data indicate that the flow system originates certainly at the escarpment. We feel that the regional system probably originates above the Niagara Escarpment and feeds water into the shale units. This flow system, I believe from subsequent work, moves at fairly deep depth below the site down toward Hamilton Harbour something in the order of a hundred feet below ground level. Hamilton Harbour will likely be the ultimate recipient of groundwater discharge from that shale unit.

To look at the local system, I should point out, perhaps, one other feature. We can see that in the shallower rock system, the creeks, major creeks, exhibit some influence on the shallow flow system, in that there is groundwater discharge occurring on some of the more major stream tributaries.

Q. Just the way you introduced that, I think it may confuse people in reading the transcript. That last comment still relates to Drawing 13 and to the regional flow system in the bedrock?

A. Yes, that's correct.

Q. Now, can you take us then to Drawing

15 and review with the Board, please, your findings with respect to the groundwater flow system in bedrock in a local context?

A. We are referring to Drawing 15, which is called "Local Bedrock Potentiometric Shallow Rock Contour Map (April, 1986)". The map is based as is constructed in the manner that we have discussed for Site D, where we measure the elevations of the water levels in appropriate wells.

Q. Mr. Sobanski, just before you go on, can you indicate to the Board in which hydrostratigraphic units this is all taking place?

A. This is in the shallow rock we are talking about now.

Q. Can you just take us to H-40-2 on the schematic just below there and just show the Board which unit you are talking about?

A. We are looking at the shallow flow system on the site that is occurring near the rock contact of the various overburden, or of the various rock units, so that we are comparing -- we are looking at which way the shallow movement within the rock occurs on the site.

Q. Thank you. All right. Can you take us back to Drawing 15 then and review with the Board your findings?

A. As I was mentioning, these are constructed in the manner that we described for Site D, where we measure the water elevations within the unit of interest and then contour. We are using here some additional control. You will see that there are some squiggly-type lines shown as little V-shaped lines. We are dealing with the shallow rock that's right at surface. You are essentially into nearly a water table case. You are in a water table case, where the rock is exposed through the central area. So, consequently, these little V-shapes represent the elevation on streams.

So, the streams are wet most of the year. They don't flow all of the time, but the water table is near stream elevation. So, we can see now that we get a little -- some squiggles on the drawing that didn't show on the other one. We are tightening in now where we have good topographic control from the surface contour maps. So, what this shows, is that the local potentiometric contour map, the horizontal gradient in this shallow bedrock flow system on site, range from about .01 to about .05.

Now, the direction of groundwater movement, in general, is still southeasterly, similar to the deeper system or the more regional system that we looked at, and we see -- from our little V-shapes, we feel that there is discharge occurring on site through the weathered parts of the shale unit. These discharge on site into these deeply incised gullies that are characteristic of Site F.

Q. Now, what about your findings with respect to the flow in the overburden, and again to review this, first of all, in a regional context, and secondly, in a local context?

A. In terms of the regional overburden groundwater flow system, I would like to refer to Drawing 14.

Q. Mr. Chairman, while everybody is locating this drawing, I might, again, say to the Board that this evidence is generally found at pages 55 to 56 of the report.

A. Drawing 14 is entitled "Regional Water Table Contour Map". This map includes a blend of overburden and bedrock wells. It is constructed to look at the water table within the regional system, and it's defined by the water levels within the standpipes. You will recall that we discussed the use of standpipes for determining the elevation of the water level or the water tables. This is one type of the observation wells that we have discussed.

Generally, the water table again slopes southeasterly toward Hamilton Harbour. The horizontal gradient varied from about .009 to 0.02. We interpret that there are, in fact, groundwater recharge zones between the till -- between the streams, with some recharge occurring through the overburden and then moving toward the streams. We didn't instrument specifically for that in the regional testimony, but it becomes more evident on the site where we have more deformations, and we can see how the streams control some of this movement through the shallow rock and shallow overburden with the equipotential lines being significantly looped to take into account stream elevations, and then the groundwater flow lines being toward the more deeply incised valleys.

For the local water table configuration at Site F, I would like to refer to Drawing 16. This is now the water table configuration determined from standpipes constructed in the overburden and in shale. This is the shallow zone again. The water table generally slopes southeastwardly from the site along the long flow lines. However, again, you can see the influence of these deeply incised valleys along the site and the control that they have on shallow groundwater movement.

Now, the depth to the water table at the site varied from .15 metres below ground level in April of '86 to about 2.9 metres below ground level, and that occurred at Well HC-7-85. The horizontal gradient in the flow system varied from .03 to .045. These are getting to be reasonably strong horizontal gradients.

MS. CRONK: Excuse me, could I have those numbers again?

THE WITNESS: .03 to .045.

MS. CRONK: Thank you.

DR. KINGHAM: When you give those numbers for gradient, Mr. Sobanski, is that essentially the subtraction of the bottom gradient from the top gradient divided by the distance? Is that what you are giving us as the gradient?

THE WITNESS: That's essentially how it's done, the difference between the contour lines. For instance, where the contour lines are closely spaced, as they are in the northern part of the site, that's a relatively high gradient. So, it's the difference -- it's the head drop over that distance is the gradient.

DR. KINGHAM: And you just told us that they range from ...

THE WITNESS: .03 to .045.

BY MR. LEDERER:

Q. The measure of the slope of the hydraulic head, isn't it?

A. Yes.

Q. Now, you have indicated to the Board that this evidence at this point has been a demonstration of the horizontal gradient or the horizontal movement of water. Could you indicate to the Board, please, as with Site D, did you do any work to establish the hydrogeological relationship between the two levels; that is, the bedrock and the overburden?

A. Yes, we did. As we did in Site D, we looked at the distribution of the vertical groundwater gradients. These are shown in Table 8 on page 57.

Q. Just to be clear, this gives you then the movement of the water in a vertical plain?

A. Yes. These are the gradients that derive water vertically.

Q. Did you review your findings or your conclusions with respect to that examination?

A. Generally, the data that we developed indicated strong downward gradients on Site F, and generally lateral to weak upward gradients south of Highway 403 down to Hamilton Harbour. The types of values that we measured covered a considerable range.

If we look at Table 8, these are the vertical groundwater gradients for April of 1986. The first gradient that we are looking at here, under Geology, is between the overburden and the shallow weathered shale. So, these would be piezometers constructed within the overburden unit measured down to the overburden bedrock contact, or just into the bedrock.

Near Site F, we have a downward gradient between these two units, generally downward, that vary between .01, which is relatively small, to 1.1, which is a unit gradient, a little over a unit gradient, which means that the unit is undergradient, and the maximum hydraulic head is being opposed, the porosity.

Q. Mr. Sobanski, could you just speak a little bit more loudly? I suspect the people at the back are going to have trouble hearing you.

A. If we look between the Site F and Hamilton Harbour, this is from about 403, Hamilton Harbour, with slight upward gradients or sorry -- yes, slight upward gradients varying from a very small value of about .002 to .1. If we now look from the overburden bedrock contact down into the deeper zone of the moderately fractured bulk shale unit down to a depth of a hundred feet or so, we find that on Site F there is a slight -- or a downward gradient varying from .1 to 1.1, and between Site F and Hamilton Harbour, we have downward gradients varying from about .008 to 0.09. These gradients of about .008, .002, are relatively small and nearly horizontal.

So, between Site F and Hamilton Harbour, the vertical gradients between the overburden and the shallow weathered shale are weakly upwards, and the vertical gradients between the shallow weathered shale looking downwards are -- into the deep rock are generally slightly downwards.

Q. Now, let's me see if I can summarize that. Am I right in saying, that in the shallow area, there are some areas of discharge, but generally the gradients are downward, in the deep area downward, and at that level, there will be no discharge between the site in Hamilton Harbour?

A. Yes. They are slightly downwards to lateral. They are nearly a flat gradient.

Q. That's in the deeper zone?

A. Yeah. The conclusion that we arrive at in the report is on page 57, and from this information, we indicate that an interpretation, that No. 1, the shallow groundwater flow system represents active local zones of recharge and discharge, and secondly, the regional groundwater flow system is active at a depth that's not discharged between Site F and Hamilton Harbour.

Q. Now, Mr. Sobanski, in the case of Site F, did you do any additional analysis in defining your understanding of the groundwater flow system at this site?

A. Yes, we did. We used a computer model to look at the flow system at Site F.

Q. Can you indicate to the Board what specifically the model was used for?

A. The computer model studies were undertaken to provide a more detailed analysis and an understanding of the groundwater flow system that occurs between Site F and Hamilton Harbour. It was undertaken to look at hydrostratigraphy, flow paths, infiltration discharge occurances and rates, and potential contaminant migration paths. It was undertaken, because we are dealing with a large flow system that has several layers within it, and being such a long system, it would be very difficult to handle these types of calculations by hand.

Q. Can you describe for the Board generally the model that you used and, perhaps, you could refer the Board to Figure 5 at page 60 as part of this discussion.

A. On page 58 of the report, we have a brief model description. This is a steady state model, which assumes that the flow system is at equilibrium. It's two-dimensional, in that we are looking at it horizontally and vertically. It's cross-sectional, as we can see. The model that's used is called FLONETS, which was developed by the University of Waterloo. It considers, as shown on page 59, potentials and stream functions, potentials being lines of equal hydraulic head, and streamfunctions being actual lines of flow.

So, the equations for them are given there, and when we set up the type of a matrix that we are talking about here, the equations are solved at each of these nodes and compared with one another to see what the impact is of changing conditions throughout the section. The equation that is used describes a steady state, two-dimensional groundwater flow in a porus medium. With respect to this figure --

Q. This is Figure 5 you are referring to?

A. Yes. Perhaps, I will describe that in a few moments. I will just carry on with the ...

Q. All right. Before you doing that

then, can you just indicate to the Board, please, is it possible to model specifically for fractured flow?

A. First of all, I think I should point out that I am certainly not an expert in computer modelling, but we have on staff people who are familiar with the use of these models. My understanding is that, yes, you can model for fractured flow. I understand that it's a very sophisticated type of modelling that is used within the nuclear industry, where they are looking at rock, burial of our hazardous high level radio active wastes in rock vaults. I understand that they require an enormous amount of hydrogeologic data in order to define the fracture networks and to define their interconnection on how the fractures are interconnected. These types of studies take a great deal of time to do, and we felt that it really wouldn't be warranted to attempt that type of approach on sanitary landfill.

Now, there are one type of fracture model that is considered to be acceptable. It is an anisotropic porous medium model which can be used to simulate fracture flow. We use that type of a model here in some of our calibrations. Anisotropic meaning that the horizontal and vertical permeabilities of various units can vary, but we found that we achieved a better fit to the field data, which we will discuss in a bit, if we used an equivalent to porous medium model without using the anisotropic. In other words, assuming that the horizontal and vertical permeabilities were about the same.

Now, there is some justification for that, in fact, because in the cores, we can see angle fractures of that occur. We think that they may extend through the units. The tritium data indicates that it does, so therefore, using this type of a model, we feel is justifiable.

Now, before we went into developing this whole technique, we discussed this with two of the top modellers in North America, Drs. Frind and Sudicky at the University of Waterloo. Dr. Frind developed the two programs, one for the streamfunction some years back, and the other for the potential, and my understanding is that Dr. Sudicky combined those into an overall model, which you see in front of you, called FLONETS. They believe that it was not an unrealistic type of simulation to use this type of a model to look at the flow patterns at this site.

Q. If I can just summarize that, do I understand what you have done here is to take a non-fracture model, but one which takes into account a porous medium? We look for the porous medium equivalent to the system with these hydraulic model data?

A. That is correct. I should point out as well, the early stages in the development of this program, Dr. Sudicky actually did some of the initial runs to look at some of the sensitivity of the various paramters in this network, and he was involved in the program in a communicative-type manner with our modeller throughout its development.

Q. All right. Now, could you indicate to the Board, when you come to use one of these models, what it means when one speaks of "calibrating the model"?

A. In our context, it means to develop a computer output that simulates field conditions.

Q. And how was this model calibrated in this situation?

A. Well, first of all, we have field data, and we want to find a flow system now that is consistent with that data. We start by setting boundary conditions for the model and then generating this finite element grid.

Q. When you talk about boundary conditions, are you talking about the conditions you see at the boundary of the area you are looking at?

A. Yes. We simulate a condition. I will tell you what those conditions are here in a moment. FLONETS is a very interesting program. We have here a finite element grid, which is consists of 912 nodes, the nodes being the intersections of these triangles and vertical lines, and we have 1,702 elements, the elements being the triangles within these units.

To set boundary conditions here, the upper boundary level is set as being the water table as measured in the observation wells Two other boundaries are fixed. The left-hand boundary is fixed some distance north of the site, and it is fixed as being a zone of non-flow. So, in fact, groundwater then moves down a path there to the base of the section at minus 30 meters elevation below sea level, and the bottom boundary is fixed as a no-flow boundary, which means then it's an extension of that flow line. So, at this end of the model, water moves straight down and then south to the bottom toward Hamilton Harbour.

Hamilton Harbour's boundary is set by assuming that that is an equipotential line, in that the hydraulic head along that line is equal in all places. So, this was the basis for the model. Now, the beauty of FLONETS is that we can see that it would be quite a feat to develop this by hand, and what one does is to input the horizontal grid on what spacing you want along the horizontal axis, that you can see that where you have more data, where your data base is closer together, like between HC-1 and HC-2, we can put a few more nodes in to try to get a better feeling for how the model works in that area, and then we put in a vertical axis fixing the number of cells and rows within this unit, and you plug it into FLONETS, and FLONETS generates the grid. So, it will be upon this grid now that we will establish our hydrostratigraphy in order to see how well the model works.

So, we put various data into this numerical model looking for a match of the known head distribution. In other words, what we are trying to do is to put -- try to put a stratigraphy on here, that when FLONETS solves all of the equations given the inputs from the hydrostratigraphic model, that we will generate the line on the top, which is the water table line, and we will also generate the vertical gradient distribution that we measure in the deeper wells.

The final model calibration required more than 15 simulations, and it included analyzing the effects of the various boundary conditions. We looked at heterogeneity. We looked to a lesser extent at anisotropy. The resulting model that we developed represents a reasonable approximation of the field data with respect to the geology, the hydraulic conductivity, the water table, and the groundwater gradients, both vertical and horizontal.

Q. All right. Now, let me just see if I can summarize all of that for you. As I understand it, what you do then is to take the data that you know? In other words, you have known field data input factors which represent the values you are trying to confirm or learn about and continue to vary those inputs until the results of the model simulate reasonably the known data that you have established through field work?

A. Actually, if you have done your work right, it works better than that, and it did in this case. The idea, in fact, is to actually generate this type of a grid, and input the paramters you know is to have it simulate in a very short order rather than for some minor adjustments, perhaps, in permeability, but what you want the model to do is to input actual field data as close as you can determine it, and then have the model generate what you are seeing in the field.

Q. Can you indicate to the Board then -- you may wish to use Figure 6, which, Mr. Chairman, you will find at page 62 of the report -- review with the Board what you learn having employed this computer simulation. I should say, Mr. Chairman, the discussion of this part of the evidence is found generally at pages 61 to 64 of the report.

A. What we are going to see is the effects of how groundwater flows when we impose upon these grids, these little elements, the known geology, in terms of its hydraulic conductivity and distribution for the five hydrostratigraphic units that we discussed originally, and then, those data in place, we run the model to see what type of results we can get.

So, this is the best fit of the computer simulation of groundwater flow system. Along the top, we show the location of the proposed landfill site as it relates to this section. HC-1 is located near the north end of the site. If I can refer to Drawing 16, you can see it near the north property boundary of Site F. We can see then where Highway 403 comes into the picture in the vicinity of HC-8. If we can refer to Drawing 2, HC-8 is located near the Ontario Hydro corridor, which will be on the south end of the site.

Finally, we have other wells progressing downward from there, HC-14, HC-11 and HC-16, which are shown on Section B-B of Drawing 2, going all the way to

Lake Ontario called Lake Ontario as opposed to Hamilton Harbour here. On the left-hand side, we have the elevation in metres above mean sea level, and along the bottom axis, the distance in metres, being in this case, up near the 4,900 metres.

These lines that are running nearly vertically across the base of the site, in the deep regional unit, are equipotential lines, the lines of equal hydraulic hit. So, this is the solution of the potential part of that equation. The other lines with the arrows on them, which start at surface, go down into the system and come back up, and finally come out in this area south of HC-14, are the streamfunctions. In other words, this is the direction of flow along a stream line

Now, we talked before that these are at right angles to groundwater flow, and you can see that they are not at right angles to groundwater flow in these cases because of the 10 to 1 vertical distortion. Now, the computer model even takes that angle into account when it plots this relationship out. If we were to show this on actual scale, which was done in one of the interrogatories, one can see that they -- the flow lines do meet at right angles to the equipotential lines.

Between each of these sets of stream lines there is an equal amount of flow of water which is described as two cubic metres per year and per unit width. So, through each of these, there is a fixed amount of water flowing. We can see that there are downward drainings generated over most of the site right down to about Highway 403, and thereafter, we can see that the arrows now start to come up south of Highway 403.

So, I will now go back to the -- that's a brief description. I would like to come back to my notes that I have made in the report, is that regionally, the deep groundwater flows under the site to Lake Ontario. This -- or you recall, that when we set our boundary conditions, this became a flow line going down the Y-axis to the bottom of the system, and then out the X-axis to Lake Ontario.

So, this whole unit, this basal unit of the shale unit that underlies the site, carries the equivalent of one of these stream tubes that we see near the site. So, this whole section is handling as much water as one of those stream tubes. So, the amount of water that's carried in the deep section, first of all, is shown by the computer to be essentially horizontal, which is what the -- our field data indicates, and the amount of water that's moving in it is relatively small.

The second point that I would like to show here is the highly fractured shale unit. This is controlling this shallow system. You can see that the lines are converging into a fairly narrow area that underlies about half of the site. Now, this was the wedge of the highly fractured shale unit that was put into the model. You can see it's sort of zigzaggy, and that is caused by -- perhaps, it's better seen here. It's zigzaggy, and the reason for that is that the elements, the rows and columns, are sloping a bit in this direction down into the section, because the section is thinning as we approach Lake Ontario. So, to simulate this on the model, we have to zigzag that layer to make it approximately horizontal.

Now, that unit acts as a permeable underdrain to the groundwater flow system, and most of the groundwater that infiltrates over the proposed landfill site and some from beyond as well, moves horizontally through this unit, and we interpret it to discharge where the highly fractured unit outcrops somewhere south of Highway 403. You will find also there is little or no groundwater infiltration into the deeper system when you get south of that discharge area. Consequently, we compute, too, that that highly fractured shale unit exerts a major control along the groundwater flow system.

If we can consider this model with respect now to the contaminant flow, it indicates that groundwater discharge, via this highly fractured unit, will be limited to a relatively small area south of Highway 403. The number given in the report is about 62 acres, and the amount of discharge within that unit still is relatively small, would be in the range of about six gallons per minute, about 14,000 cubic metres per year.

Q. All right. Now, can we try and summarize all of that? Do you have a schematic prepared that shows generally the groundwater flow regime that you have reviewed with the Board? Mr. Chairman, this also is not in the report, so, perhaps, it ought to be exhibited as Exhibit H-40-3. Now, if my friends will just permit me, what we will see here is -- this really is H-40-2, but now added to it findings with respect to the groundwater flow regime, and Mr. Sobanski, what do we see here?

A. Maybe we can finally see what we are trying to get at with this model. The model, itself, is fairly complicated, sort of a view of the system.

This permeable unit underdrains, acts as a drain, permeable drain, to groundwater coming in from above it and some of the groundwater coming in below it.

Q. Now, to be absolutely clear, that's the highlyly permeable layer that we said earlier is pinching out about halfway up above the site?

A. That's right. This is the highly permeable layer, and this explains why we find the steep vertical groundwater gradients on the proposed landfill, itself. If this were a relatively uniform type of material, given the slope and the thinning section, one would probably expect to find springs all the way down the slope to Lake Ontario. A tight permeable system would tend to saturate, and you get a lot of surface run-off, but we have strong gradients on site, strong hydraulic gradients, and they are created by both this poorly permeable unit and the highly permeable unit that underlies it.

So, the underlying zone carries more water, tends to underdrain this unit. It has a lower head within it. It tries to get enough water through it. It does that by generating a high hydraulic hit through this overlying unit. So, this has always been a sort of a -- not a mystery, but a question on this site as to why we have them, and we feel that with this type of a system, that we can explain why we see the type of gradients that we do, and the model, of course, is used to simulate these gradients and to check, in this type of a similation, it gives us a fairly good fit.

So, what we see, is that for the system that occurs within the site boundaries and a little bit beyond, the water that is collected within -- that flows within these upper reaches of the bedrock arrive at this highly permeable unit, and then somewhere downgradient from the site, we have got shown between Highway 403 and CNR, where we have bullrush areas, that it discharges slowly to ground surface.

Now, the deeper system isn't quite correctly shown. This line should have been a little flatter, taking it right to Hamilton Harbour, but the general concept is shown. This is just a sort of a schematic for people to view, is that the deeper part of flow system moves essentially laterally down to Hamilton Harbour. So, again, most of the action, if we can call it that, in groundwater, is occurring within this piece of ground near Site F created by this tight layer and this permeable underdrain layer, which gives us strong, vertical gradients, and it acts as an underdrain to the whole -- essentially what would be all of Site F.

Q. Now, if I can summarize that then, what you have is the permeable layer which acts as an underdrain or control, collects what comes to it, and the remainder goes to depth and leads to Hamilton Harbour?

A. That's correct.

MR. LEDERER: Now, Mr. Chairman, with your permission, over the lunch hour, I am going to ask Mr. Beechinor to just take that arrow and just straighten it out so it doesn't mislead anybody who looks at the exhibit without having heard the evidence.

THE CHAIRMAN: Fine.

MR. LEDERER: Thank you, sir.

BY MR. LEDERER:

Q. All right. Now, Mr. Sobanski, with the groundwater flow system defined, did you, as you did at Site D, do any work to establish groundwater chemistry?

A. Yes, we did.

Q. Could you then review with the Board, please, the work you did and the findings determined with respect to groundwater chemistry insofar as inorganic elements are concerned? I should say, Mr.

Chairman, this evidence generally is now beginning on page 65 of the report.

A. We sampled and analyzed waters from 30 observation wells from the various strata at Site F in order to establish chemistry as it is today. The chemical results are documented in Appendix 12 of the appendix document. In order to define the chemical variation in groundwater, we again did water chemistry profiles of the major anions and cations, and these are shown in Drawings 18 and 19. We don't have overheads of those. It's handled in a manner similar to that which we discussed for Site D. We could, perhaps, look at a few of these briefly. In Drawing 18A -- these are found near the back, Mr. Chairman. They are right at the back among the drawings, way at the back of the report.

DR. KINGHAM: On H-40A.

THE WITNESS: There is a series of maps there.

MR. LEDERER: H-40A, you will find Appendix 12 to the overall results on Drawing No. 18 or 18A. Specifically, in this case, you will find a water chemistry profile.

THE WITNESS: We are looking now at the major anion profiles for HC-1-85 located near the north site. We see here figures that were set up similarly to Site D, in that we have, on the left-hand side of the graph, the depth in metres below surface of the sampling peizometer or standpipe. Then we have, across the horizontal axis, the alkalinity, the sulphate, and the choride expressed in milligrams per litre.

Here, again, we have used the logarithmic scales because of some sizeable changes that do occur in the chloride. The alkalinity is fairly constant throughout the depth, and we are dealing here now essentially with some glacial till when we get into the rock and deeper piezometer.

The sulphate concentration, we can see declines slightly as with increasing depth, while the chloride, for the first two readings, is in the 20 range. That's down to a depth of about 20 metres. We are then at the 30 metre depth range, takes us a substantial increase into about 300 milligrams per metre range.

At HC-4, which we described as being located near the southwest corner of the existing Bayview Landfill, we have a similar profile, but here the important thing to note is that chloride, where we got deeper into the rock, suddenly we are into chloride concentration of 10,000 milligrams per litre.

HC-5-85, located down toward the southwest corner of the property, has decreasing alkalinity with depth. The sulphates are quite high, at over a thousand milligrams per litre throughout the entire section, and we can see, again, the rapid increase of chloride with depth in the order of 10,000.

HC-8, located not too far away, a bit to the southeast of HC-5, has high chloride concentrations throughout its depth, being something in the order of about 20,000, a depth of about 30 metres.

Q. All right. Now, Mr. Sobanski, I am not sure that there is a value in going through each of these tables. Before we look at the overall results, could you just review with the Board, did you also undertake, for Site D, as you did at site -- sorry, for Site F, as you did for Site D, a Piper trilinear drawing?

A. Yes, we did.

Q. All right.

A. The Piper plots are shown on Drawing 17?

Q. All right, and did you also examine the chloride concentration distribution?

A. Yes, we did. To look at the chloride concentration distribution with depth, we prepared

Drawing 21.

Q. All right. Now, am I right that what this is doing is examining the existing water quality?

A. Yes, that's correct.

Q. Now, could you, perhaps, by reference to Table 9, review with the Board the results of this work. Mr. Chairman, Table 9 is found on page 67 of the report.

A. These chemcial facies or types are developed from the Piper trilinear plots. On the left-hand side, we have the drilling site, which goes from HC-1-85, which is on the north end of the property, down to HC-14-85, which is located down near Hamilton Harbour. We are following now Section A-A on Drawing 2.

In the upper reaches of the study area, we have a magnesium sulfate water, and it's evident from the facies table that this rapidly progresses into a more mature water, a sodium chloride water, as one reaches the southern end of the property at about HC-8. From there, the groundwater essentially stays as a sodium chloride-type of water until it reaches Hamilton Harbour.

Q. Now, could you indicate to the Board, please, what all of this tells you about the existing water quality at Site F, and Mr. Chairman, it will assist the Board, I think, to refer at this point to Roman Numeral page xi, which is part of the Executive Summary at the front of the report.

A. We concluded that there is a dramatic deterioration of groundwater quality with increasing depth in the shale. The natural quality of the groundwater over much of the area is poor, and it doesn't satisfy the Ministry of the Environment drinking water objectives.

I think one figure that is of interest is Drawing No. 21. This is called a "Chloride Concentration Contour Map". On this map, we trace, again, from Falcon Creek on the north to Hamilton Harbour on the south, the various well instrumentation that we install. Here, beside each piezometer or standpipe, we have plotted the chloride value that we determine through chemical analysis. We then contoured those values to see the type of chloride distribution that we get with depth.

What we generally find is, on surface, for a very shallow depth, down to about the top of the weathered bedrock, there is a shallow rind of fresh water flowing on a sea of briney water. The maximum types of values that we measure at the depth of 30 metres run at 24,000 at HC-8.

Q. Now, just to be clear about what we mean by a rind, again if my friends will permit me to lead on this, we have heavy chloride or salted heavy waters which are met by the rain water coming down, which is a fresh water. Am I right that the fresh water is lighter and, therefore, floats on top of the water coming up from below?

A. Yes. There are two effects in place here. That is one.

Q. Thank you.

A. The second is that the stratigraphy, this clay till that occurs in the area, also serves to protect that upper unit from these very strong concentrations at depth. In other words, we have talked about the clayey till cap with the overlying sands that occur downgrading or south of the proposed landfill site. So, because of the limited discharge potential upward through that -- we are now referring to Drawing 6 -- we have two factors; one is fresh water falls and fights the high chlorides. It's similar to a salt water encroachment. A problem that you get in the island or around seashores where you have a bubble of fresh water sitting on sea water.

So, we have that as one factor, the fresh water falling, and the second factor is, that while there is this tendency for the groundwater to want to discharge, the clay till helps protect this upper unit from major contamination. You can see, in fact, if you look at Drawing 6, that where the till seems to be absent in our borehole HC-12, there is a significant decrease in the groundwater quality in its portability actually, whereas at HC-9, we have a -- in the till chloride concentration of about 126, which isn't too bad given that drinking water is 250, when we get down to Indian Creek at HC-12, that chloride concentration is 1,700 in the same shallow zone. So, we can see that the till, for some protection, helps to keep this poor quality water at depth.

DR. KINGHAM: Can you be any more explicit in your statement, "There is dramatic deterioration of groundwater quality with increasing depth in the shale"? Is that referring to inorganic components only at this stage?

THE WITNESS: We are just talking about the chlorides, yes.

MR. LEDERER: Just bear with us for a moment.

DR. KINGHAM: You will get to the rest.

THE WITNESS: We go, Dr. Kingham, from

concentrations of around 50 to nearly 20,000, and these types of values, in the ten to twenty thousand range, are representative of the concentrations that occur within that highly fractured shale unit that is underdraining the site. They run in the range of ten to twenty thousand.

BY MR. LEDERER:

Q. You just said this a few moments ago, but to put it into context, what is the Ministry of Environment drinking water standard?

A. Two hundred and fifty.

Q. All right. Now, picking up Dr. Kingham's point, did you look at any analysis of organic chemistry in these waters?

A. Yes, we did. We used work that had been done by Gartner Lee that has been used in connection with their plume delineation study on the adjacent Burlington site, and their preliminary results indicated that there was no off-site migration of priority pollutant organics.

Q. Now, in your study, you have referred to which of their studies? What year was that study done?

A. That was done in the 1985, and we

were in touch with them throughout their monitoring of the subsequent work for '86 as well. In the '85 monitoring report, they indicated that leachate attenuation and dilution they say, "appeared to renovate leachate quality sufficiently that it is indistinguishable from background water quality in the shale." They concluded that, "It is unlikely that the leachate plume will ever cause any significant off-site impact on groundwater." Now, that was in their 1985 monitoring report.

Q. All right. Now, subsequent your report being prepared, Exhibit H-40, has the 1986 work of Gartner Lee, with respect to the existing Burlington site, been released?

A. Yes, it has.

Q. All right. Have you reviewed that?

A. Yes, I have.

Q. Can you indicate to the Board the conclusions which Gartner Lee came to with respect to organic chemistry in their 1986 monitoring report?

A. I refer to two pages in Gartner Lee's report. The first being on page 1, where they deal with Conclusions. The first conclusion deals with impact, and it's conclusion (i). It states that,

"The impact of the leachate plume on

ground waters to the south of the landfill appears to be negligible. There is some evidence that leachate may have moved 25 metres or more southward, but the plume does not appear to have moved as far as the North Service Road. Any leachate which bypasses the toe draining collection system and enters the groundwater flow system into shale bedrock appears to be significantly diluted and attenuated. No concentrated leachate was found in any of the plume delineation groundwater monitors."

Now, with respect to that conclusion, there is another statement that I would like to refer to on page 41 of their report. This is Section 7.3, and it's entitled "Impact of Leachate Plume On Local Water Resources." Now, the well that they are going to be talking about is located -- well nest rather, is located 25 metres downgradient from waste, and it is identified as Well 24, which is located approximately in the middle of the property about --

MS. TANNER: Could you catch us up to -- we are a bit lost here.

MR. LEDERER: I beg your pardon?

MS. TANNER: What page are we on?

MR. LEDERER: You don't have this report. What Mr. Sobanski is doing is reading to you from Gartner Lee's 1986 monitoring study. This was a study that -- 1986 plume delineation study, excuse me, which was published since Exhibit H-40 was prepared, but is in effect part of a continuing program which is referred to -- 1985 study, which I think is referred to on page 68. There is continuing work being done with respect to that site. We can get -- I believe that all the parties have copies of this report. I can certainly get them.

MR. GARROD: Not me.

MR. LEDERER: Pardon me? They are not hard to get hold of, but if the Board wants to see them, we certainly can get them. It's not difficult.

THE WITNESS: What we are looking at here --

MR. LEDERER: Now, just a second. All that Mr. Sobanski has done is to update what is in his report, as, presumably, we would all expect him to do. All right. Go ahead, Mr. Sobanski.

THE WITNESS: I think the update may be leaving a little bit of a confusion as well. What we are looking at is a landfill site, existing landfill site, of the City of Burlington, and what impact it has had on groundwater quality as a result of disposal operations that commenced in 1972. So, Gartner Lee has installed a series of wells downgrading from the site to see what the impact on groundwater is.

Now, this portion of the Burlington Landfill site is equipped -- this is the new portion -- is equipped only with a toe drain. The waste lies directly on top of the bedrock throughout most of that area as far as we know, so that it was excavated to the shale and, perhaps, even into the shale and then disposal was done on the shale. Similar to the type of operation we are talking to for Site F, the difference being that here we are using a simple toe drain, which is a drain to capture leachate, just installed at the toe of the waste, where the waste meets the land as opposed to toe drains and a total underdrain system that are being proposed for Site F.

So, what these people are doing then is saying, well, what has happened to 25 metres from that fill since 1972? So, we are looking at about a 15-year period since disposal commenced at a distance of 25 metres from the site.

Now, when they discuss this particular well -- first of all, they talked about the possibility of some contaminants, and they are referring to the upper well in that unit. When they talk now about the lower three wells, this is the next little excerpt I would like to read in.

BY MR. LEDERER:

Q. Before we do that, is it clear now what we are talking about?

A. So, we are looking at the performance of a site here that is 16 years old without -- it has a toe drain system, but it's not a fully underdrained leachate collection system, and it also rests directly on the rock, as will Site F. So, we are looking at impacts over a considerable period of time.

It says here, in the first paragraph,

> The third objective of the study was to assess the significance of the existing plume impact on local groundwater and surface water resources. Based on the water chemistry in monitors 24-i, 24-ii and 24-iii --"

with the i, ii and iii being in roman numerals,

> "-- located 25 metres downgradient from the landfill, it appears that the

leachate plume moving southward from the landfill will have negligible impact on local groundwater and surface water."

They do detect, from time to time, some traces of what may be contaminants, but what they found was, that as they purged the wells more and developed them more, then in many cases the values fell away down toward background levels.

MR. LEDERER: Now, Mr. Chairman, I should just say that Mr. Estrin has asked whether I will file the report, and as I have indicated, I have no objection, but what I would like to know is who doesn't have a copy so I can buy them from Gartner Lee. I don't want to especially buy ones that we don't need. So, I will certainly get three for the Board, and if anybody else --

THE CHAIRMAN: One will be sufficient for the Board.

MR. LEDERER: Fine. Well, if anybody else who hasn't gotten one wants to advise me over the lunch break, we will take care of that. Now, I am sorry, this has gotten so interrupted. Does the Board understand what that report is, and generally the conclusions that are drawn?

THE CHAIRMAN: Yes.

MR. LEDERER: Thank you.

BY MR. LEDERER:

Q. Now, Mr. Sobanski, quite apart from Gartner Lee's work and referring back to page 68 of your study, did you refer to any other studies with respect to an examination of organic chemistry in this groundwater?

A. Yes, we did. Mr. Beechinor indicated that we installed a nest of stainless steel observation wells at Location HC-15 located downgradient across Highway 403. These serve as a supplement for the some of the information that Gartner Lee was collecting on their site, but a greater distance from the landfill. The wells are located at depths of 6, 12 and 28 metres. We found no detectable concentrations of priority organic compounds in any of those wells. The results are given in Appendix 12.

Now, according to investigations by the University of Waterloo in the mid-'80s, some 1, 1, 1-trichloroethane was found at Morrison Beatty 18, MB-18, located south of Highway 403, a distance of maybe 350 metres or so from the site.

Q. Mr. Sobanski, just so we can identify the routes, is this what is referred to by J. P.

Hewetson, 1985?

A. Yes, it is, and I will correct the distance. According to the report, it's 875 metres south of the Bayview Landfill site. It's 900 metres south of the Bayview Landfill site. Now, that indicated to them that there was evidence of groundwater contamination related to landfilling at Bayview, which commenced over 30 years ago or about 30 years ago.

I should note that the -- we note in our report that the concentrations of that organic were found only in the parts per trillion range. These are very low values. They weren't replicated to my knowledge, so consequently, their significance is not totally known. We installed a nest of wells near theirs. That's HC-9. We conducted organic analyses on those into the parts per billion range, not parts per trillion, and we found no traces of priority organic pollutants in the parts per billion range.

Q. All right. Now, why did you do parts per billion when the unit discovered or apparently identified as in the range of parts per trillion?

A. We can't get -- when we use commercial labs in Ontario, we are unable to get detection limits into the parts per trillion range.

They normally would have to be sent to someplace in the United States or to the Ministry's lab which has, according to Gartner Lee's report, about a 10-month backup of samples. So, we work with the commercial labs in the parts per billion range.

Q. What is the unit for the Ministry of Environment standards in this area?

A. The Ministry hasn't set a great deal of standards for the organics, but many that are available are in the parts per billion range. There are some that go into parts per trillion for some various offices.

Q. And just to be clear, did you find anything at a parts per billion range?

A. No, we did not. The results, I should point out, are shown in Appendix 12 of the second volume.

Q. All right. Now, can we turn to page 69 of your report, and with this data in hand, data collected with respect to the existing sites, are you able, please, to review with the Board your conclusions with respect to organic chemistry in this groundwater?

A. Could you repeat that question, please?

Q. What's your conclusions with respect

to organic chemistry?

A. We didn't detect any, but if the low values found at Morrison Beatty 18 are real -- and that is, that we have got one or two parts per trillion of something in the water -- it would still be consistent with the model that we -- the mathematical model that we have developed. The types of transit times that we are talking with our model, as we will get into shortly, is in the order of about 30 years. So, we don't know the results of that work exactly. The parts per trillion range, it could come off the pipe, it could come from glues, the wells weren't constructed in any special way to look for trace organics. There were possiblities of other contaminants, and when we deal with parts per trillion, the value in the right and wrong place can give you a problem. So, our evidence is, that if there is any contamination, it isn't severe, No. 1. No. 2, if there is slightly some related to the landfill, it would still be consistent with the model as being the ultra site.

Q. All right. Now, can we move away from your analysis of the quality of the groundwater and look at chemical works you may have done to help you with hydraulic conductivity. As with Site D, did you undertake any tritium analysis for Site F?

A. Yes, we did.

Q. All right. Could you indicate to the Board, please, what you found, first of all, in the overburden? Well, perhaps, you could do overburden and bedrock together and review this in the context of the drawings that are in the report?

A. Yes. Again, we are looking for pre and post 1952 waters.

Q. Just before we go any further, where do you find this in the report?

A. This is Drawing 20 near the back of the report, behind the major anion and cation graphs that we saw.

Q. Now, to make absolutely clear, although we have been over this a couple of times before, could you indicate to the Board why, in this case, you did this kind of analysis?

A. Again, we are looking for a pre and post 1952 waters. We are using it to give us some idea of whether or not the tritium results reflect the hydrostratigraphy of the site, the gradients, etcetera, is there any indication within this information as to whether there are interconnections through the rock and the like. Do these drawings, in other words, make sense?

In the overburden, I should -- the overburden in HC-5-85 occurs in depth of about eight metres. In HC-8-85, it occurs at a depth of about 5.7 metres. In the overburden, the tritium value ranged considerably. At HC-8-85, we have both .03 tritium units, which is less than our 2.3 marker that we are using for this study to indicate pre and post 1952 water.

At HC-5, it was considerably higher, varying from -- well, being a maximum of 36.6 tritium units. One can see at the overburden bedrock contact here as well, which may also represent -- are partially representative of the overburden, 25, roughly 25 tritium units in HC-5-85. If we look at that information then and use our 2.3 as a marker, it would indicate that at HC-8 tritium, post 1952 tritium, does not penetrate into a depth of even three metres, while in HC-5-85, we can see that the tritium has penetrated to the overburden bedrock contact as a minimum at a depth of about 8 metres. In the report, we said that this difference is likely due to a spacial variablility in the hydraulic conductivity or desiccation in the upper clayey till.

Now, if we look at the bedrock, at HC-8, we find the same situation as we did with the overburden. The tritium values, all the way down to a depth of about 30 metres, are quite low, varying from .2 to .17 tritium units, or we could say it's about .2 tritium units from 10 metres to 30 metres. If we look at HC-5, however, we see that we have post-tritium water, post-52 tritium water, to a depth of about 18 metres at 9.0 tritium units, and at 30 metres, we have 4.57 tritium units at a depth of 30 metres. So, what we are looking at then, in one case, is pre-1952 waters throughout the profile at HC-8, then we are looking at post-1952 waters all the way through the section at HC-5-85.

We concluded that fractures, possibly the fractures in the shale, to these depths are hydraulically connected to surface. Now, I have taken a more detailed look at it again to see if there was any other possible interpretation to this information as we did with Site D. Interestingly, at HC-8-85, there is an upward hydraulic gradient from the piezometer at 10 metres to the piezometer at about three metres.

So, in other words, there is a potential for upward flow from the rock into the overburden. This would effectively prevent the penetration of tritium from precipitation because, in fact, we are dealing with a discharge creating into a very shallow zone at this well.

If I look at HC-5 of 85, this is one of these wells that has a strong hydraulic gradient downward from the overburden down into the deepest zones at 30 metres. I took the values, thicknesses at this site, for various units of overburden, and our interpretation of where the massive shale was, or the highly fractured shale was, and also where we get into the regional type of flow system, and I must admit, we applied some values that weren't used in the report. I applied a .1 porosity, effective porosity, throughout the entire section, because the whole section, in this particular site, has a relatively low permeability.

Now, if I applied a very low hydraulic conductivity, then undoubtedly I can move water through the section very quickly, or rather, a low effective porosity. The velocities would be very high. So, what I did, was I used .1 through each of these units and the actual measured permeability in each of these piezometers, and I found that it would take about 24 years to move the groundwater from surface to a depth of about a hundred metres.

Now, if I were to use the model values of porosity and permeability, that value would change to about 44 years.

Q. Can I just interrupt you? Did you say a hundred metres?

A. Sorry a hundred feet, a hundred feet. So, if I were to use the actual values that we have used in the models -- I shouldn't say actual. These are the average values that went into numerical model -- it would take around 44 years to move tritium from surface down to a depth of 30 metres. So, given that we have about a 33-year period at the time of this report, since the highly tritiated water fell, it really isn't surprising, that under the given gradients and under the hydraulic conditions that we have measured, that we would find tritiated water at a depth of 30 metres. They sort of fall together, and we get the right order of magnitude in terms of number of years of transit time.

So then, just to come back to that, just briefly again, I feel that in HC-8-85, we don't have tritium at depth at this location, because we have an upward gradient from the 10 metre piezometer that prevents downward flow. At HC-5-85, I feel that the information that we have there, in terms of hydraulic gradients, hydraulic conductivity, and estimates of the effective porosity, would lead us to conclude that tritiated water, falling on ground surface here, could have reached a depth and obviously reached a depth of 30 metres in the period of time since 1952.

Q. Does this help you at all with respect to the hydrogeologic interpretations that you made with respect to this site?

A. It helps us to the extent, yes, that we feel that it gives us an indication that the model which we were discussing was in terms of the time factors involved in moving contaminants at the site are fairly consistent with what we are seeing in HC-5-85.

MR. LEDERER: Thank you. Mr. Chairman, it's fairly close to one o'clock. If you would like to break for lunch now, we could do that, or else we could also go through the water balance. It should be quite quick, and leave us to get into contaminant migration, which is obviously the key issue, immediately after lunch.

THE CHAIRMAN: Proceed.

BY MR. LEDERER:

Q. Now, Mr. Sobanski, as with Site D, we have looked at the flow systems and we have looked at groundwater chemistry. Did you do, for Site F, a water balance as you did for Site D?

A. Yes, we did.

Q. Could you take us through that calculation, please?

A. The water balance is shown on page 73 to 75 of the report, page 48. Without belaboring the point again, precipitation is broken into its various components. From Environment Canada, we get a couple of components, which is the precipitation and the evapotranspiration, and then we have the last factor to deal with, which breaks down into run-off and groundwater recharge.

So, from Environment Canada, we obtained a value of precipitation of 869 millimeters per year based on the 10-year average found in Appendix 6. Of that, they calculate that 511 millimeters is returned to the air or atmosphere by evaporation and evapotranspiration. We have ignored again the change in storage, because we are using long-term data. So, with that information, we arrive, by subtracting the two, of having 358 millimeters per year of groundwater recharge and surface run-off to take into account.

If we could refer to Figure 7, and I would like to start here by making an apology, in that we have detected an arithmetic error in this calculation, and we have corrected it and would like to provide everyone with a corrected copy of this portion of the water balance. There is a sticky strip on there that one can take off and, perhaps, apply halfway and stick it into the report.

Q. Mr. Chairman, it may be helpful if everybody could put this in their report, as Mr. Sobanski has said, but nonetheless, it is coming in as a separate document. It may be wise to exhibit it separately. Would it make sense to do it as H-40-4?

A. The title of this drawing has changed slightly. We have added a little proviso on the side. It's Figure 7, Schematic of Water Balance, Revised Figure 7, June 15, 1987, Site F, Hydrogeological Report, Volume 1. We handle this calculation in the same manner that we did at Site D. Here we calculate the groundwater recharge flux based on the five major hydrostratigraphic units by applying Darcy's Law, Q = KiA.

Now, while there has been an arithmetic error in this calculation, it doesn't affect the overall results, because ultimately, we use the value of infiltration that was generated by the mathematical model, which gives us a more rigorous calculation of the infiltration rate. So, we are doing it this way, but, in fact, these values that you see here are not used in the final calculations of contaminant migration at this site, nor does the arithmetic error change the estimated recharge rate here, which is 22.5 millimeters per year.

Using this technique, applying areas and gradients and hydraulic conductivities, both vertically and horizontally, we come up with a calculated recharge rate into all of the flow systems of 22.5 millimetres per year. Now, the recharge rate that is calculated by the computer model is 13.7 millimetres per year. So, therefore, since the computer model is more rigorous, we have used the value given by the computer model as opposed to this schematic where there is a hand calculation.

Q. Can you just indicate to the Board what you mean by more rigorous? What is it about the use of the computer here that makes the results more reliable?

A. Well, the computer takes into account better the inter-relationships between these various zones, and we think it gives us a better value. The final water balance for the site then is given on page 74. That is that precipitation is 869 millimetres per year, evapotranspiration 511 millimetres per year, the surface run-off 344 millimeter per year, and the groundwater recharge about 14 millimetres per year, which is relatively low, about half an inch per year.

MR. LEDERER: Now, Mr. Chairman, with respect, I think this would be the appropriate time to adjourn for lunch.

THE CHAIRMAN: Two-thirty.

DR. KINGHAM: I just want to make sure -- maybe, Mr. Sobanski, can confirm, that on that figure that you have given us, the new one, where you show in zone -- in the second zone, the QH has now gone up to .135, where it used to be --

THE WITNESS: Nothing.

DR. KINGHAM: 10 -5. So, that's the big one in there?

THE WITNESS: Yes, and it should have been obvious in the review.

DR. KINGHAM: That's not another mathematical ...

THE WITNESS: This is the corrected one. The error was made in this general area and carried all the way through the whole system.

--- NOON RECESS

--- UPON RESUMING AT 2:30 P.M.

MR. LEDERER: Mr. Chairman, we are still without Mr. Tidball, and I am prepared to progress on the basis that his interest is a little bit different, but I think -- I admit that I don't want to be the one to make the decision.

THE CHAIRMAN: Well, let's give him another minute and see what happens.

MR. LEDERER: Thank you, sir. Mr. Chairman, you will recall, that as we broke for lunch, we had reviewed the geology, the hydrostratigraphy, which is based on the geology. We had looked at the groundwater flow regime, which is, in fact, based on the hydrostratigraphy, and we had looked at the quality of water as shown by the groundwater chemistry, both with respect to organics and what we have been able to learn here as a result of the presence of these earlier sites. Sorry, for inorganics, and what we have been able to learn with respect to the pre-existing sites with respect to organics, that again we have used tritium analysis to see what we can learn about our own conclusions with respect to hydraulic conductivity, looked at the water balance, and as you recall from Site F, we are now ready to look at the actual migration of contaminants as we build from the evidence you have already heard.

I should say to the Board, there was some concern expressed, just for those of us who are here for the Region, that the evidence with respect to the findings in relation to organics may not have been as clearly understood or as clearly understandable as we would have hoped, and I am hoping that the Board has followed that evidence and the basic findings.

THE CHAIRMAN: Fine.

BY MR. LEDERER:

Q. All right, Mr. Sobanski, did you, as with Site D, do any work to assess the mechanisms for contaminant migration at Site F?

A. Yes, we did.

Q. Could you review with the Board, please, the results of that work? What mechanisms are we looking at here?

A. Again, in terms of transport mechanisms, we are looking at advection, diffusion and aspersion, and counteracting these movement mechanisms, we are looking at absorption again, and I point out that this is -- again, it's a fairly conservative look at it, at the absorption part, the attenuating mechanisms, because there are many other attenuating mechanisms that play in the landfill.

As we handled Site D, I would like to go into the advection part again, and this is the contaminant transport controlled by linear groundwater velocity, and here we have a table, which is similar to that shown for D. This is Table 12, page 97 of Report H-40 at Site F.

Across the top, we have the hydrstratigraphic unit, the direction of groundwater flow. It's called groundwater flow, the hydraulic conductivity, the hydraulic gradient, the effective porosity, and finally, the linear groundwater velocity, expressed both in centimeters per second and metres per year.

Now, again, the linear groundwater velocities are calculated from the product of hydraulic conductivity times the hydraulic gradient divided by the effective porosity. So, these two columns arise from the preceding three. The first hydrostratigraphic unit is the upper weathered and slightly fractured shale or fractured shale. Our movement would be downward from the landfill into lower zones. The hydraulic conductivity of that unit was 1 x 10 -5 cm/s. The average hydraulic gradient is .08, and the effective porosity, we have applied a fractured medium porosity of .001. This gives us a linear groundwater velocity of 250 metres per year, a high velocity.

In the weakly fractured shale, again the movement would be downward from the landfill. The hydraulic gradient we discussed before, it's assumed to be about 10 -7, an average that has been derived from the range of about 10 -4 to 10 -10. The hydraulic gradient of that unit is about one. In other words, it's totally underdrained by the highly fractured shale unit. The effective porosity we discussed, that I applied a near matrix porosity value to this zone of about .1. Our linear groundwater velocity is know fairly low at .3 metres per year.

In the highly fractured shale, we are now going to move any leachate that may arrive in this unit laterally toward the south and across Highway 403. The hydraulic conductivity is 1 x 10 -2 centimetres per second. The hydraulic gradient is about .01, and the effective porosity is .01. This is an assumed value that we also discussed before. The linear groundwater velocity is extremely high at 3.15 kilometres a year, 3,150 metres per year.

Now, we next consider the discharge zone till, which is -- we are now looking at the area where the model indicates that there will be an upward gradient and discharge to service, so the --

Q. Perhaps, we could just take out one of those schematic exhibits and just show the Board what you mean by the discharge till. H-40-2 or H-40-3.

A. On Exhibit H-40-3, the movement that we are looking at for contaminant migration is downward through the weathered material, the weathered shale, then through the massive unit, massive shale unit, then into the highly fractured zone, and the lateral movement off-site towards the south, and finally, we call the discharge zone till, is discharged up through this unit back to ground surface. So this is the discharge zone till.

So, for the weathered unit, we consider downward movement. For the weakly fractured unit, we consider downward movement. For the highly fractured unit, it's lateral movement, because we saw from the model that it's taking all of the flow or most of the flow, and finally, the contaminants would move laterally and discharge through the surficial till. So, now we have, at this point, an upward movement of groundwater in the discharge zone.

So, when we look at the discharge zone till on Table 12, we now see upward groundwater movement to the ground surface. The average hydraulic conductivity of the till and sand combined is about 3 x 10 -6, the hydraulic gradient about .08, the effective porosity 25 percent, indicative of a granular medium, and finally, linear groundwater velocity, under those conditions, those hydraulic conditions, is about 4.3 metres per year.

The next factor we considered was diffusion. Again, this is movement that results from concentration gradients. We do not feel that diffusion will be a significant mechanism in contaminant transport at this site. However, the diffusion of a contaminant from the fractures and into the surrounding rock may generate some attenuation of contaminants as they migrate through the fractures. So consequently, we did apply an effective diffusion to coefficient to the shale at the site, and this has been measured in the laboratory by Dr. Cherry to be 5 x 10 -7 centimetres square per second.

Dispersion is the next transport mechanism, and this results as a -- it's a spreading due to heterogeneities in the geologic materials.

Q. Just to remind the Board, dispersion, I think we said last week, increases with distance, because it's simply the natural effect of the spreading of this stream into the surrounding material?

A. That's correct. It follows the small intricacies of the rock that are branched in various directions and tends to spread out, and the front tends to get more diffuse the further that you move from the site.

In our studies, we have used the longitudinal dispersivity, and the values that we used were the same as we used for Site D, and that was five percent for the clayey till, 10 percent for the weakly fractured massive shale, and 30 percent for the weathered and more highly fractured shale units, and before we finally get to the Ogata-Banks equation, which we have used in both cases, we have to deal with absorption.

Absorption is, again, the mechanism whereby contaminants are bound to the soil particles.

Q. Now, last week when you discussed absorption, first of all with respect to inorganics, you indicated to the Board that there were two values that indicated the ability of the soil to absorb inorganics. So, would you just remind the Board of how you do that?

A. Yes. These are the cation exchange capacity, the ability of a medium to exchange cations, absorb them, and the other is the pH of groundwater affects contaminant migration, in which case we look at the carbonate content of the soils again to see whether they are able to neutralize the acidic solutions that are formed when leachate is generated.

Q. Could you review with the Board your findings with respect to the cation exchange capacity and the pH level of these soils and your conclusions as to the ability of these soils to absorb inorganics?

A. This is from Appendix 3 in the second volume of the report. It appears with the other soil analyses. In the upper graph, we have the cation exchange capacity of the shale unit, and at the bottom, we look at the carbonate mineral content of the shale unit as well. The hydrostratigraphic unit is shale in both cases.

We tested for the cation exchange capacity, two samples, one from HC-2-85, and other from HC-10-85. The sample depth is next given. The cation exchange capacity in milliequivalents per hundred grams is about 65 milliequivalents per hundred grams, which is a relatively high value indicating that the shale has -- shale bedrock has a high cation exchange capacity. So, these reflect a significant potential for the shale to absorb inorganic groundwater contaminants.

The next values that are shown on the figure, again we have taken two samples, but this time from the same well, and we have done a carbonate mineral analysis on the rocks. Both are from HC-4-85, both from shale at varying depths within the shale. The bottom line on this is that the calcite and dolomite content, is in the order -- on the average of about 25 percent. It's based on the two values which range from about 17 to 33 percent. Again, that we feel that this represents a large neutralization capacity, and that the carbonate within the shale, which would be used for cover material, will maintain the pH of the ground waters at levels that will encourage the metals to be absorbed on particles, on soil particles.

Q. I might just says, Mr. Chairman, this figure that Mr. Sobanski has been referring to is found as the third last page of Appendix 3, which is part of Exhibit H-40A. H-40 is the reports, H-40A are the appendices. All right now, can you just conclude for us then what these values, first of all, for cation exchange capacity, and secondly, for pH, tell us about the capacity of these soils to absorb inorganic materials?

A. The soils are very good. Shale rock, itself, has a high cation exchange capacity and a relatively large concentration of carbonate minerals within it, which would help to adjust the pH of leachates that are formed.

Q. All right. Can we now look at the ability of these soils to absorb organic material, and would you review with the Board the element that indicates the propensity of the soils to absorb those materials?

A. If I could have -- as in Site D, the absorption of organic contaminants will be controlled by the total organic carbon of the soil, the foc, fractured organic carbon. We have looked at the organic carbon content at various wells at the site and at varying depth get some idea of what sort of organic carbon contents we are dealing with. So, the hydrostratigraphic unit is the shale.

You can see the variety of sample wells that we used, HC-8, HC-4 -- HC-3, HC-4, HC-7, HC-8, 10 and 12 from various depths, and we find that the organic carbon content varied from .1 to .64 percent by weight with a mean value of about .18, about .2 percent by weight. This indicates that there is organic carbon within the shale materials that would assist in attenuating organic contaminants that may migrate through them.

Q. Well, what does that mean? Does organic absorb or not?

A. Well, we believe they will.

Q. Would you compare that value to what you found at Site D for this mechanism?

A. Site D was about .38 on the average, I believe. I have a little note here that says that. So, it's somewhat less than Site D, but there is still organic carbon available within the soils.

Q. All right. I should say, Mr. Chairman, that this figure is the second last page of Appendix 3, which again is found at Exhibit H-40A.

Now, Mr. Sobanski, with the mechanisms identified, did you apply the Ogata-Banks equation to Site F?

A. Yes, we did. The Ogata-Banks equation in the report, page 40, is shown on page 101, and if we can go through the exercise that we did yesterday of correcting a couple of these letters. Now, the first correction is we see a bracket after the complimentary arrow function, erfc, in your books. Scratch that and move it between the one-half and the arrow function. So, right now, in the report, this bracket is shown here. If we could just move it to there. That's --

DR. KINGHAM: That's the square bracket?

THE WITNESS: That's the big square bracket, yes. This isn't from the book. This is from another report we have. Then in the equation 8, the little "r" becomes a small "n" as we change to the other report. That's the
D* = r. De over big R is now little "n", De over R, and finally Vc is equal to big V, divided by R, and scratch the K.

Q. All right. Now, Mr. Sobanski, can we turn to Figure 11, and can you review with the Board, please, the contaminant pathway that you applied the Ogata-Banks equation to with respect to Site F?

A. We developed individual calculations using the Ogata-Banks equation for four individual components of the groundwater flow system, and on page 101, it says six, and that's -- I think that carried over from the Site D. Report. That should read four on the bottom of page 101.

MR. ESTRIN: Sorry?

THE WITNESS: Page 101.

DR. KINGHAM: Last paragraph, first line.

MS. TANNER: What is it supposed to read?

THE WITNESS: It should read four.

MS. TANNER: Instead of six?

THE WITNESS: Six, yes. In fact, the figure that we are showing, the schematic that we show here, has five, and we will exclude one of those at the moment, having not really looked at it. It's shown also on the big blowup, so whichever one is easier to read. There will be lateral migration through the weathered shale from the landfill. However, we have not considered this flow path, because we are equipped with an underdrain system here and with perimeter tiles. So, we are not going to consider this migration through the weathered shale at this site.

BY MR. LEDERER:

Q. Just before we leave that, where is that going to discharge?

A. These will discharge to a sanitary sewer, and it will be picked up and discharged to a sanitary sewer.

Q. Can you say where they discharge in the absence of any collection system?

A. In the absence of any collection system, it will be on site, right at the toe of the waste.

Q. Thank you. All right, give us the pathway then.

A. The pathways that we modelled now are the remaining pathways on the diagram. First, downward migration through weathered shale, then migration from that point downward through the weakly fractured shale, lateral migration through the highly fractured shale, and finally, upward migration through the discharge zone till. So, as we did for Site D, we are going to make individual calculations for each of these flow paths, assuming the contaminants have just arrived at any one of the four.

So again, the weathered shale, we consider a little calculation on how long it takes and what the concentration strengths are as we move through that unit. When this unit starts to see some contamination, we start a new calculation all by itself, and then we do that for all four units, and ultimately will end up summing them together to give us a total picture of contaminant migration between the landfill and the discharge zone till at surface.

Q. All right. Now, in looking at these units or pathways, could you indicate for the Board, please, what contaminants you modelled for them? What contaminants you considered in your equation?

A. For the weakly fractured massive unit and for the discharge zone till, so these components of the model, the first component -- sorry, the second component and the fourth component of the calculation, we considered migration of a non-absorbed conservative contaminant, such as chloride, which will move at the same velocity as groundwater. We considered again a weakly absorbed contaminant, such as the methyl ethyl ketone that we discussed previously for Site D, and finally, we looked at moderately absorbed contaminants, such as xylene or trichloroethylene to see how they would behave going through the weakly fractured shale and through the discharge zone till.

Q. What about the other two units, the weathered shale and the highly fractured shale?

A. We saw previously that the groundwater velocities through both of these units are relatively high, varying from some 300 metres a year, I believe, to -- check the number of -- in the weathered shale, 250 metres per year, and in the highly fractured shale, 3,000 metres per year, 3,150 metres per year. So, we considered here, that through these two portions of the flow system, for calculation purposes at least, that we would consider only the migration of the chlorides.

Q. All right. Now, can you review with the Board, please, the results of these applications of the Ogata-Banks equation, and Mr. Chairman, I should indicate for the Board that the discussion of these results was found generally at page 105 to 111 of the report, and I believe Mr. Sobanski will be referring to a series of figures as he did in the discussion of the Site D results.

A. One other point that I wanted to make before we get onto this, Mr. Lederer, is that I just want to clear up this business of the modelling only for chlorides. We felt that, because of the high groundwater velocities, it would be best to be conservative, not to assume that there would be any absorption in the route at all, and I think that -- that's a very conservative assumption, because from data being derived from the other sites, it would appear that there are contaminant mechanisms -- contaminant attenuation mechanisms actually working at the site, but from the point of view of this calculation, we are only going to talk about chlorides for these two zones when we do the models.

Now, first of all, if we can refer to Figure 12 in the report, which occurs on page 106, we are looking at migration downward through the weathered shale. The graphs are set up in the same manner that they were for Site D. This is the uncoupled calculation, where we have a constant contaminant input. Our value Co then, which is the concentration within the landfill, will be reached at sometime in the future, because we are not considering a declining input yet. The downward groundwater velocity is 8 x 10 -4 cm/s, the thickness of the weathered shale unit averages about 20 metres, and dispersivity is six metres.

Looking at the figure, itself, in the past, we saw figures that gave us time across the bottom in years. Here we have a figure that shows its time through the unit as being in days. So, for breakthrough, which we used as being Co of .1, you can see the breakthrough time is in the order of 10 days when first arrival of contaminants would come through that unit using the various input paramters that we have. Thereafter, the value rises to a C/Co of about one in something in the order of 110 days or so.

The next figure I would like to refer to is Figure 12 -- sorry, Figure 13, 13A, pardon me. This is the contaminant migration downward through the weakly fractured massive shale.

Q. Can you just show us that on Figure 11, please?

A. Yes, we are now considering a

calculation for this unit only. Whenever it sees contaminants, it starts to react, and that is times zero as far as it is concerned.

Here we see that, on our time scale, we are back up into years again. This is an uncoupled calculation again at constant concentration within the landfill. The downward groundwater velocity is 1 x 10 -6 cm/s, the thickness of the unit is about 15 metres, dispersivity about .75 metres, and here we have applied the coefficient of molecular diffusion, which in this case is 5 x 10 -7 cm/s.

Now, we see here two contaminants, a non-absorbed contaminant at R = 1, such as a chloride, and in weakly absorbed contaminant with an R of 1.48, retardation factor 1.48. So, here we see that the breakthrough time is somewhat longer for the conservative ions, such as chloride, a .1 C/C zero breakthrough time would occur something in the order of 25 five years or so, 25 to 30 years.

Now, I am reading off the graphs. The exact number that we have picked in the book may be a little different. For the weakly absorbed organic contaminant, the breakthrough time would occur something in the order of about 45 years. These values then peak in terms of chloride after about a hundred years, and in terms of a weakly absorbed contaminant, after about 140 years. So, this model, just as a reminder, takes us through the weakly fractured shale to the top of the highly fractured shale unit underlined on site..

Q. Just before we leave that zone, can we look at your work with respect to the moderately absorbed contaminant, which I believe is Figure 13B?

A. All of the values given, the input parameters for this model are the same as for the weakly absorbed contaminant, except that the retardation factor is now 16 instead of 1.48, and one can see the effect that this retardation has on materials that are moderately absorbed. We now talk breakthrough times in the order of 500 years to come through that unit, and finally, they would peak a considerable period of time after that, perhaps in the order of about 1,500 years. So, for anything that is absorbed in some degree, just by the attenuation essentially and some diffusion, these valuations start to stretch out a long time, indeed, compared to the chloride ion.

Could we refer now to Figure 14. If we are looking now at lateral migration through the highly fractured shale, and coming back to the drawing of the schematic of the potential pathways, we are now dealing with the bottom pathway, which is migration to this permeable unit southward past the 403 highway. The point of discharge here is taken as being about 1,400 metres downgradient from that site. So, when we look at the contaminant concentration at this point in the southern part of the highly fractured shale unit, some 1,400 metres from the landfill, the groundwater velocity is 10 -2 cm/s. It says downward, and that should be -- should be lateral. The distance to the discharge zone is 1,400 metres, and the dispersivity is 140 metres.

Again, on the horizontal axis, we can see that we are dealing with time in days again. Because of the fractured nature of the medium and the relatively low porosity that we have applied to it, velocities within the unit are quite high. So, we see here that the contaminants that arrive through this unit, in a period of about 75 days, using a C/Co of .1, something in the order of 75 to 200 days. Thereafter, the concentration rises, and reaches a maximum of C/Co, being one, and somewhat in excess of about 300 days.

Finally I would like to refer to Figure 15, which is the last calculation of the fourth flow path that we have discussed. We are now going to consider upward migration from this point at the outflow end of the highly fractured shale unit, and its impact now as it comes through the glacial till and sand to a point somewhere on surface.

Here again, we can see the effect of retardation through the glacial till and slower groundwater velocities, and we are looking in this calculation at the non-absorbed contaminant, a weakly absorbed contaminant, and a moderately absorbed contaminant. A groundwater velocity is now about 10 -6 cm/s, the thickness of this discharge unit is about 12 metres, and the dispersivity about 6.6 metres. We have used the coefficient molecular diffusion of 1.5 x 10 -6 centimetres squared per second. So, with respect to the conservative contaminant, we will have breakthrough through that unit, a C/C zero after approximately 25 years.

In terms of a weakly absorbed contaminant, a breakthrough time of about 35 to 40 years, and finally, a moderately absorbed contaminant would come out at a time somewhat in excess of 250 years. These would peak the chlorides fairly quickly after about 70 years, the weakly absorbed contaminant, after about 135 years, and the moderately absorbed contaminant would go on for a considerable period of time before it reached C/C zero.

So, what we are looking at is the same type of a treatment that we discussed for Site D, is the development of individual pathways and calculations on how various contaminants will behave within them, and now we will go through the same type of a procedure that we did on Site D to carry the calculation further.

Q. All right. Now, just before we do that and to be completely clear, as we did in Site D, could you review with the Board, please, or identify for the Board the key pathway for the migration of contaminants insofar as Site F is concerned?

A. The key pathway is through the groundwater, and that is migration downward through the shale that will underlie the site, a weathered shale unit, then downward through a weakly fractured shale unit, which is the fairly low permeability unit that we discussed. Once it arrives at the highly fractured shale unit, it will move laterally off the site and finally move upward to discharge through the surficial till. Just one more time, from the schematic H-40-3, we are talking about contaminant migration through the shale into the highly fractured shale unit and finally charged southwards somewhere past Highway 403.

Q. All right. Now, as with Site D, did

you couple together the various equations, the various runs of the Ogata-Banks equation which you undertook with respect to the components of that key pathway?

A. Yes, we did.

Q. Did you include all components of the pathway in this combination of equation results?

A. No, we didn't.

Q. Can you indicate to the Board what you didn't include, and why?

A. We didn't look in great detail at the -- when we coupled these models, we didn't look in great detail at migration downward through the weathered shale, because the breakthrough time is so rapid. Also, lateral migration through the highly fractured shale hasn't been considered in the coupling.

What we did, for simplicity, is we took the two calculations for the migration downward through the weakly fractured shale and took the upward migration through the discharge zone till, and we coupled those and integrated them in order to produce a model for the site. We have essentially assumed that downward migration through the weathered shale and the lateral migration through the highly fractured shale will be instantaneous.

Q. All right. Then could you review

with the Board, please, the results of that coupling?

A. I would like to refer to Figure 16 of the report, which is on page 114. In this figure, we are looking at the chloride concentration in groundwater discharging to the ground surface at the discharge zone. So, this is our -- the fourth -- we are looking at this flow path into what we could call here the marsh on Drawing H-40-3. The first time of arrival, here we have taken out the C/Co and put in our chloride concentration of 1,500 milligrams per litre to service as a fresh concentration for leachate in terms of chloride concentration, and the first time of arrival at the discharge zone till, in this case, would be in the order of about 60 years. The chloride concentration would then increase and would reach a peak at about 130 years. The arrival times for the -- the arrival times for -- we don't have a curve for this one, but the arrival times of moderately absorbed contaminants, such as the xylene and trichloroethylene, would be longer by a factor of about 15 times.

Q. All right. Now, as with Site D, and again concerning this coupling, did you consider the issue of declining contaminant concentrations over time?

A. Yes, we did. As for Site D, we have

in this report for Site F, Figure 17, which occurs on page 117. We have, again, assumed that the initial chloride concentration in the leachate will be 1,500 milligrams per litre in fresh garbage, and as the easily leached contaminants are taken from the waste, that will decrease to a concentration of about 100 milligrams per litre after 50 years. So, this is the same decline model that we looked at for Site D.

Again, we did not have -- we have also done the same type of a reduction for the organics. We mentioned before that we don't have a good basis for that reduction, although we know that it will occur. We have used the same type of a decline curve for the organic inputs in the leachate. Now, when we measured the leachate concentrations out there, the organics, they were fairly high, and for the calculations, we assumed an initial input of both 1,000, which was measured on vacation and another was 200, which is more representative of landfill leachates. This is for the weakly absorbed organic contaminants, such as the methyl ethyl ketone.

Now, in the case of the chlorides, we are then looking at the milligrams per litre, and in the case of the organics, we are going back to the micrograms per litres, which is three orders of magnitude smaller. So, milligrams per litre or parts per million, and for the organic contaminants, we are look at parts per billion.

I should point out that the high concentrations of organics at Burlington, which in Gartner Lee's report are shown could be quite variable, probably reflect past disposal of industrial wastes in this landfill. We feel that in the management of future landfills, there will be less of these organics disposed at these sites, and this will -- this will, I am sure, come to pass because of the Ministry's implementation of Regulation 309, which strictly governs the movement and disposal of hazardous wastes in the province.

If we can look at Figure 18, here we have the coupled model for the chloride concentration that emerges through the discharge zone till. Again, it's taken the pathway of instantaneous movement, according to our assumptions, down through the weathered shale and slow movement through the weakly fractured shale, very fast movement through the highly fractured shale unit, and then finally upward through the discharge zone till. I hope I called that weakly fractured in the second pathway.

So, the results are now shown in Figures

18, 19 and 20 of the report. Perhaps, we can review these briefly. The first graph, Figure 18, is for chloride concentration in the groundwater discharging to the ground surface at the discharge zone. Now, we can see there has been a significant reduction from the peak concentration of 1,500 milligrams per litre that was assumed previously. Here, we have a breakthrough time, oh, something in the order of about 60 years for chloride to arrive at surface downgradient from the site. A peak concentration would occur -- will be about 350 milligrams per litre in about 90 years' time. Finally, there would be a tail-off in the chloride concentration until it reached an equilibrium of our assumed end value after about 180 years. So, for the duration of the elevated chloride concentrations from the site would be in the order of 80 to 90 years over the span from 60 to, perhaps, 150 years. It would be elevated chlorides downgrading from the site.

If we look now at Figure 19, here we are looking at a weakly absorbed organic contaminant assuming a high level of input initially, a thousand micrograms per litre, one part per million. Here, the breakthrough time would occur in the order of about a hundred years, and you can see that the curve is more spread out. It peaks after about 150 years at a concentration of about 100 micrograms per litre and thereafter declines.

This is the same curve, a similar curve, using an initial concentration in the landfill of 200 milligrams per litre for the weakly absorb contaminant. After a period of about a hundred years, the first breakthrough would occur at about a concentration of about 10 micrograms per litre or 10 parts per billion. It would then peak at the same period, as we saw in the previous diagram, after about 150 years, at a concentration of about 20 to 25 parts per billion, and thereafter, it would tail-off.

Q. Now, Mr. Sobanski, if we can refer to page 133, and would you review with the Board, please, the overall from having conducted this review?

A. The advective flow calculations show the first arrival of conservative contaminants, including the weakly absorbed organic compounds, would occur approximately 60 to a hundred years from now. So, this would be the first arrival at ground surface after the contaminants have followed the four component flow paths system that we have indicated in our calculations. The maximum increase in chloride in the discharge zone would be about 350 milligrams per litre. We do not feel that, in this particular case, that this would be a severe impact.

Q. Can you indicate to the Board what -- perhaps, you can just put Exhibit H-40-3 or 2, it doesn't matter. Now, if you could just again point to the Board, please, where the discharge zone is, Mr. Sobanski?

A. Yes.

Q. Could you just show the Board again where the discharge zone is on Exhibit H-40-3?

A. Yes. We are talking about the marshy area, an area somewhere south of Highway 403, extending two or, perhaps, slighty beyond the CNR tracks.

Q. Now, what is the impact of all of this on that discharge zone in terms of the use of water?

A. The model shows and the calculation show that the leachate that is generated from the site will move into this highly fractured shale unit. That site contained -- that water system contains very poor quality water. It has chloride concentrations in the 10,000 to 20,000 milligrams per litre range. So, consequently, impacting a poor quality water of that nature, with 350 milligrams per litre, in our opinion, would not be a severe impact. Where the discharge zone occurs -- and, perhaps, it's some diffuse area -- the concentration increase above background is going to be in the order of about three percent, which is relatively low. So, 350 over 10,000 is about three-and-a-half percent. It's not a significant degradation of a material of water that already has extremely bad quality, but again, more specifically on your question, the discharge zone occurs south of 403 and then extending southward from there. There are marshy areas in this vicinity, which likely indicate these discharge gradients.

Q. And just in relation to that three percent, can you just find the chloride contour of the exhibit you used? Now, using this exhibit, Drawing 21, as an example, are you able to give us some indication of what impact this would have on chlorides?

A. This is Drawing 21, entitled "Chloride Concentration Contour Map". We talked earlier this morning about the fresh water rind that occurs on top of a zone that contains very poor quality water. This fresh water zone on the top is an equilibrium with that poor quality water below. If we look at HC-9, for example, the shallowest standpipe had a concentration of 50 milligrams per litre chloride.

Near the rock contact, the concentration has increased to 1.6, and then as we go deeper and get into this unit that we are talking about, the highly fractured shale unit, we start talking chloride concentrations in the order are 17,000, but this is sitting here as a dynamic system today, and what it is seeing are natural conditions. So, some diffusion is taking place, some movement is taking place from this poor quality water zone into the upper zones, which are protected by that till there and also by fresh precipitation falling on the land.

Now, if we increase the concentration in this highly permeable unit by a small factor of 350 milligrams per litre, or if we use 10,000 as a background, about three-and-a-half percent, I would anticipate that the type of an increase that you would get in that fresh water zone would be about the same, about three-and-a-half percent. In other words, this is a dynamic system that already is seeing the effects of terrible quality water from below, and our increasing that should not change that significantly. We would increase it by three-and-a-half percent, which means at a background concentration of 126 milligrams per litre. That would rise to about 129 milligrams per litre, and I don't think we would see anymore impact than that.

Q. Just to remind the Board again, what

is the Ministry of Environment drinking water standard for chlorides?

A. Two hundred and fifty..

MR. LEDERER: Now, Mr. Chairman, it's twenty-five to four. If you are of a mind to take an afternoon break, this probably would be as good a time as any. I am actually hoping to finish this direct examination this afternoon, although I expect it will take the remainder of the afternoon.

THE CHAIRMAN: Yes, we will take a few moments.

--- SHORT RECESS.

--- UPON RESUMING

MR. LEDERER: Mr. Chairman, there is a Ministry of Environment policy, which may or may not have application here, and I gather that Mr. Tidball is intending to refer to it, and it's wise to raise it now. He has, again, what I understand are the complete copies of the documents. I confess I haven't seen it in quite this form before.

BY MR. LEDERER:

Q. Mr. Sobanski, are you aware of what's known as the Reasonable Use Guidelines?

A. Yes, I am.

THE CHAIRMAN: I am sorry, what was that again?

MR. LEDERER: I have asked Mr. Sobanski whether he is aware of what is colloquially known as the Reasonable Use Guidelines. Now, these will be presumably subject to some form of proof from Mr. Tidball ultimately, by as I say, it seems best to exhibit them now, and the quid pro quo for my filing them is that they get an E initial, E-154.

THE CHAIRMAN: E-154.

BY MR. LEDERER:

Q. All right. Mr. Sobanski, are you familiar with these guidelines generally?

A. Yes, generally. They are fairly new, and I have a reasonable idea of what's in them.

Q. All right. Now, what I would like to know is whether or not -- let's assume, for the moment, that the discussion, which we were having just prior to the break with respect to the existence of the fresh water rind and minimal impact on water in the discharge zone, let's assume for the moment that that is wrong. Have you considered the impact of these guidelines on this proposal for landfill at Site F?

A. Yes, I have.

Q. All right. Can you review with the Board, please, your view of how these guidelines might be applied under these circumstances?

A. First of all, if we were to first of all use the assumption that we had just talked about prior to the break, then we wouldn't expect a severe impact on existing fresh water quality within the hydrostratigraphic units downgrading from the site. However, Mr. Lederer has asked what if, and, in fact, we have a discharge of the materials that emanate from the landfill. In that case, somewhere within the -- wherever the discharge area occurs, somewhere south of 403 at surface, there would be an increase in chloride concentration of 350 milligrams per litre over some background that would probably be in the order of 10,000 in a relatively small increase.

My feeling on Site F is that it's a fairly unique situation, and my own feeling is that the reasonable use criteria should not be applied to this site given the poor quality of the water into which contaminants would move, and also given the concept of reasonable use. The reasonable use concept applies to landfill sites mainly, proposed and operating sites, for sites being accrued for expansion. In addition, it applies to exfiltration lagoons and large subsurface sewage systems.

Now, the Ministry, in with this guideline or criteria, is considering present and potential uses of groundwater and the amount and quality of the groundwater that is available. It's my considered opinion, that if there were to be a development to take place on the south side of the 403, it would be in the form of some sort of an industrial expansion or commercial enterprise, and I believe that these would be tied into the water and sewer systems that are available immediately adjacent to the site.

However, even if one considers then the potential use for domestic purposes, it seems to me unlikely that one could develop this type of a supply to serve a subdivision development, for example. I cannot deny that one might be able to, if the materials are permeable enough, to develop some -- a few moderate supplies, perhaps, dug wells that could obtain some fresh water supplies from this zone. However, the materials are, in general, poorly permeable. At depth, we run into the tills. So, a lot of fresh water isn't coursing down into this unit.

I feel then, that if several wells or many wells were to be developed in the -- on the NSP property south of the site, that we would get the type of problem that develops in coastal areas, where you overpump an aquifer which overlies poor quality water at depth, and that we would, in all likelihood, get salt water intrusion into the wells, whereby we would develop little cones around the wells and then start to draw water upward from the deeper, more contaminated zones, but mixing nine (phonetic) contains 17,000 milligrams per litre of chloride.

In addition, I don't believe that water supplies developed in that unit would be too reliable if one were to put several of these supply wells in, because one runs the risk that in years of less than adequate rainfall, that the quality might deteriorate in any event, but coming back to reasonable use for this particular area, again I feel that we, in all likelihood, it being now an industrial type property, I doubt that it's going to be sold for subdivision and established on individual wells and septic tanks. It would be my opinion that it would be developed as some sort of an industrial complex similar to the one that is found to the east of King Road, and in that case, these facilities, I believe, for that type of a development, will be based on surface water and on sewage system, the central sewage system, because there just isn't enough groundwater available, I don't believe, in that glacial till to supply large quantities of water.

Q. You say "surface water", and I presume you meant "serviced water"?

A. Serviced water, yes. Well, it's both. It is service water and it is surface water.

Q. Thank you. Now, just to be absolutely clear on this, if this were developed for domestic use at all, is servicing available in this area?

A. Yes, sir, just as it would be for industrial development facilities, water and sewer is available in the property.

Q. And to get some idea of the notional quantity, you mentioned the possibility of digging several wells. If you were to dig one well, can you indicate, in your opinion, how many homes that would service, a single well?

A. Well, I would think -- you know, you might get enough water out of this to serve a single well. We haven't tested it. It is a glacial till. We may get a little water off the top of the rock, but as soon as we get toward the top of the rock, the water quality deteriorates dramatically. We go from 126, from our interpretation to the blue line, which is a thousand, in a relatively short vertical distance.

So, my feeling is, that even trying to extract water from that rind of fresh water, could create long-term problems in terms of salinity in any wells that we may devleop there.

Q. All right. Before we leave this, did you consider the Reasonable Use Guidelines in relation to Site D?

A. Yes, we did.

Q. What was your conclusion there?

A. Site D is a total containment site. It is a hydraulic trap that will capture any leachates produced from the landfill and a portion of the groundwater around the site, and consequently, it meets the reasonable use criteria, in that it would not allow any contaminant egress, and there would be no changes in groundwater quality.

At Site D, it may be that the existing groundwater quality would not let us interfere with the quality at all in any event. The Reasonable Use Guideline criteria says, that where the quality of the water exceeds the Ministry's recommended drinking quality standards, then no change is allowed. As we have discussed, Mr. Chairman, of the sulphate values, for example, at Site D and also the chlorides in some cases, exceed Ministry of the Environment drinking water quality criteria. However, with the hydraulic trap in place, there would be no egress from the site.

Q. All right. Now, can we follow through to the end of this report, and if you could turn to page 123 of Exhibit H-40, and could you indicate to the Board, please, with all of the analysis having been completed with respect to Site F, what hydrogeologic factor should be considered in designing a landfill at that location?

A. We have considered several factors that are summarized on page 123. First of all, any landfill constructed at Site F would be predominantly founded. Its base would be predominantly founded in the Queenston shale in the rock.

No. 2, there is essentially one pathway through which leachate might migrate off-site with the groundwater, and that is the pathway that we have been discussing, downward migration through the weathered shale, further migration downward through the massive weakly fractured shale, then lateral migration through the highly fractured shale zone, and finally upward migration through the discharge zone till downgrading from the site.

Leachate migrating laterally through the weathered shale unit would be captured by the on-site treatment or collection system, where it would be collected for treatment and discharged to sewage treatment plant. The dominant hydrostratigraphic unit at the site, in terms of contaminant migration, is the massive weakly fractured shale unit. The tests that we have run on it indicate that it would have good attributes for waste disposal. It has a high cation exchange capacity of 65 milliequivalents per 100 grams. It has organic carbon in it, about .2 percent by weight, and it has a low hydraulic conductivity to restrict rapid movement of leachate through it at about 10 -7 cm/s. So, these are the type of factors then that we considered when we considered the design of this site.

Q. All right. Now, you have begun to refer to a new exhibit, which we will come to know in more detail in a few moments, but since you have put it up, perhaps we could exhibit it as well, Mr. Chairman, since it is not found in the report anywhere. So, it would be H-40-5, I believe.

THE CHAIRMAN: Five.

THE WITNESS: Now, for the record, this is called a "Hydrogeology With Landfill In Operation".

BY MR. LEDERER:

Q. Now, Mr. Sobanski, with respect to Site F, did you undertake any analysis to assist you in considering leachate control at this site?

A. Yes, we did. We did a sensitivity analysis. It was something that I wanted to look at. It's a difficult sort of a concept to describe. What I want to do is to see how sensitive these hydrogeologic units are to installing a landfill on top of it. If we didn't engineer it, how sensitive, how much water, moves through this zone, what sort of range of values are we looking at. If we have tile collection failure or something like that, how much movement can there be through this bottom unit.

It's a bit of a sensitivity analysis to give me a feeling for how much water, how much leachate this flow system can accommodate, and I have shown this on page 125, which is Figure 21. This is the FLONETS model again, and what I have done here is assumed, for a moment, that there were no tile collection system, and I am going to pond a lot of extra water on top of the stratigraphy in the area that we are going to put this landfill site on. What it amounted to was taking out our upper row of -- in that finite element model we saw, we took out the upper row, and we added another row to it on top, and then what we did is, we assigned a new water table to the top of that zone, which is 10 metres higher than the existing water table on the site.

So, I have mound to 10 metres, 30 feet of water on top of the shale unit, to see how much this flow system can handle. How much do we have to be concerned about this unit taking more water through it. We assigned hydraulic conductivity to this zone now, which would be garbage in this case, of about 10 -4, which is sort of an average value that we are using in Ontario for garbage permeablilty.

Now, we run it through FLONETS and find out how much additional water or leachate would come out of the discharge zone. If we go back to the original model of FLONETS without just ponding the pile of water on top of it, we had an outflow of 28 metres cube per year per unit width. So, we have increased it a little bit from 28 to 33. So even by ponding a great deal of water on the shale sediments, that 10 -7 layer, that low permeability layer, restricts a lot of the movement of water through it.

So, this is just to give me a feeling for how sensitive this is to the type of tile drainage we would put underneath the site. The tile drains, we can't stop the downward movement of water. Some will bypass the drains because of the strong vertical gradients at this site. The other thing that shows up on this is that, of the additional water that's infiltrating, about 30 cubic metres would discharge at the toe, but this isn't that important a number, but under this condition, that would, of course, be picked up by toe drains, but, in fact, the 30 cubic metres cubed per year doesn't represent anything in the analysis that I am doing here. I am looking at the sensitivity of this unit to carry water by ponding the water on top of it. So, we can see that it moves from 28 cube metres to 33, which isn't a very large increase.

Looking back at the report now, page 124, the average infiltration into the underlying weathered shale beneath the fill increased to 22.6 millimetres per year for a net increase of 8.9 millimetres per year, and the discharge increased by 3,000 cubic metres per year, or about 1.3 gallons per minute, which isn't an awful lot of water at the discharge end. Again, any discharge that would occur in a situation like this would be picked up by toe trains and sent to a sewage treatment plant, but in actual fact, this mounding condition will not occur. Again, it's a sensitivy anaylsis. Tiles would be placed at the base of the cell, as we talk about the design. They will be placed here to keep the water table within the landfill cells at approximately their current level, so that the first model is indicative of the environmental impact that would occur at this site.

Q. Let me see if I can summarize that. The change here is that you have now assumed, in waste disposal site at the location of Site F, assumed that water in that waste will mound to about 10 feet and determine that the impact of the imposition of that waste or that additional water will not be great and will not affect the modelling that you have done?

A. Yes. I should just point out that you said 10 feet, and it's 10 metres.

Q. Sorry, excuse me. I too have found it impossible to move to metric. I expect to learn it from my daughter. All right. With that analysis in place then, can you indicate to the Board, please, beginning at page 126, what landfill operation methodology you are suggesting for this site?

A. We are suggesting an operation that is similar to the operation that was suggested for Site D. It would be a combination of a trench fill and an area fill method. We will dig deep shale excavations on the site. They would -- in the southern end, it would be mainly the shale, and in the northern end, it would be till, but this will require or provide us with some below ground capacity for waste disposal, and the dug material will provide us with daily and final cover for the landfill. The trenches will be progressively filled, and then we will build an area fill, large mound, on top of the trenches. As with the sanitary landfills, the waste will be spread in thin layers, will be compacted, and it will be covered with earth daily.

Q. Can you indicate to the Board the leachate control system that you are suggesting at this site? Perhaps, you can describe it in reference to Exhibit H-40-5 and explain its impact on the hydrogeology in these areas.

A. Given the hydrogeologic conditions at this site, we considered two engineering methods, Mr. Chairman. One was to provide a -- just a leachate underdrain system on top of the shale, which would form the base of the site, and the second was to use a liner to line the shale and collect leachate off of the liner. These are new, large and above-ground landfills. Leachate underdrains and collection systems are commonly installed as a precautionary measure, even if our calculations were to show that a simple toe drain would suffice to protect the environment. We have said that we are going to more sophisticated sites in Ontario, become more highly engineered.

At Site F, a leachate underdrain system would be installed in that concept to collect leachate in the landfill that's generated and comes through it, and also any that emerges or tries to emerge at the toe of the landfill. The leachate production rate that we are assuming here is 12 inches a year again, 305 millimetres per annum.

Now, most of this leachate would be collected in the underdrain system, and it would be disposed and treated in an appropriate manner, which would be a tie-in to the sewage drain system, which is not located too far away. First, the sanitary sewer, and then to the treatment plant.

A few moments ago, I alluded to the fact that these drains cannot capture this vertical component to groundwater flow. Some leachate would move downward through the units that we have been describing in detail here. So, these drains will not significantly affect the amount of water that will infiltrate downward. Hydraulic entrapment, you will recall, Mr. Chairman, where we want to form a hydraulic trap with the base of the cell below the hydraulic potential in all of the important zones. We can't do that here, because of the strong gradient. The gradient through this unit is one, which means that for every foot we go down, the water table also drops a foot. So, we can never catch it. We would essentially, to form a hydraulic trap here, have to dig the whole site into the underlying highly fractured unit, which occurs at some depth beneath the site. So, we cannot practically achieve that.

So, the system here is a tile system to pick up the infiltration, most of the 12 inches that comes out, and then a small amount would still follow the flow path that we have been discussing. If we consider for a moment that we are going to get 12 inches of infiltration into the site, as the Ministry prefers we consider from finished landfill, then the amount of egress demonstrated here in the marshy area, which is about 14 to 23 millimetres, means that we can easily calculate then our captured efficiency if 305 comes in here and around 20 goes out on the west side near the marsh, the south side near the marsh, this gives us a resultant capture efficiency of 93 to 96 percent. Now, that capture efficiency wouldn't be as high if the amount of infiltration that comes through the cover material is lower than 12 inches.

Q. So, you are proposing that the underdrain system, which will collect approximately 95 percent of the leachate, the remaining five percent of which will proceed through the highly permeable layer?

A. That's correct.

Q. Now, you indicated that you considered the application of liners at this site. Could you review with the Board, please, your conclusions with respect to that analysis?

A. We are dealing now with pages 128 to 133. We consider liners for the protection of water resources, where -- we are in hydrogeologic environments where significant off-site impacts can incur. These would be zones of high hydraulic conductivity and low attenuation capacity, such as sands and gravels. We don't believe that we have that situation here.

We also use them where we have significant hydrogeologic complexities. We don't believe that the site falls into these categories, but the Region of Halton asked us to look at the possibility of applying a liner at this site. They asked us for our consideration of it and our comments on it.

We have two types of liners that we could consider. One would be a synthetic membrane and the other would be a natural clay liner. The main advantage of the synthetic membranes is that they have a very low hydraulic conductivity, something in the order of 10 -11 cm/s or 10 -5 feet per year, a very small value.

The main disadvantage that we have found in literature with these types of systems is installing a membrane that is non-leaky, and there is certain question as to longevity of these materials under various types of service. They are extensively being used in the United States on hazardous waste disposal sites. Unfortunately, if they leak, I think you spend more time trying to determine why the thing is leaking than you are with the environmental impacts. You just raise a whole new series of questions, and they are very difficult to monitor for these, given that we have such large areas.

We have used natural clay liners in Ontario at the Brock West site, a thin blanket of bentonite in the sand has been used to give us a low permeability of liner of about 10 -8 cm/s, and that's a Metro Toronto site. It's a natural swelling clay, and we have also used a glacial till as a liner at the Keele Valley Site. That's currently being installed.

Currently, from our discussions with the Ministry, clay liners are favoured in Ontario where they may be required. These materials have a higher hydraulic conductivity in the order of 10 -7 or 10 -8, but they are much thicker. When you are dealing with the liner at Keele Valley, it would be in the order of five feet thick.

So, I make mention in here to a paper by Milligan in 1983, and he noted that there wasn't too much difference between the synthetics and the naturally -- the natural type of liners, because there was a tendancy to pond water on the synthetic membranes. You can generate very high hydraulic gradients across the membrane. In other words, the membrane may only be fractions of an inch thick, and we may carry several metres of head of water on top of them.

So, Milligan says here that a one millimetre thick synthetic liner, with permeability of 7.5 times 10 -11 cm/s and a head of two metres, so we are ponding two metres of water on top of it, it would pass about as much leachate as a one metre thick clay liner with a hydraulic conductivity of 5 x 10 -8 with the same two metres of head. So, while synthetic membranes have very low permeability, they nonetheless do have some permeability and respond to the heads that are imposed upon them. Another thing we point out in the report is that an obvious advantage of the clay liner, it does give us some attenuation capabilities, the natural attenuation capability, by using clay as opposed to a plastic.

We looked at some liner performance estimates, which one can read in the report. We didn't feel there would be a significant advantage here to putting a liner on the site, because the low hydraulic conductivity of this underlying shale unit is already acting as a barrier to fluid movement, and to impose something that's even an order of magnitude greater in -- lower in permeability on top of it, that doesn't really change the amount of infiltration significantly, because now the 10 -7 layer acts as an underdrain to the 10 -8 layer, but the calculations are given in the report.

So, from this we can conclude that a liner wouldn't really be an effective method of providing additional environmental integrity at this site, and we didn't feel, with the costs involved and the small amount of benefit that we would derive from it, that a liner would be warranted or recommended.

Q. Now, at page 136, and could you review with the Board, please, the contingency plans you are suggesting for this site?

Remembering again that the primary system that we are proposing is an underdrain system for the landfill, which would capture the bulk of the leachate, the contingencies that we are suggesting are two-fold for groundwater. One is natural attenuation, which would occur as the contaminants move through the ground. We note here there would be about an 80 percent reduction in the peak concentrations of things like chloride as a result of natural attenuation.

In terms of the second contingency that we consider is the purge wells, as we have at Site D. We have established, from the pumping test at Pumping Well 1, that purge wells are feasible at the site, and they should be also effective. We estimate that three or four purge wells along the south boundary could control the contaminant migration in the highly fractured units if it becomes necessary. We would install the wells in the buffer zone along the south side of the property, itself, in the area north of the North Service Road, and north of the hydro corridor. The amount of pumpage that would be required from these wells is relatively low. We estimate it to be on the order of about 7.3 imperial gallons per minute or 15,000 cubic metres per year.

The perimeter leachate tile, a perimeter leachate tile collection system would serve as a backup for any surface water problems that may arise. We could get, perhaps, some side slope discharge of the leachate, which we could drain down into the primary tile system. Another possibility would be that we might have a failure in some area with some leachate ponding, and in that case, we would install a perimeter tile collection system to pick that up, and it would be pumped to the sewer trunk and then be taken to the sewage treatment plant.

Q. All right. Now, can we look at page 139, from memory, I suspect, not that different from what you said about Site D. Could you just review the monitoring and reporting program?

A. The proposed monitoring program is very similar to Site D. The zones that we would monitor would be a bit different, but again, we want to monitor quality in the vicinity of the landfill to assess and ensure the adequacy of our design and to protect local groundwater and surface water resources if we have impairment due to unforeseen circumstances.

Again, data would be collected from groundwater monitors located close to the landfill cells and from monitoring wells located within the property boundaries. These would be regularly assessed for changes in groundwater chemistry. The surface water lagoons, sanitation lagoons, and any storm water captured within the landfill cells would also be monitored routinely.

We would also monitor the quality of the leachate within the site at selected manholes. Again, we don't expect gas to be a problem. There are no nearby structures that need be protected. We have landfill on essentially two sides of this. However, we would install gas monitors with the observation wells. We would also install them adjacent to all on-site structures that would be in the north and south buffer zones. We are also proposing that we put combustible alarm systems in these on-site structures to serve as an alarm. We can purchase alarm systems that work for protecting methane gas.

Again, as with Site D, we would propose a 40-year monitoring period at this time, 20 years during site life and 20 years following closure. However, the final analysis, the longevity of the monitoring, will be determined by the Ministry, I am sure, to satisfy, itself, that we have no short-term or long-term problems with the sites.

In terms, again, of the groundwater monitoring, conducted in a manner similar to Site D, the on-site wells would include nests of standpipes and piezometers to monitor the various units in the shale. Off-site wells would comprise selected downgradient domestic wells, we understand. There may be a couple in operation. We can also include those in the monitoring system.

Following the installation of the wells, we would determine background quality, and subsequently, we would analyze for the site these wells, either quarterly or semi-annually, for landfill contaminant indicators. We should conduct a volatile organic scan annually on wells to ensure that organics aren't removed. I think, in this regard, we will be guided to some degree in the results of Gartner Lee's monitoring program, which is ongoing and will be providing this data as time goes on. It gives us the opportunity then to modify the program in accordance with what their finding is of the Burlington Landfill

Site.

We would propose, that in the off-site wells, it would be monitored only on an annual basis, because there would be significant monitoring on the downgradient side that would pick up any contaminants, and given that even though we are talking extremely fast groundwater flows here, a groundwater does move rather slowly. In the wells, it maybe located halfway down to Hamilton Harbour, and shouldn't be adversely affected by this operation in such a time frame that we couldn't respond to hooking them onto a service water supply if we were totally wrong.

In terms of the surface water monitoring, we would take -- it would take the same form as the groundwater monitoring, and similarly, we would monitor the sediment ponds again. We are doing the routine contaminant indicator analyses that we discussed for Site D. We list them here as a conductivity, pH, alkalinity, chloride, sulfate, calcium, sodium, magnesium, potassium, phenol, and dissolved organic carbon. This, again, would be backed with volatile tile organic scans as required.

In terms of leachate monitoring, we would select several manholes within the system, and we would monitor for fluid levels within the landfill to make sure that the tile systems are operating as proposed. We would also measure the leachate quality from these manholes to tie that back into the contaminant migration model that we have developed, and this would allow us then to refine that model as time progresses.

In terms of reporting, we would follow the accepted practice of annual reporting, which would be prepared and summarize all of the monitoring activities then results. Again, it would include an interpretation of the data and recommendations for any additional monitoring or remedial action which may be necessary.

Q. Now, Mr. Sobanski, we have spent a considerable period of time reviewing the work that you have done and the landfill technical studies with respect to Site D and Site F. Are you able to give to the Board now any conclusions you have as to the appropriateness of both these sites for landfill?

A. Yes. It's our opinion that both Sites D and F are suitable for sanitary landfilling, given the engineering systems that we are recommending be installed at the sites.

Q. Notwithstanding that conclusion with respect to both sites, were you instructed to do a comparison of these two sites as part of the comparative analysis that we have heard about in evidence before this Board?

A. Yes, we were.

Q. Could I refer you then to Exhibit H-14, and specifically to Appendix A. Do you have a copy of that if front of you, sir?

A. Yes, I do.

Q. Could you indicate to the Board, please, who prepared this letter and the charts which follow it?

A. This was prepared by me. It was sent to Mr. Walker at Walker, Wright, Young Associates Limited.

Q. Can you indicate to the Board, please, what instructions you received prior to the preparation of this material?

A. We were asked to rank the sites, from our point of view, as to which was the most suitable for waste disposal.

Q. If you could just review with the Board, please, the approach you took in undertaking this analysis?

A. We used an approach similar to that used in the Phase 2 Stage 2 report.

Q. Phase 2 Stage 2, page 2C?

A. Yes, Stage 2C report, wherein we -- at the back of the report, you will see that we have prepared a series of tables of Table 1, Table 2 and Table 3. These tables -- first of all, Table 1 looks at existing constraints to site development as we did in 2C, and we can, by comparing back to 2C, see how these sites compared between our knowledge that we gained through the detailed studies and the lesser knowledge that we had at the time that we did the Stage 2C report. It's of interest, as we say, in this letter report, but we don't believe that it's particularly germane to the process here, because, in our opinion, either site would have to be highly engineered in order to mitigate a potential impact.

In Table 2, you look at the potential impact of engineered systems on water resources, as we did also in the Stage 2C report. In Table 3, the assessment of potential impacts of the installation of contingency systems is shown.

Now, we should note that we are not really -- the assessment isn't quite parallel in what we did before. We know now that we can install certain facilities. We don't have to guess. We have a good feeling for these impacts. We state here, on page 2, that

"The following comments refer to your request for our ranking of Sites D and F in their order of preference.

From the outset, we clearly state that both sites, D and F, have been designed and engineered to be environmentally acceptable to serve as a regional landfill. That is, both sites are hydrogeologically safe, as designed. We are prepared to support the application for approval of either or both of the sites on this basis. On a comparative basis, differences between the two sites are small, but obviously there are differences and each site has some advantages over the other. The following lists major advantages of each site."

If we look first at Site D, firstly, "The soils would be easier to excavate." Here we are dealing with a glacial till as opposed to a shale over portions of the site at that depth.

"Surface water control will be easier to achieve." The land is flatter. We don't have to deal with high run-off from steep slopes at Site D. I should point out that an advantage for Site D is a disadvantage for Site F.

Thirdly, "The design at Site D is simpler and more straightforward." At Site F, we are dealing with two level leachate control systems. At Site D, we are dealing with a more conventional, straightforward design.

Consequently, we are arrive at point 4, the "Installation of the tile collector system is more straightforward." At Site D, we have the advantage that the tile collection system will be very efficient, because we have a hydrogeologic setting suitable for the formation of the hydraulic trap that we discussed last week. So, this is a system that could contain all of the leachate that would be generated at the site, which would then be sent to sewage treatment plant for treatment.

At Site F, we have already mentioned that there will be some escape of contaminants through the highly fractured unit. Site F, on the other hand, also has some advantages. They are in a different vain. First of all, there are no downgradient groundwater users certainly within a close distance of the site. The groundwater at the site is very poor quality and non-potable. The unit into which we are -- may discharge contaminants as a chloride concentration of varying between 10 and 20 thousand milligrams per litre. There is a municipal, piped water supply available to all residents downgradient of the site. The fourth advantage we list is that there are no surface water users downgradient from the site. In many areas, the stream is carried in underground conduits, and it isn't even physical. No. 5, we see no foreseeable future uses for groundwater or surface water in the vicinity of this site, given that it is being slowly encapsulated into an urban area.

At Site F, we have a groundwater flow system that is nearly unidirectional, and our contingency systems would be easier and cheaper to install if we required them. At Site F, if we used, for example, the purge well contingency, we can install them downgradient from the site between the North Service Road and the landfill. That Site D -- Site D does not have a unidirectional groundwater flow system. The shallow zone is on a groundwater divide, the deep zone in the rock is on a groundwater divide, and consequently, one would have to collect leachate possibly from several areas on both sides of the fill.

Q. Mr. Sobanski, just before you go onto No. 7, if I were to read that, instead of unidirectional it says undirectional, can I assume that is a typographical error, or are we missing something there?

A. I would think so, yes.

Q. Thank you. Go on, please.

A. No. 7, "A site is available near the site to receive leachate" and to us, of course, as designers, that's a very important feature. The sewer trunk is right there and ready to receive leachate from Day One.

I concluded my letter to Mr. Walker on the following page, page 4. I have said that,

> "Considering the advantages of each site, we feel that those of Site F outweigh those of Site D. In particular, Site F is better from the point of view of public health and safety, because there are no groundwater and surface water users. Therefore, we favour Site D over Site F."

Q. Read that again?

A. Pardon me, "Therefore, we favour Site F over Site D."

MR. LEDERER: Mr. Chairman, that, at long last, concludes the direct examination of Mr. Sobanski, and it seems reasonable to me to adjourn for the day.

Nethercut & Co. Ltd.
Toronto, Ontario

THE CHAIRMAN: It seems reasonable to all of us, I think, especially the witness. We will adjourn until Thursday morning at 9:30.

--- At which time the hearing was adjourned until Thursday, the 28th day of June, 1987 at 9:30 a.m.

CERTIFIED CORRECT:

Cindy Littlemore

Cindy Littlemore, C.S.R.