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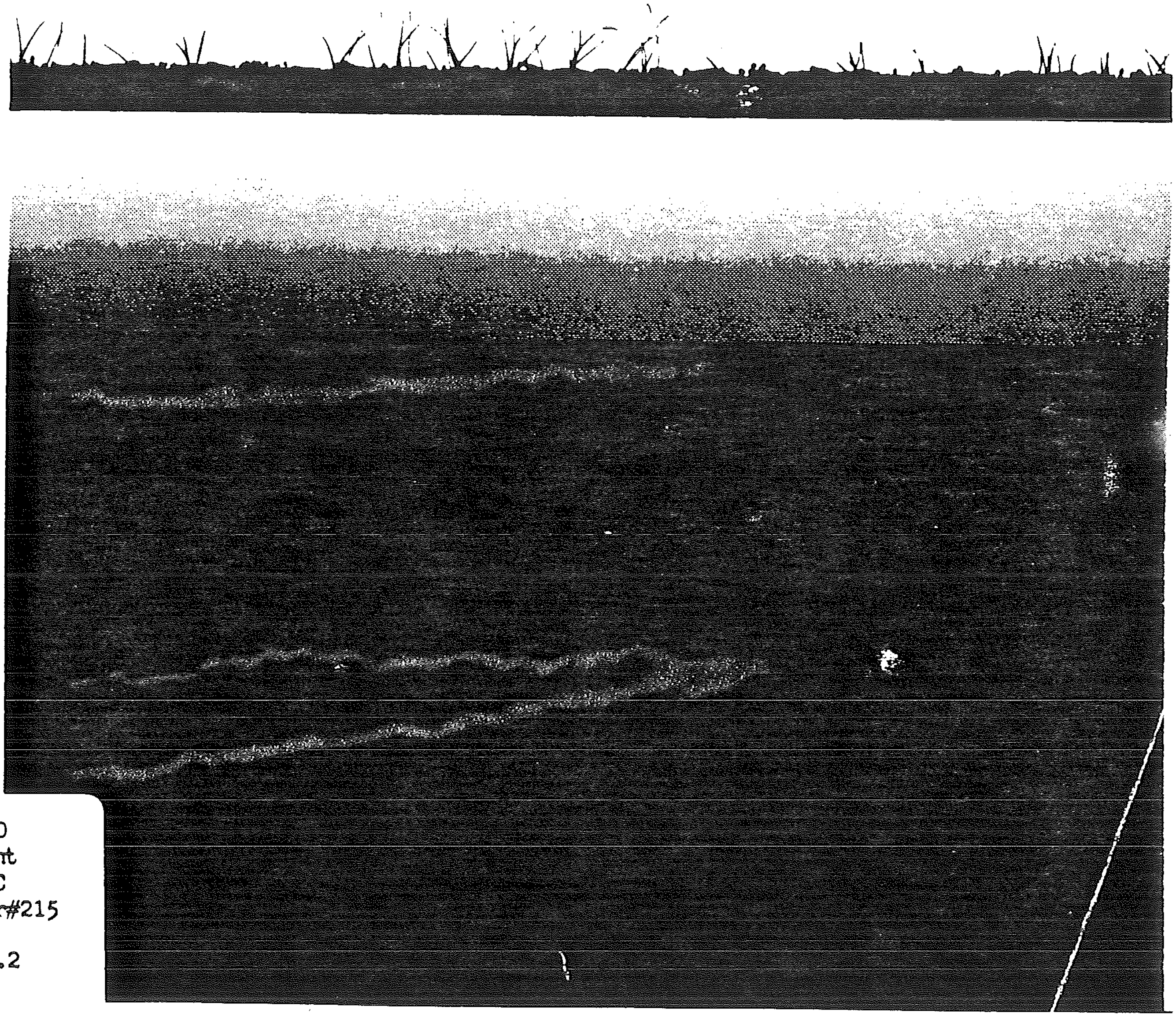
Compaction-Strength-Stabilization Properties of Weathered Surface Clays of Southwestern Ontario



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Compaction-Strength-Stabilization Properties of Weathered Surface Clays of Southwestern Ontario

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This report is the result of an Ontario Joint Transportation and Communications Research Program, Project L-3, and is published without prejudice as to the application of the findings.

University of Western Ontario designation
GEOT-2-78.

Abstract

purpose

The research presented in this report deals with the interrelationship of compaction behavior and near surface weathering of clayey, crustal soils in southwestern Ontario. The specific purpose was to determine the fundamental relationships between oxidation weathering that produces swelling clays from soil chlorites and the resultant compaction-strength-stabilization properties of the soils.

The area selected for study is deficient in long-term supplies of granular soils for base course construction; greater utilization of the clays themselves may be necessary. It is believed that the variations in soil mineralogy and behavior identified in this report are significant to roadway design and construction and provide a useful base for future soil-cement or soil-lime studies.

The work commenced in December 1973 and was originally scheduled for completion in October 1974. It was subsequently extended to January 31, 1975 to enable completion of studies at Sarnia.

The project was sponsored under the Ontario Joint Transportation and Communications Research Program (Project L-3). The work itself was carried out primarily in the Soil Mechanics and Soil Chemistry laboratories of the Faculty of Engineering Science, The University of Western Ontario. Support facilities in the Materials Science laboratory were used extensively for the X-ray studies.

Contents

1/Introduction

The clay deposits between London, Sarnia and Windsor in southwestern Ontario have a surface area of more than 2500 sq. mi. (6475 km^2). They are, therefore, of major geotechnical importance to the construction industry, particularly highway and roadway construction and maintenance. The majority of the deposits are quite thick and are believed to be "water-laid" tills. They are characterized by a very stiff to hard brown surface crust overlying firm to stiff clays that are only slightly preconsolidated.

Except for large bridges and high embankments, where bearing capacity and settlement considerations of the deep clays are required, roadway design and construction is concerned mainly with the crustal materials, which are used extensively for embankment fill. In particular, the upper 6 to 15 ft. (1.8 m to 4.6 m) of the crust is frequently used as clay borrow for embankment and subbase construction. Thus, it is the brown desiccated, oxidized soil from the upper crust that is involved in these compaction operations.

Recent research (Ogunbadejo, 1973; Ogunbadejo and Quigley, 1974) has shown that the near surface soils in the crust at Sarnia, Ontario, have highly variable compaction characteristics that are directly related to the degree of weathering. In particular, the chlorite present in the parent soils is known to oxidize and alter to swelling clay (smectite), reaching amounts of up to 15 percent of the surface soils. Leaching of carbonate from the surface soils downwards further complicates the composition and related compaction problems. //

The purpose of this project has been to assess in detail the practical aspects of near surface weathering on the compaction properties of crustal clay soils between London and Sarnia, Ontario. Three readily accessible sites with existing excavations were selected for study, namely, the Glencoe-Ekfrid Township landfill site; a highway borrow pit at Warwick; and, the Sarnia landfill site. Each site is discussed in detail.

2/Scope of Project and Procedures

2.1/ Scope

Soil classification, mineralogical and physicochemical testing generally comprised the first phase of the testing at each site. Some preliminary compaction testing was also done at this stage to confirm the existence of the expected variations in density. Once the interrelationship of mineralogy and compaction behavior was established, tests to determine the stress-strain and swelling characteristics were undertaken.

The mineralogical and physicochemical work was critical in the interpretation of the data, comprising about 45 percent of the project. Early exploratory tests with cement stabilization could not be interpreted because of the mineralogical variations in the crust and were therefore deferred in favor of an extended mineralogical testing program. The swell potential calculations and measurements comprised about 25 percent of the study and the remaining compaction-strength studies about 30 percent. The entire testing program was carried out over a nine-month period.

2.2/ Procedures

The field and laboratory work performed at each site consisted generally of the following sequence of operations:

1/ field sampling from exposed cuts at the three study sites, followed by grain size, Atterberg limit and specific gravity testing;

2/ extensive mineralogical and physicochemical testing to determine the mineral composition and degree of weathering; This work included carbonate, X-ray diffraction, glycol retention and potassium analyses using methods described in Appendix I. Of particular interest is the X-ray weathering index used to assess the relative amount of oxidation weathering of chlorite to smectite;

3/ preliminary compaction testing to establish the variation in maximum dry density and optimum moisture content with depth using the degree of weathering as the controlling factor;

4/ compaction of Harvard miniature specimens, which were then subjected to unconfined compression testing, to determine the stress-strain relationships of the weathered and unweathered soils;

5/ swell tests on disks of soil compacted in a special split mould of Harvard miniature size; The swell potentials were measured at 1 psi (6.9 kPa^2) loading and compared with calculated values using the method of Seed et al, 1962. The percentages of both swelling clay and soil carbonate played significant roles in soil swelling; therefore, this phase of the work was expanded to include studies on fractionated soil with and without soil carbonates, and also homoionized with sodium cations.

6/ plotting and interpretation of the tests results.

3/Site Locations and Geology

In this section the location of the three sites is considered with respect to the geology of the area. Previous work, including relevant mineralogical studies, is also discussed.

3.1/ Site Locations

The locations of the three study sites in relation to the surficial geology of the area are shown in Figure 1. All sites (Sarnia, Warwick and Glencoe) are located on St. Clair clay plain soils, believed to be comprised of water-laid till deposits of the Huron ice lobe (Chapman and Putnam, 1966; Dreimanis, 1961 and 1973).

Detailed site locations are given in Figure 2 for the Glencoe site and in Figure 3 for the Warwick and Sarnia sites. All three sites are located in the northern part of the clay plain; therefore, a large information void exists for the Wallaceburg, Tilbury, Windsor areas, representative of the southern portion of the clay plain.

3.2/ Geology of the Area

The water-laid till deposits of the area are believed to have been emplaced by a combination of lacustrine and ice contact processes beneath buoyant or nearly buoyant ice lobes from the Huron basin during deep water conditions associated with Lake Whittlesey and Saginaw (Dreimanis, 1973). Source materials included previously existing unconsolidated sediments plus shale and carbonate rocks of Devonian age. At least two till sheets of this origin exist in the area, as discussed at length by Quigley and Ogunbadejo, 1975, and Dreimanis, 1961.

The tills usually consist of silty clay, with clay comprising 40 to 60 percent of the total. Sand comprises 0 to nearly 20 percent of the total, depending on the location.

The composition of the till is dominated by carbonates (calcite and dolomite), quartz, illite and chlorites. The chlorites are the most interesting mineral component: They are chemically unstable under the oxidizing conditions existing in the crust and alter to smectite (swelling clay) as described in detail in section 3.3.

Previous studies of the geology and engineering behavior of these thick clay-till deposits include Legget (1946); Soderman, Kenney and Loh (1961); Soderman and Kim (1970); Adams (1970); Dreimanis (1961 and 1970); Ogunbadejo (1973); and, Quigley and Ogunbadejo (1975).

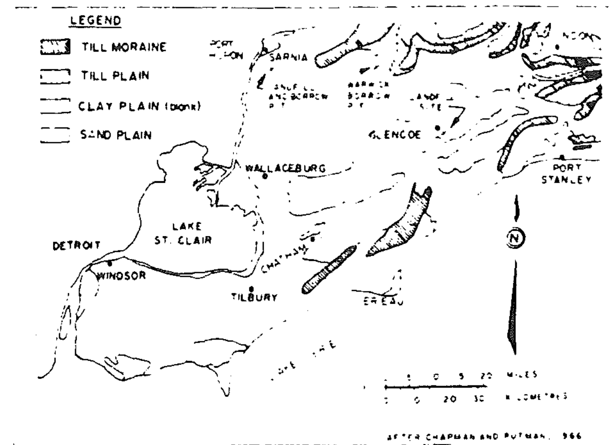


Figure 1/Surficial Soils of Southwestern Ontario and Site Location Map

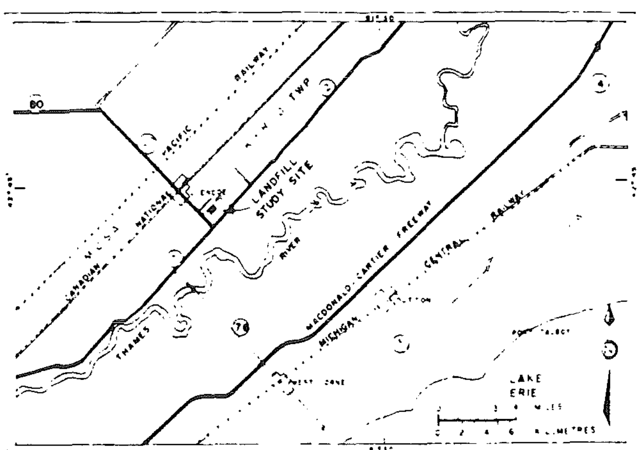


Figure 2/Location Map, Glencoe-Ekfrid Township Landfill Site

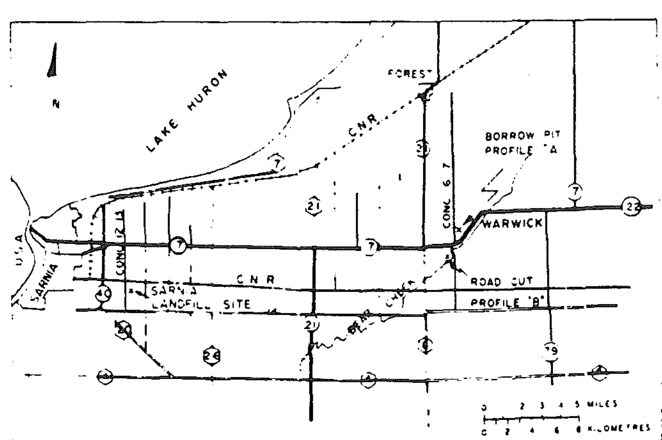


Figure 3/Location Map, Warwick, Borrow Pit and Road Cut, Sarnia Landfill Site

3.3/ Mineralogy of the Crustal Soils

The surface layer of clay till has been extensively desiccated and oxidized by natural weathering processes to form a crust. This crust is very stiff to hard; is characteristic of the clay deposits; and consists of an upper brown zone and a lower grey zone. The brown oxidized zone extends below the present-day lowest ground water levels and is believed to have been developed (in part) during a previous dry period 5000 to 7000 years B.C. (Soderman and Kim, 1970; Dreimanis, 1970). The actual process probably consisted of upward migration of pore fluid to satisfy surface evaporation and transpiration requirements. Highly variable thicknesses of grey crust at Lambton, Ontario, were attributed to desiccation by deep tree roots in forested zones (Adams, 1970).

At Sarnia, Ontario, part of the strength gain within the grey crust has been attributed to carbonate migration from the surface downwards (Quigley and Ogunbadejo, 1975).

Surface leaching throughout the study area has removed the carbonate from the uppermost 0.6 to 1.6 ft. (0.2 to 0.5 m) of soil. In some areas the soil may be carbonate-free to a depth of 3.3 ft. (1.5 m); however, this probably represents a "gley" deposit [infilling of a depression by surface creep or sloughing (Dr. A. Dreimanis, personal communication)]. Frequently a hump exists in the carbonate profile, indicating redeposition at depth.

Surface oxidation plays a significant role in crust formation by creating oxides and hydroxides of iron that act as cementing agents. In southwestern Ontario, oxidation also attacks the soil chlorite, altering it to smectite, as discussed in considerable detail by Fanning and Jackson (1966); Brady and Dean (1966); Quigley and Dreimanis (1972); Ogunbadejo and Quigley (1974); and Quigley and Ogunbadejo (1975). Basically the process involves oxidation of Fe^{++} within the crystal structure to Fe^{+++}, thus reducing the negative charge of the clay crystal. This permits the chlorite to split and expand, creating a smectite (swelling clay). Ogunbadejo and Quigley (1974) report an increase in swelling clay at Sarnia from 2 percent (unweathered) to 15 percent (weathered) at the surface. These changes result in a reduction in size of the 0.7 nm (7°A)* (002) iron chlorite peak towards the surface and a corresponding increase in size of the 1.4 to 1.5 nm peak of wet or glycolated smectite. The ratio of the 1.4 to 1.5 nm: 0.7 nm peaks is a useful nonlinear measure of the amount of weathering and in this report is referred to as X-ray weathering index.

Observation of borrow pits in the test area showed that highway fill was being extracted from the entire crust; so that both weathered and unweathered soils are compacted within many embankments. The purpose of this project was to assess the practical significance of this weathering on the compaction-strength stabilization properties of the soils.

*Note: 0.1 nm = 1°A

4/Sarnia Test Results

The Sarnia test site is located on grassland within the boundaries of the city landfill site about 4.5 miles (7.2 km) east of the city (Figure 3). The soil mechanics of the site have been extensively studied (Ogunbadejo, 1973); therefore, it serves as a particularly useful reference site. Also, the in situ weathering seems to be more extensively developed at this site than elsewhere.

The test results for the Sarnia soils are presented in Figures 4 to 13 and in Tables 1 to 5 in Appendix II. In the following sections, reference is made only to data presented in the figures.

An existing drainage trench was channel sampled for this study, yielding the soil profile shown in Figure 4. The soil is brown highly fissured, clayey silt till throughout. In the zone immediately below the 6 inches (15 cm) of topsoil, there was some evidence of complete removal of pebbles by leaching.

4.1/ Soil Classification and Composition

Soil texture, Atterberg limits and activity are plotted in Figure 5. The grain size is fairly constant with depth, although the percentage of clay increases from about 30 to 45 percent towards the surface. This may reflect the loss of silt-sized carbonate by surface leaching.

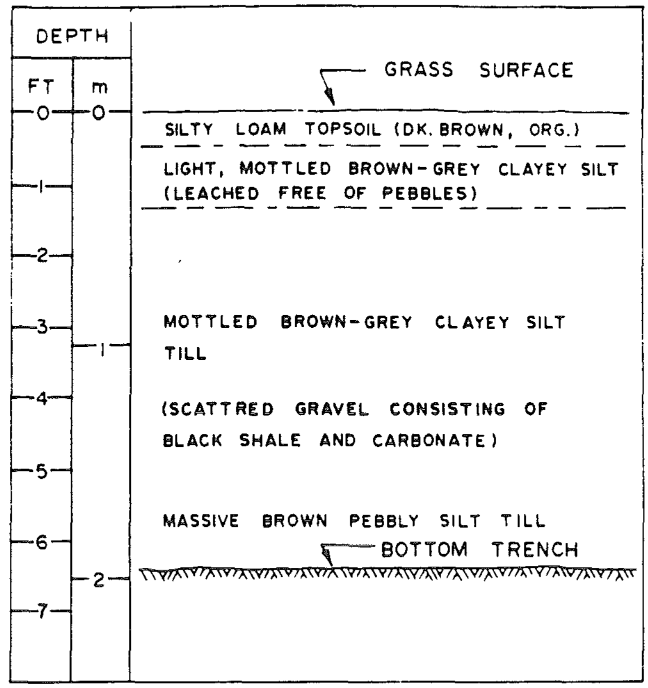


Figure 4/Sketch of Soil Profile at Sarnia

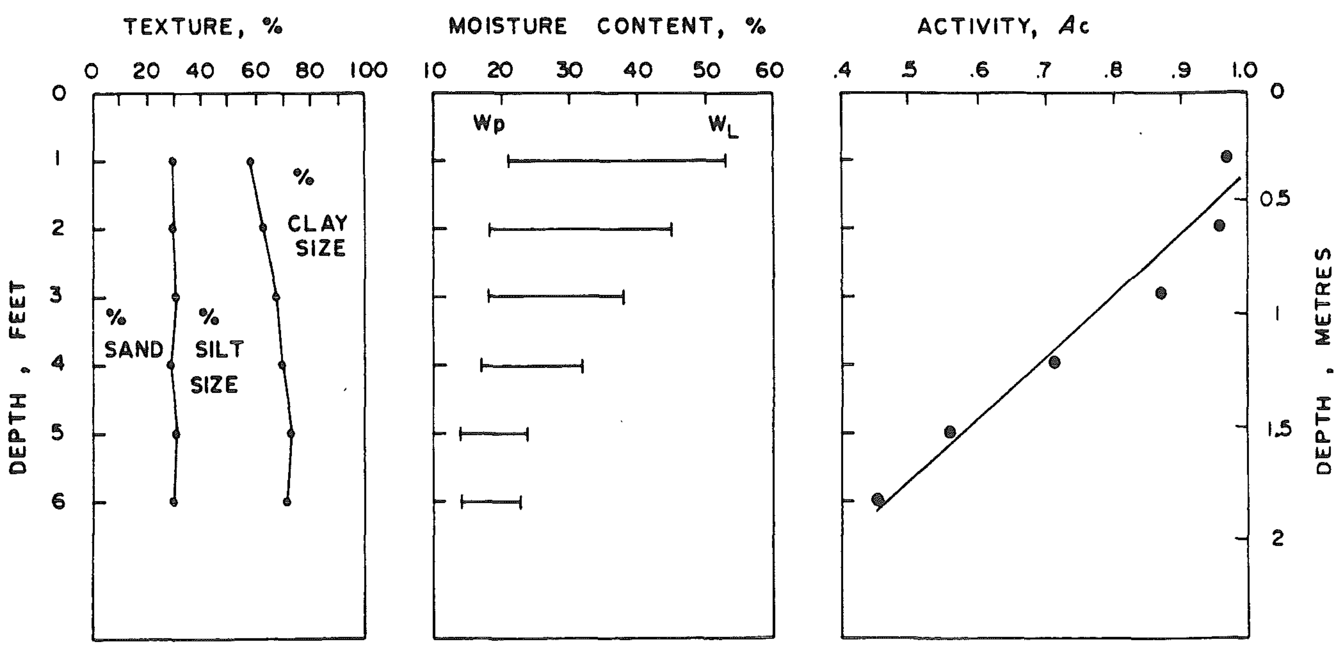


Figure 5/Grain Size, Atterberg Limits and Activity, Sarnia Soils

Both the liquid and plastic limits increase towards the surface. The liquid limit, in particular, increases from 20 to 52 percent, which yields a corresponding increase in activity from 0.45 at the 5 ft. (1.5 m) depth to 1.0 at the 1 ft. (0.3 m) depth. These increases are directly related to the increase in smectite towards the surface and are illustrated by the X-ray traces in Figure 6.

Detailed reference to Figure 6 indicates the presence of abundant 1.0 nm illite in both the 1 ft. (0.3 m) and 5 ft. (1.5 m) samples. The 0.7 nm peak represents Fe chlorite, and comparison with the 0.7 nm peaks for water-wet samples indicates that much more is present in the 5 ft. (1.5 m) sample. At the 1 ft. (0.3 m) depth the chlorite has been weathered by oxidation to produce the swelling clay represented by the 1.5 to 2.0 nm peaks. It is evident that much less swelling clay exists at the 5 ft. (1.5 m) depth.

The percent carbonate in the whole soil (less pebbles) is shown in Figure 7. The marked decrease towards the surface reflects the extensive leaching associated with downward percolation of groundwater.

Also shown in Figure 7 is the X-ray weathering index, which, for purposes of this report, has already been defined as the ratio of the 1.4 to 1.5 : 0.7 nm peak of oriented water-wet clay. The curve shows that at the 6 ft. (1.8 m) depth, the 1.5 nm peak is about the same size as the 0.7 nm peak. Towards the surface, however, the 1.5 nm peak height increases to three or four times the height of the 0.7 nm peak, reflecting the alteration of iron chlorite to smectite. At Sarnia this alteration occurs as deep as 15 ft. (4.5 m), so the X-ray index curve shown reflects only the upper part of the total curve.

The glycol retention of the $<2\ \mu m$ clay fraction increases from about 50 mg/g at the 6 ft. (1.8 m) depth to greater than 100 mg/g at the surface (Figure 7). This increase reflects the increasing amount of smectite and the associated increase in surface area of the clay soil.

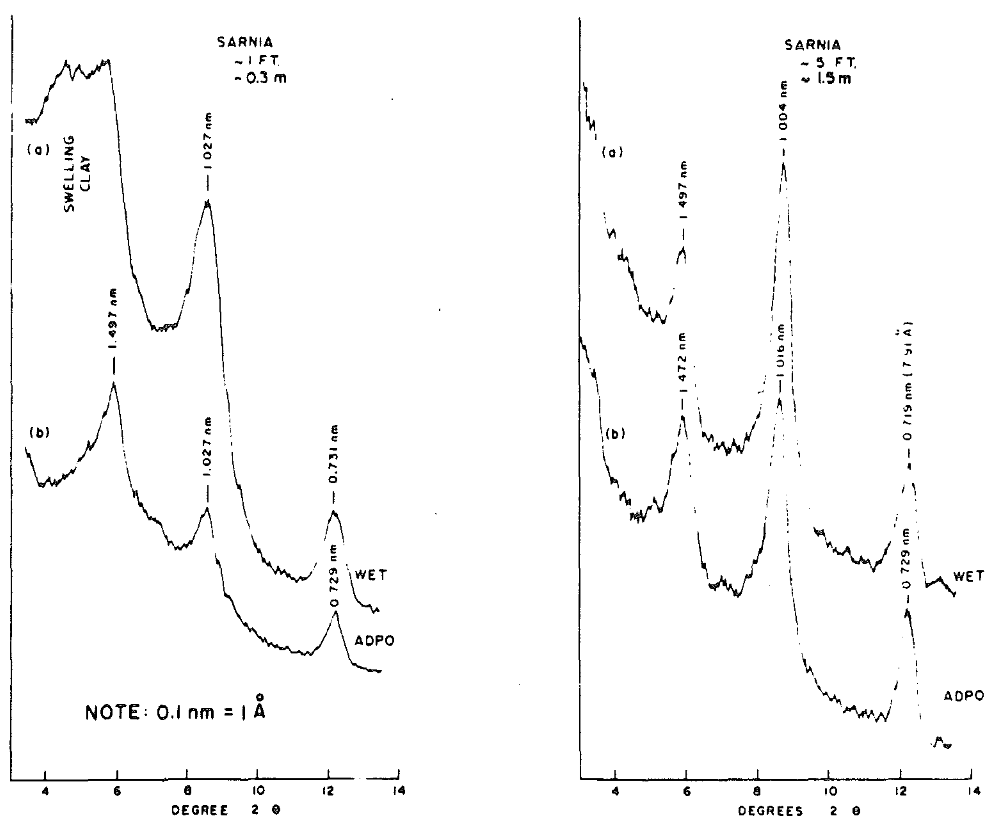


Figure 6/X-ray Diffraction Traces of Sarnia, $<2\mu m$ Clay Samples from 1 Ft. (0.3 m) and 5 Ft. (1.5 m) Depths: (a) Wet; (b) Air-Dried; Preferred Orientation

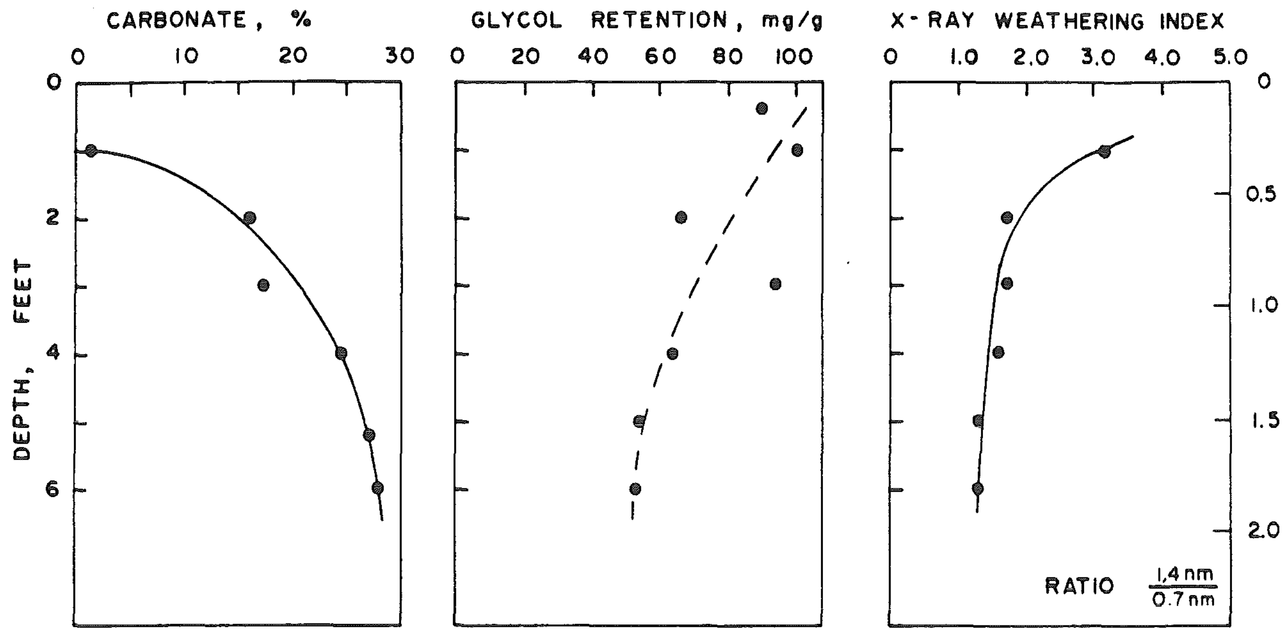


Figure 7/Chemical Changes with Depth, Sarnia Clay Crust

4.2/ Compaction-Strength-Depth Relationships

The effects of the increased smectite on compaction behavior are clearly illustrated in Figure 8. The soils from 6 ft. (1.8 m) yield a γ_d (max) of 120 pcf (1920 kg/m³) compared to 105 pcf (1680 kg/m³) at the 1 ft. (0.3 m) depth. The corresponding values of w_{opt} increase from ≈14.5 to 21 percent. These results are typical of both an increased clay content or an increased activity towards the surface, both of which occur at the site as illustrated in Figure 5. It should be noted that these results were obtained using a Harvard miniature compaction device with a 40 lb. (178 N) spring and 20 tamps on each of five layers of soil. (Test methods in Appendix I.)

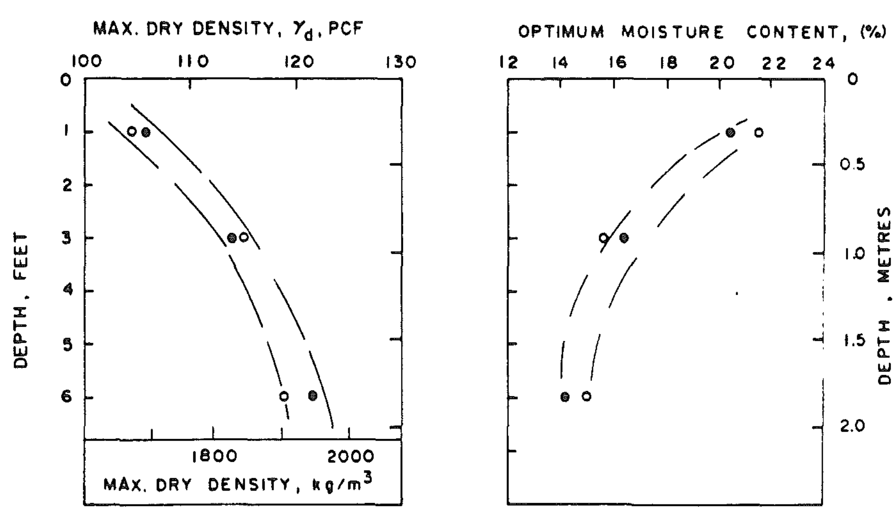


Figure 8/Compaction Density-Moisture Relationships, Sarnia Clay Crust

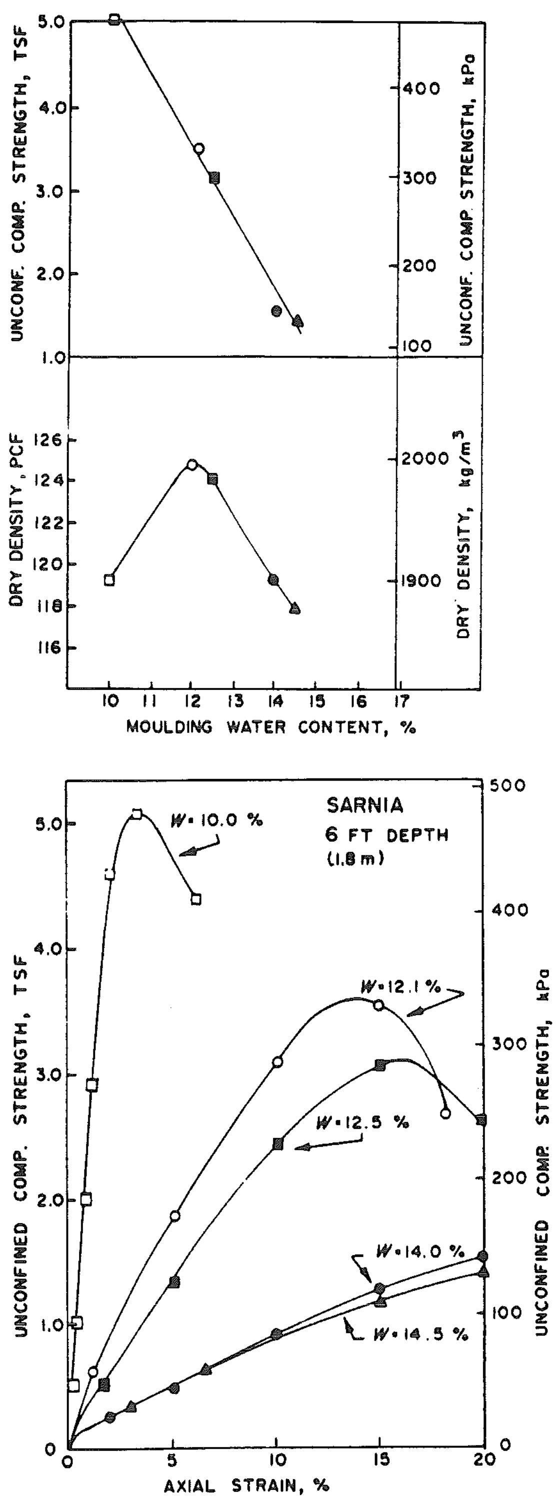


Figure 9/Compaction-Strength Summary Plots, SA #S-A6, 6 Ft. (1.8 m) Depth, Sarnia Soils

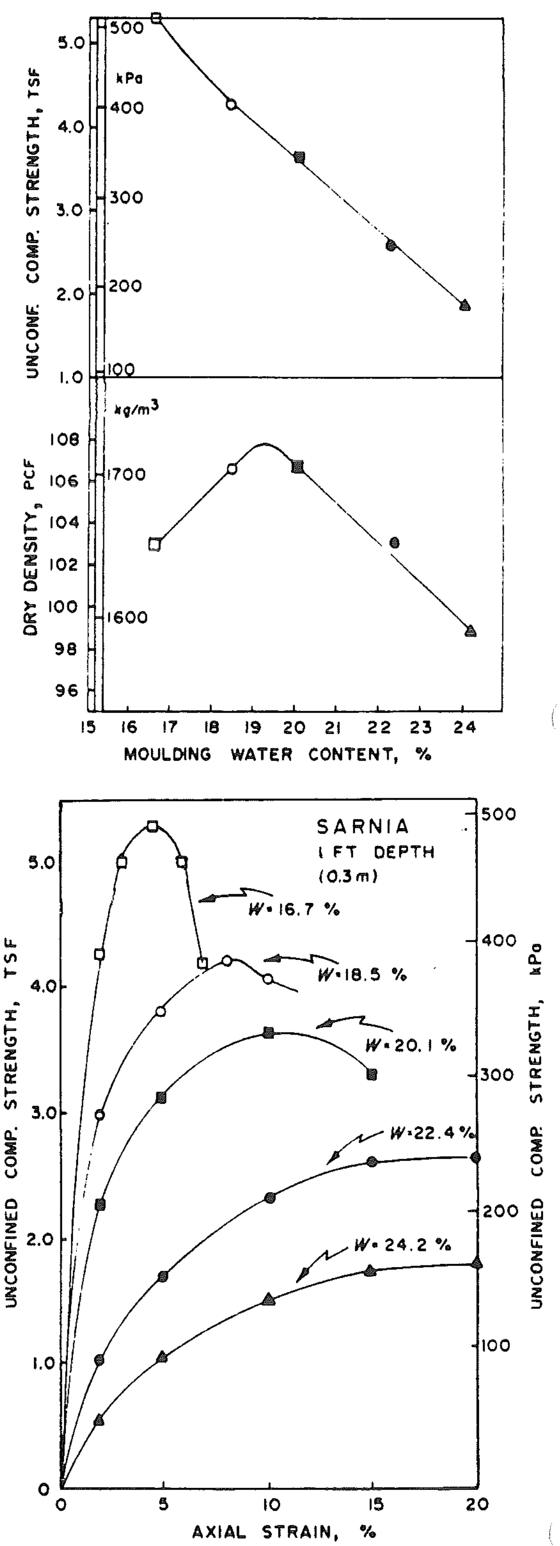


Figure 10/Compaction-Strength Summary Plots, SA #S-A1, 1 Ft. (0.3 m) Depth, Sarnia Soils

In Figures 9 and 10 the compaction-strength relationships are plotted for the Sarnia soils from the 6 and 1 ft. (1.8 and 0.3 m) depths, respectively. Within the range of moulding water contents employed (10 to 24 percent), the unconfined compressive strength shows a nearly linear relationship with moisture content, with the driest soils yielding the highest strengths. This is in marked contrast to the Glencoe results in which the strengths dropped off both above and below the optimum water content.

The soil from the 1 ft. depth (0.3 m) (with abundant smectite and little, if any, carbonate) has an unconfined strength of nearly 4 tons/ft.^{2} (380 kPa) compared to a value of 3.3 tons/ft.^{2} (316 kPa) for the less weathered soil from the 6 ft. (1.8 m) depth. This is in spite of a much higher water content (≈19 percent compared to 12 percent) and a much lower dry density [≈108 pcf (1730 kg/m^3) compared to 125 pcf (2000 kg/m^3)].

Stress-strain curves for the compacted soils show steep slopes at small strains for the soils compacted dry of optimum. With increasing water content the curves become increasingly flat; the compressive strength decreases; and the failure strain increases from about 3 to 20 percent.

4.3/ Swell Potential

Swell potential calculations were made using the method described by Seed, Woodward and Lundgren, 1962. The equation is as follows:

$$S\ (\%) = (3.6 \times 10^{-5})\ (Ac^{2.44})\ (C^{3.44})$$

Actual swell potential measurements were also carried out on small specimens compacted in a ring built into a split Harvard miniature compaction mould as described in Appendix I. A normal load of 1 psi (6.9 kPa) was used for all tests.

The swell potential values calculated from the values of activitity (Ac) and percent clay (C) are plotted in Figure 11. Values as high as 12 or 13 percent are calculated for the 1 ft. (0.3 m) ~~deep~~ soils, whereas the measured value was only 6 percent. This indicates that these soils are considerably less prone to swelling for a given activity than the soils tested by Seed et al, 1962. The main factors are probably that 1) the smectite is a low charge vermiculite rather than true montmorillonite; ~~and, 2) the soil carbonates greatly impede swelling.~~

The swell curves for three samples from Sarnia are shown in Figure 12. It is felt that both the 3 and 6 ft. (0.9 and 1.8 m) samples should have shown some swell as they did at Warwick and Glencoe. Most swelling was complete within 24 hours.

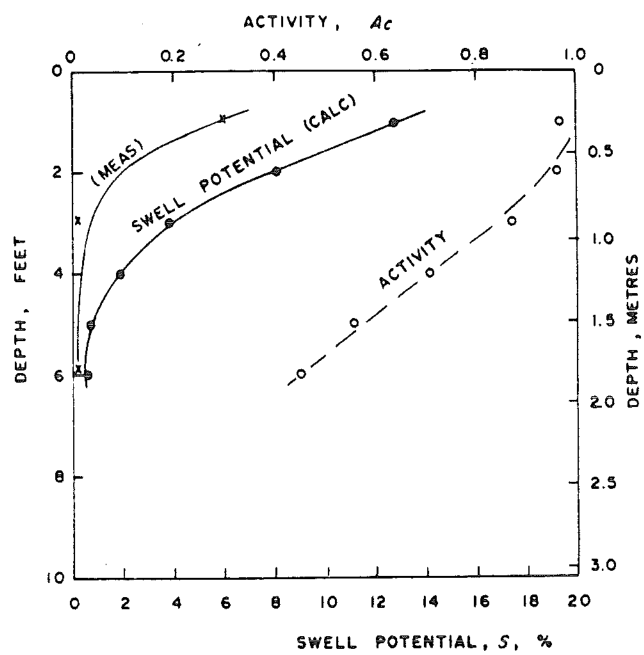


Figure 11/Activity and Swell Potential Sarnia Soils (Calculated and Measured)

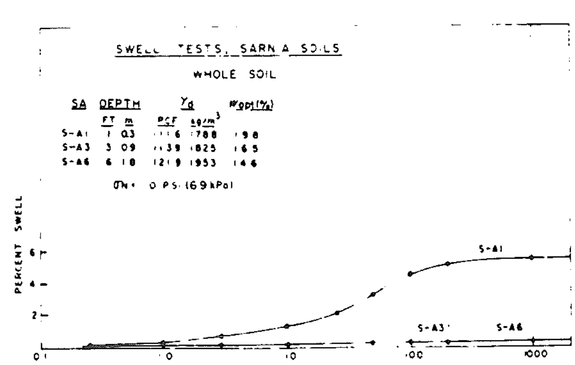


Figure 12/Swelling vs Time Curves, Sarnia Soils

4.4/ Shear Strength Parameters (Residual)

The results of multiple traverse, drained direct shear tests run on compacted Sarnia samples from the 1 and 6 ft. (0.3 and 1.8 m) depths are shown in Figure 13. It has been known for some time (e.g. Kenney, 1967) that montmorillonite has a residual friction angle of about 10° compared to 27° for illites and chlorites. The surface soil yielded a ∅res of 19.5° compared to 29° for the soil at the 6 ft. (1.8 m) depth. This reduction is directly related to the increased smectite content of the surface soils. Embankments, river banks and dykes constructed of crustal soils in southwest Ontario should exhibit the same 10° variation in friction angle as noted here for the Sarnia crustal soils.

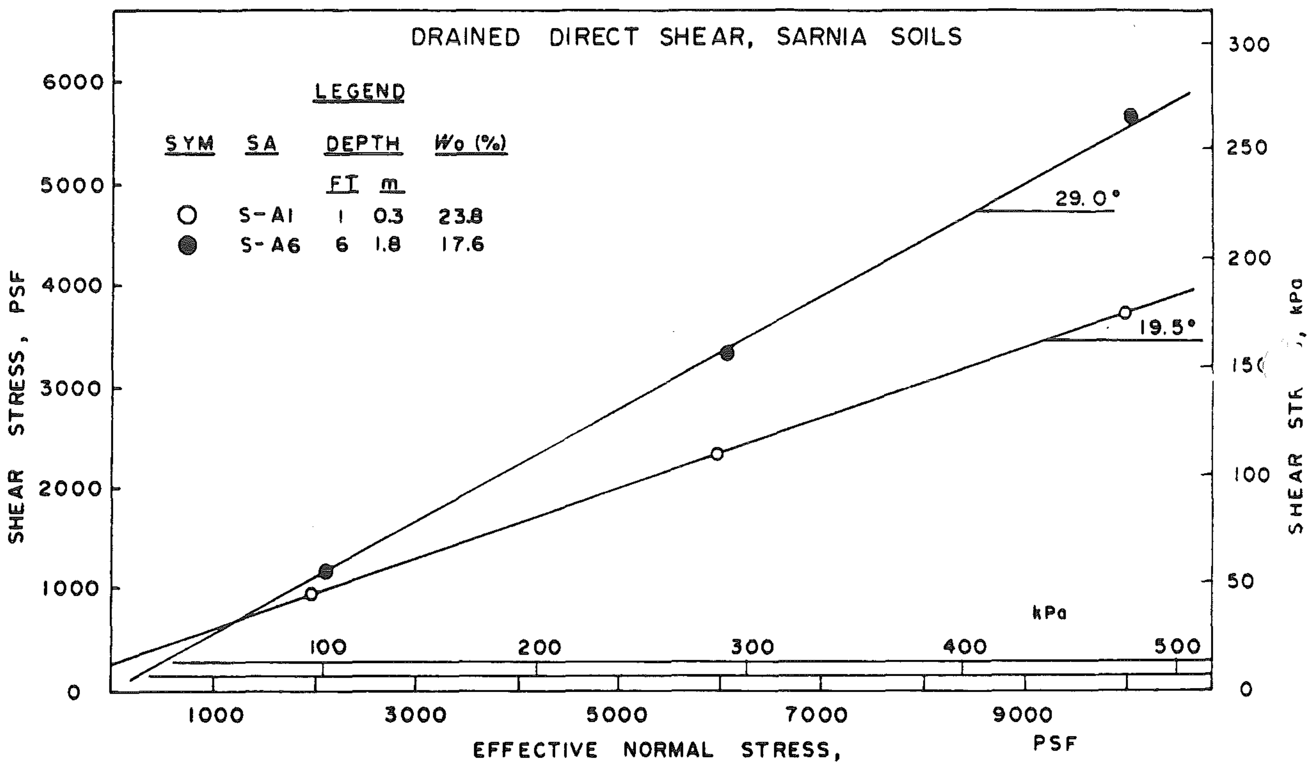


Figure 13/Residual Strength Parameters from Multiple Traverse Drained Direct Shear Tests on Sarnia Soils

5/ Warwick Test Results

Two sites were studied at Warwick. The initial site (Profile A) was a 9 ft. (2.7 m) deep borrow pit from which soil was excavated for use as highway subgrade fill for new Highway 402 between Sarnia and London. Initial sampling was done during frozen ground conditions of the early winter of 1973-74. Later sampling was impossible because the pit filled with meltwaters and remained full for the entire summer of 1974. A road cut (Profile B) south of the borrow pit was sampled during the summer to check the earlier results from the borrow pit. The locations of both Warwick sites are shown in Figure 3. The test results are plotted in Figures 14 to 21 and tabulated in Tables 6 to 10 in Appendix II.

The surface soils at the borrow pit (Profile A) were badly disturbed by earth-moving equipment apparently used to place the pile of organic debris shown in Figure 14. The soil sampled and tested was a brown, fissured silty clay till that contained a more silty stratum between the 5 and 7 ft. (1.5 and 2.1 m) depths. At the 6 ft. (1.8 m) depth the colour changed from brown to grey.

At Profile B (road cut) the brown, pebbly clayey silt till extended to shale bedrock at the 9 ft. (2.7 m) depth. A layer of laminated silts and clayey silts occurred in the till between the 2 and 3.5 ft. (0.6 and 1.1 m) depths. The till between this layer and the topsoil appeared leached. Abundant black shale pebbles occurred in the till directly above the bedrock contact.

5.1/ Soil Classification and Composition

Profile A: The till at the borrow pit consisted of about 50 percent clay and 50 percent silt sizes except for the silty stratum, which contained more silt as shown in Figure 15. The liquid limit showed an increase from about 32 percent at the 8.5 ft. (2.6 m) depth to 43 percent at the 1.5 ft. (0.5 m) depth, a feature also noted at Sarnia and explained by an increase in swelling clay towards the surface.

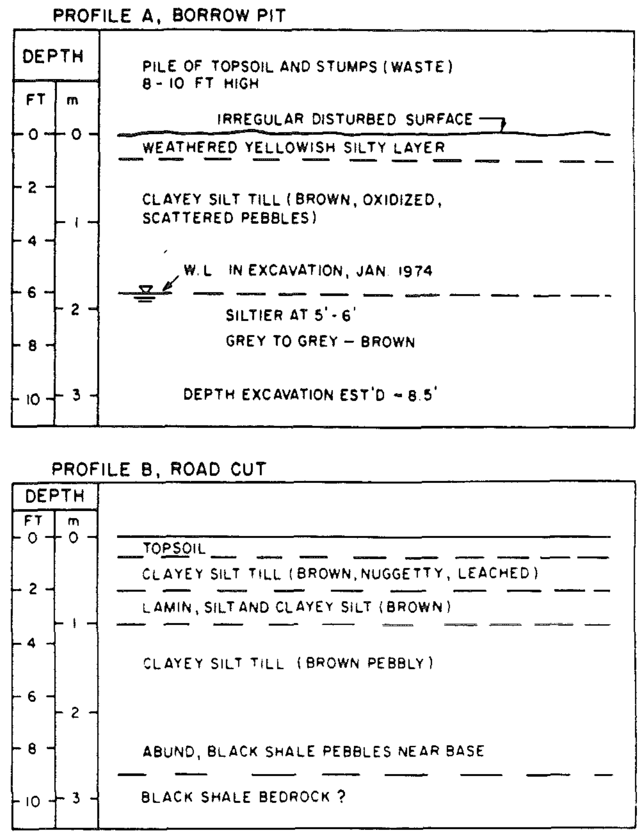


Figure 14/Sketches of Soil Profiles A and B, Warwick Sites

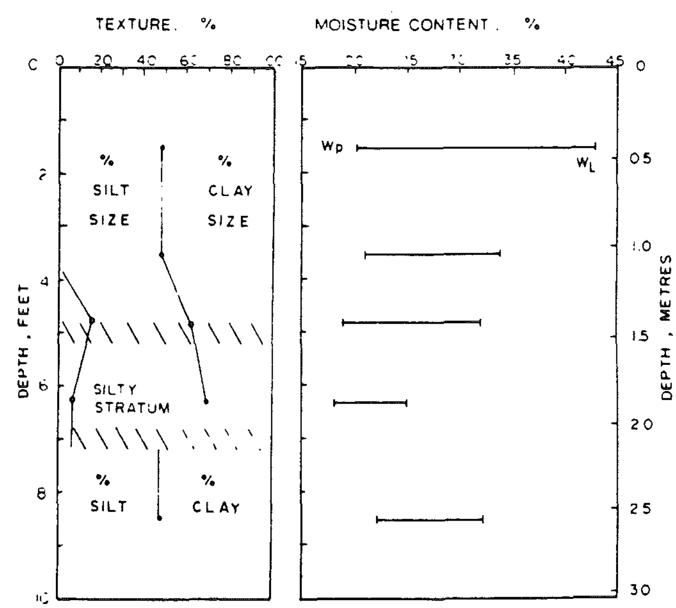


Figure 15/Grain Size and Atterberg Limits, Warwick Profile A, Borrow Pit

The X-ray traces in Figure 16 show an increase in swelling clay towards the surface as a result of oxidation weathering of chlorite, as previously discussed for the Sarnia soils (i.e. a reduced 0.7 nm and an increased 1.4 to 1.5 nm peak towards the surface). The ratio of the 1.4 to 1.5 nm: 0.7 nm peaks (weathering index) given in Figure 17 indicates a near suface ratio of up to 2. At Sarnia this ratio reached 3 or more near the surface, indicating more extensive weathering. The ratio is also much higher at the 6 ft. (1.8 m) depth (1.0 at Sarnia compared to 0.4 at Warwick), indicating a greater depth of oxidation weathering at Sarnia, as discussed by Quigley and Ogunbadejo, 1975.

The carbonate is leached from about the upper foot of the profile, but reaches normal concentration (20 percent) at 2 ft. (0.6 m). The hump in the carbonate curve at 3 ft. (0.9 m), (28.6 percent),

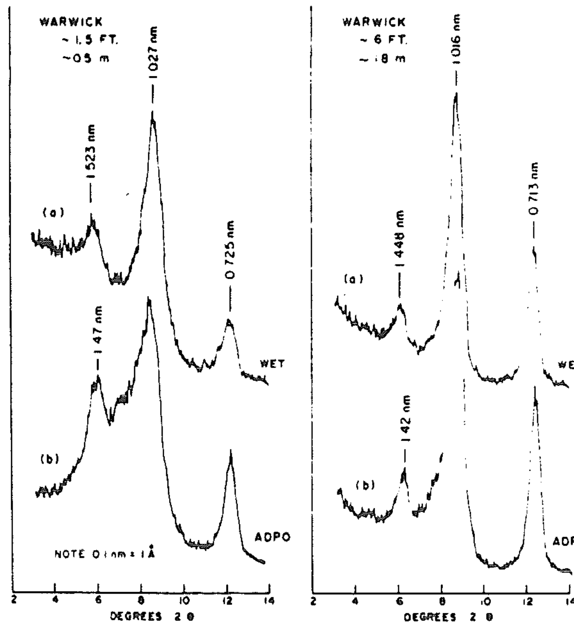


Figure 16/X-ray Diffraction Traces of Warwick, <2 μm Clay Samples from 1.5 Ft.(0.45 m) and 6 Ft.(1.8 m) Depths: (a) Wet, (b) Air-Dried; Preferred Orientation

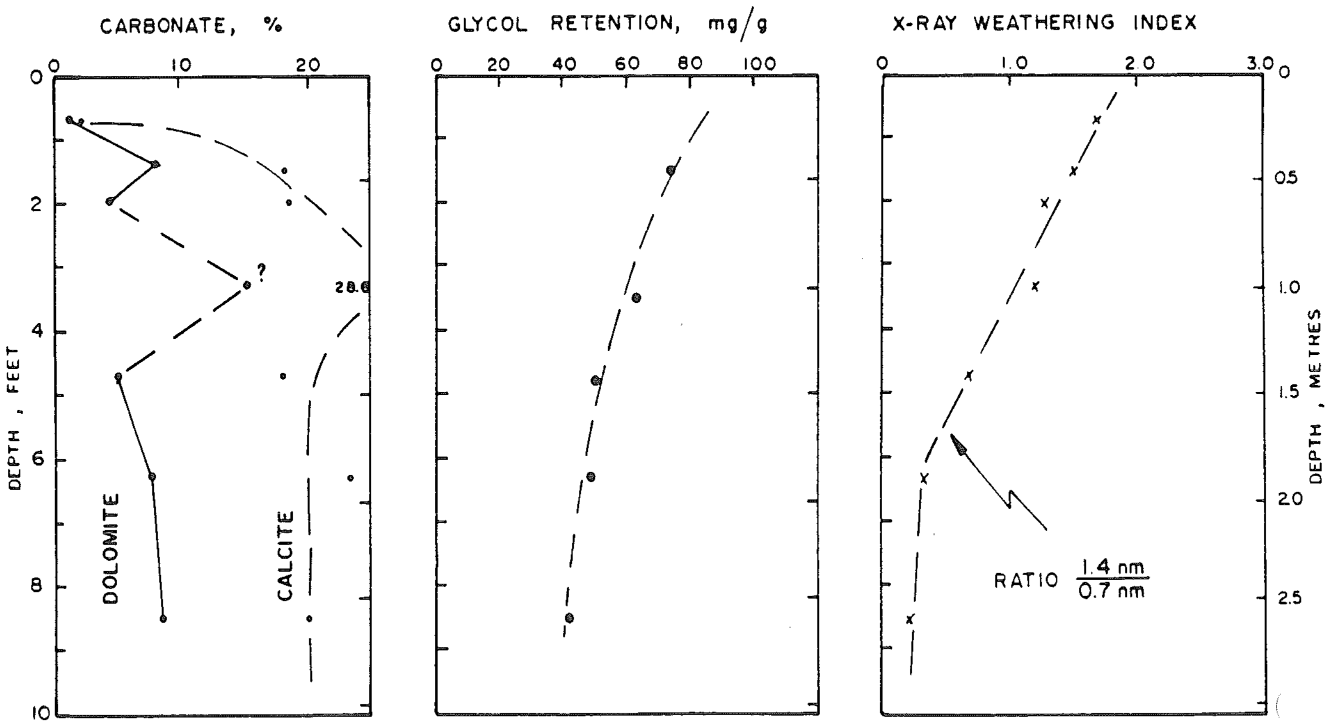


Figure 17/Chemical Changes with Depth, Warwick Clay Crust, Profile A, Borrow Pit

may represent a redeposition zone or an error in sampling. The carbonates are rich in calcite similar to the Glencoe soil discussed later.

The glycol retention values increase from 40 to 80 mg/g towards the surface, again reflecting the presence of swelling clay with its high specific surface area.

Profile B: The soils from the road cut varied considerably in grain size as shown in Figure 18 and did not seem to be as extensively oxidized as at the borrow pit. For example, the liquid limit did not increase greatly towards the surface (Figure 18); the carbonate was low only near the topsoil (Figure 19); and, the glycol retention increased only very close to the surface (Figure 19). The weathering index showed some increase towards the surface, but no rapid rise as shown by Profile A.

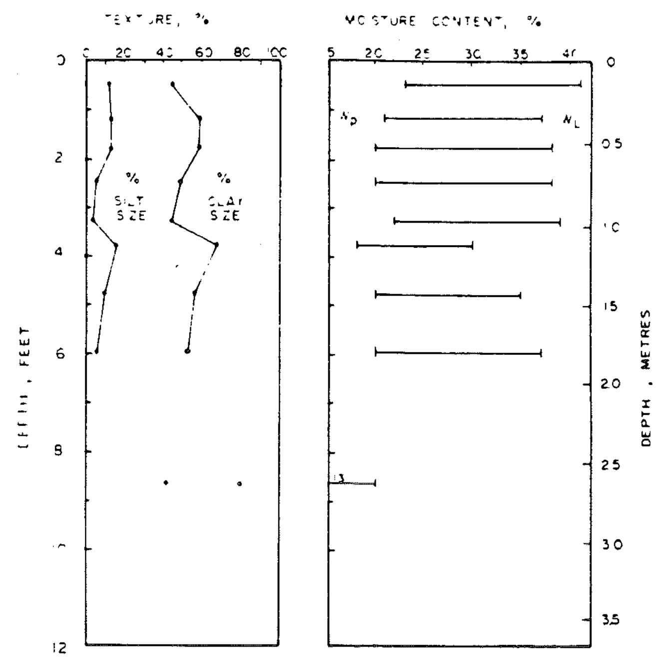


Figure 18/Grain Size and Atterberg Limits, Warwick, Profile B, Road Cut

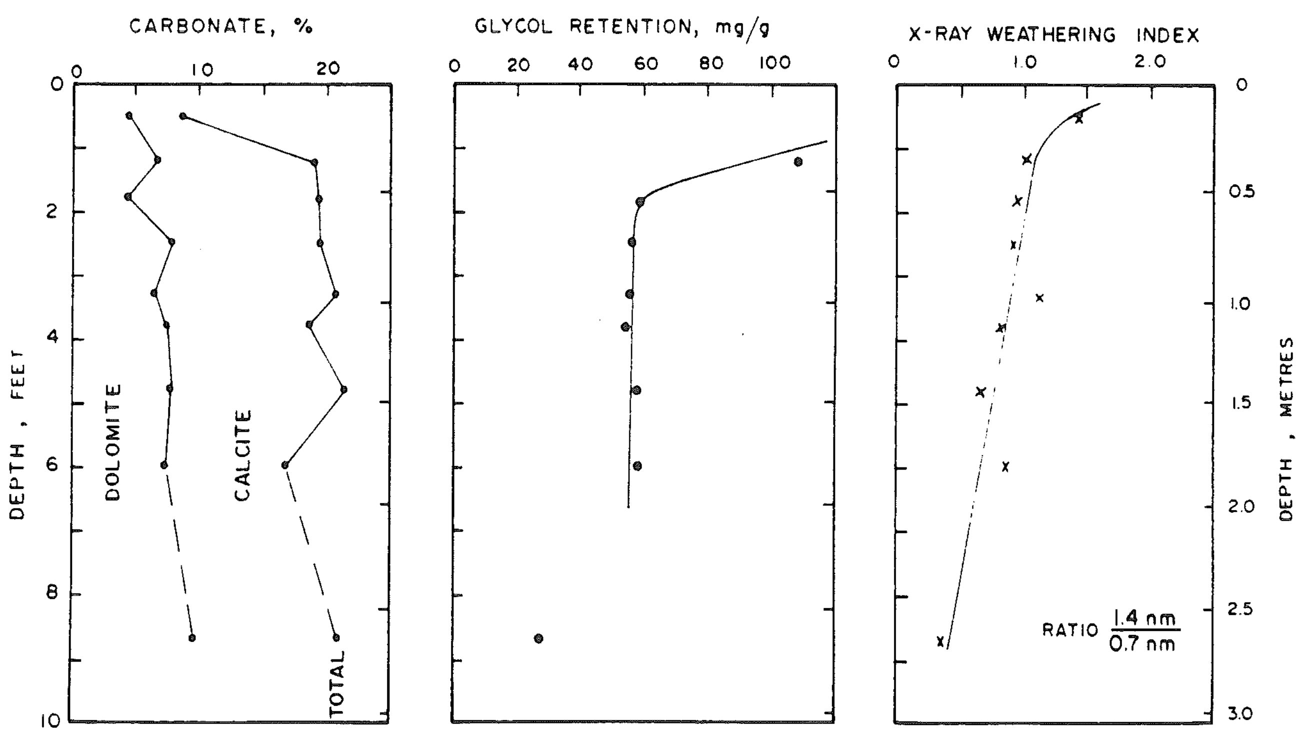


Figure 19/Chemical Changes with Depth, Warwick Clay Crust, Profile B, Road Cut

5.2/ Compaction Results

The results of Harvard miniature compaction tests performed on the soils from the borrow pit only (profile A) are presented in Figure 20. Except for the anomalous value caused by the silt layer at 5 ft. (1.5 m), γ_d (max) for the till decreases from about 112 pcf (1790 kg/m³) at the 8.5 ft. (2.6 m) depth to about 107 pcf (1710 kg/m³) at the 1.5 ft. (0.5 m) depth. The corresponding optimum moisture contents increase from about 18.5 to 20 percent. These trends are similar to, but not as great as, those exhibited by the Sarnia soils, where γ_d (max) decreased from 120 to 105 pcf (1920 to 1680 kg/m³) towards the surface. This may be attributed to lesser amounts of swelling clay in the Warwick profile.

5.3/ Swell Potential

Swell potentials were not measured for the Warwick sites; however, they were calculated and the results are plotted in Figure 21. All but one of the calculated values are less than 4 percent. This indicates little danger of swell, since measured values are likely to be less than half the calculated values, as noted at Sarnia and plotted in Figure 11.

The single high value of 12 percent at the 1.5 ft. (0.5 m) depth for Profile A is probably real enough, and some swell should be expected from near surface borrow materials low in carbonate.

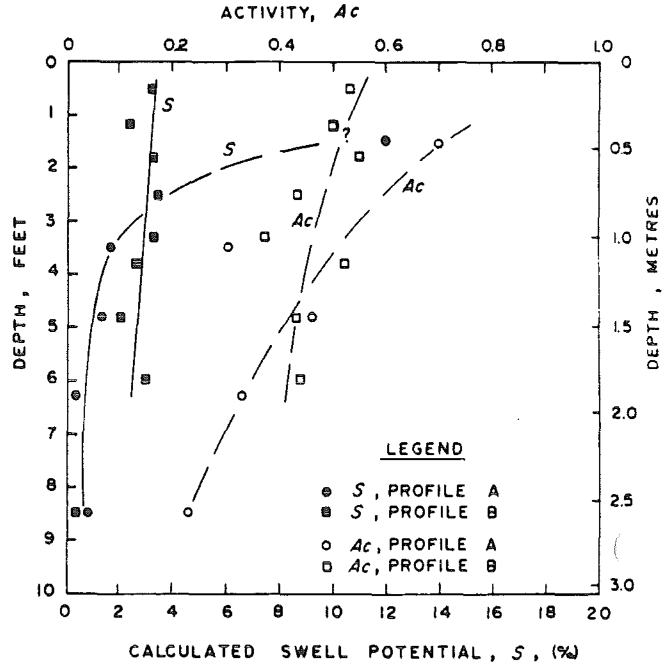


Figure 21/Activity and Swell Potential, Warwick Soils, Profiles A and B

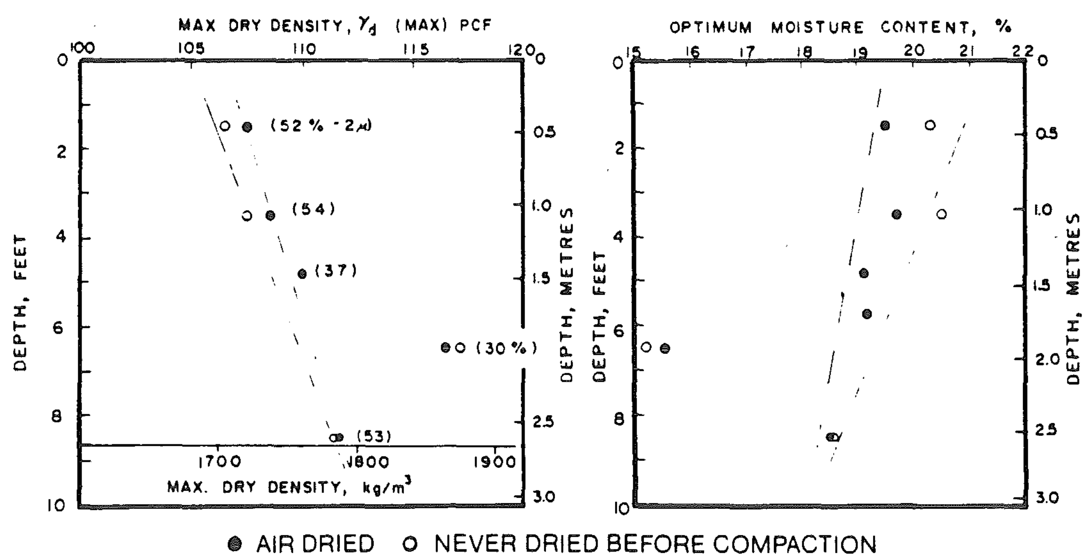


Figure 20/Harvard Miniature Compaction, Warwick Weathered Crust, Profile A, Borrow Pit, Percent Clay Size in Brackets

6/Glencoe Test Results

6/ Glencoe Test Results

The Glencoe test site is located on grass land just east of Glencoe and north of Highway 2 as shown in Figure 2. The trench dug for garbage disposal was about 15 ft. (4.6 m) deep, thus a good section was available for easy study. Sampling was done during January and February 1974 while the ground was frozen and full of ice lenses (along the fissures), so in situ water contents were not obtained.

The section consisted of brown, fissured clayey silt to silty clay with a variable content of pebbles. Usually it looked like a till; it is therefore inferred to belong to the "water-laid" type of till discussed under Geology. A descriptive log of the section is presented in Figure 22.

More effort was devoted to this site than the other two, since it was closest to London and could be easily resampled. The mineralogical and textural changes were also complex, and it took longer to unravel the technical controls on the soil behavior. In particular, extra swell tests were run on fractionated soil, carbonate-free soil and sodium homoionized soil in an effort to establish the range of potential swelling properties.

6.1/ Soil Classification and Composition

Plots of texture, Atterberg limits and activity are given in Figure 23. Below the 4 ft. (1.2 m) depth the till consists of about 60 percent clay size, 38

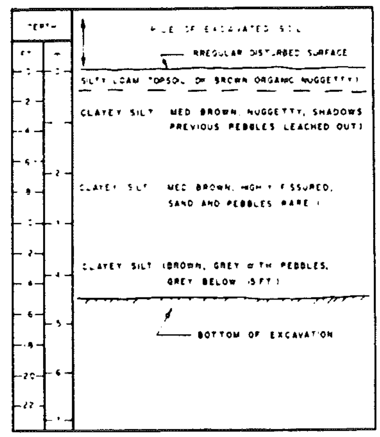


Figure 22/Sketch of Soil Profile at Glencoe, Ekfrid Township Landfill Site

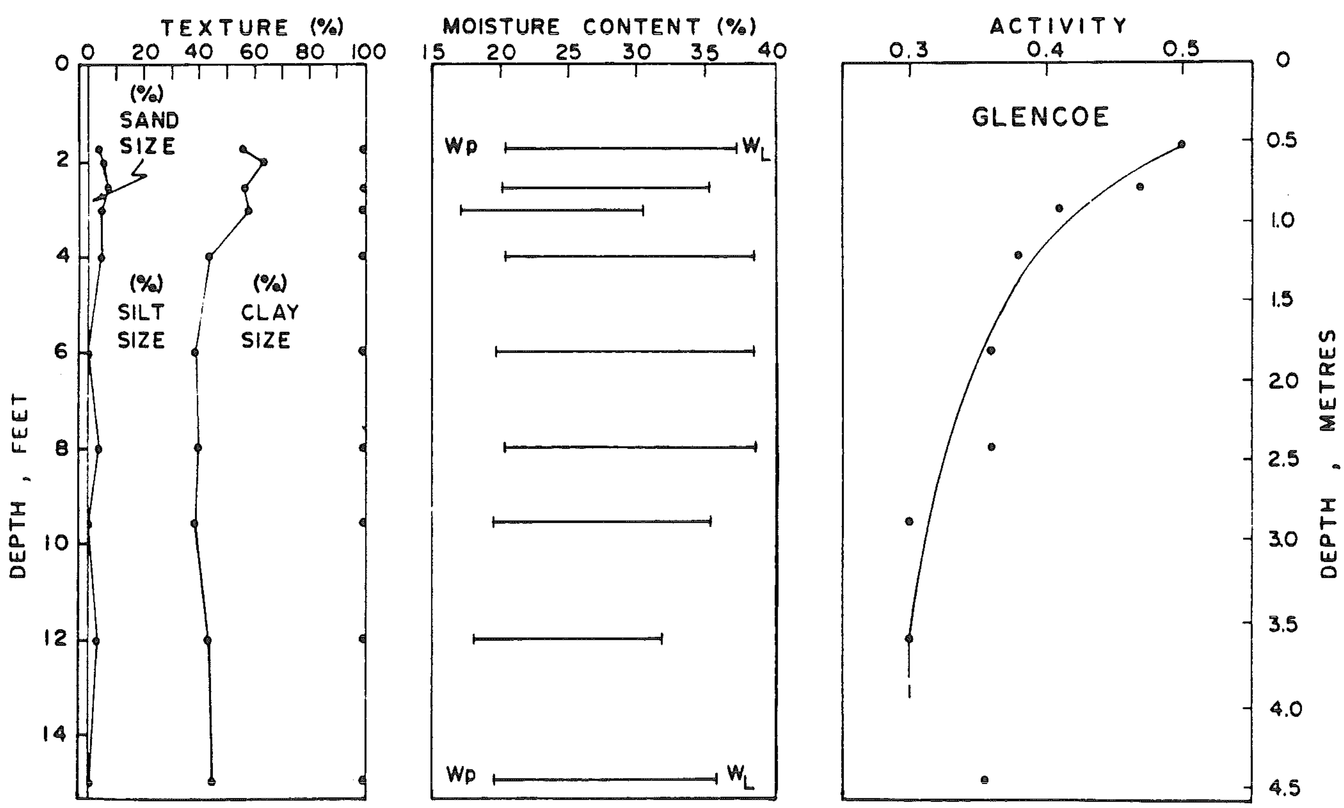


Figure 23/Grain Size, Atterberg Limits and Activity vs Depth, Glencoe Clay Crust

percent silt size and 2 percent sand size. Above 4 ft. (1.2 m) the clay content decreases to about 40 percent, and the silt fraction increases to about 50 percent.

The liquid limit does not increase much towards the surface, staying constant at about 38 percent despite a decrease in clay content. The presence of swelling clay is shown by the activity that increases steadily from 0.3 at the 12 ft. (3.6 m) depth to 0.5 at the 2 ft. (0.6 m) depth. This is still only half of the activity reported for the Sarnia area surface soils.

X-ray traces of the wet < 2 μm fractions from the 2.5 and 6 ft. (0.8 and 1.8 m) depths are presented in Figure 24. Once again the 0.7 nm peak decreases in size towards the surface and the resultant 1.4 to 1.5 nm peak increases in size, indicating destruction of Fe chlorite and production of smectite.

The X-ray weathering index for the whole profile shows an increase from about 0.3 at the 15 ft. (4.6 m) depth to 3.0 at the 1 ft. (0.3 m) depth as shown in Figure 25. These values

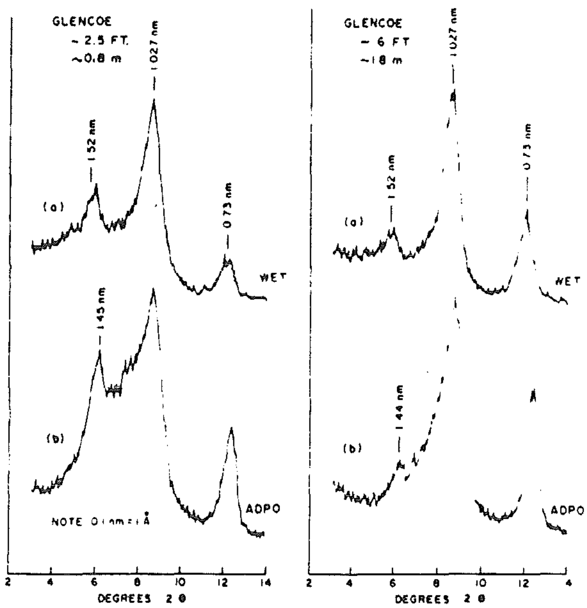


Figure 24/X-ray Diffraction Traces of Glencoe, <2 μm Clay Samples from 2.5 Ft. (0.75 m) and 6 Ft. (1.8 m) Depths: (a) Wet; (b) Air-Dried; Preferred Orientation

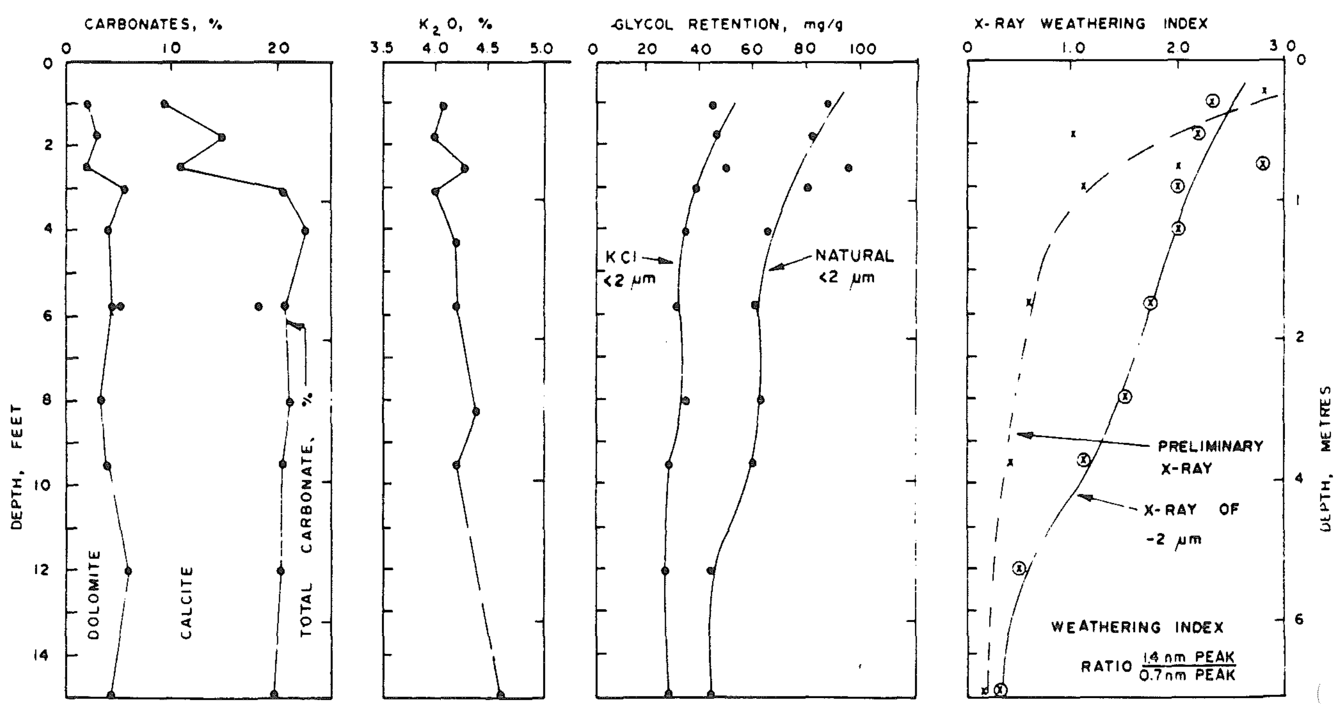


Figure 25/Chemical and Compositional Changes with Depth, Glencoe Clayey Crust

[especially those above the 9 ft. (2.7 m) depth] are comparable in size to those obtained for the deep weathering at Sarnia.

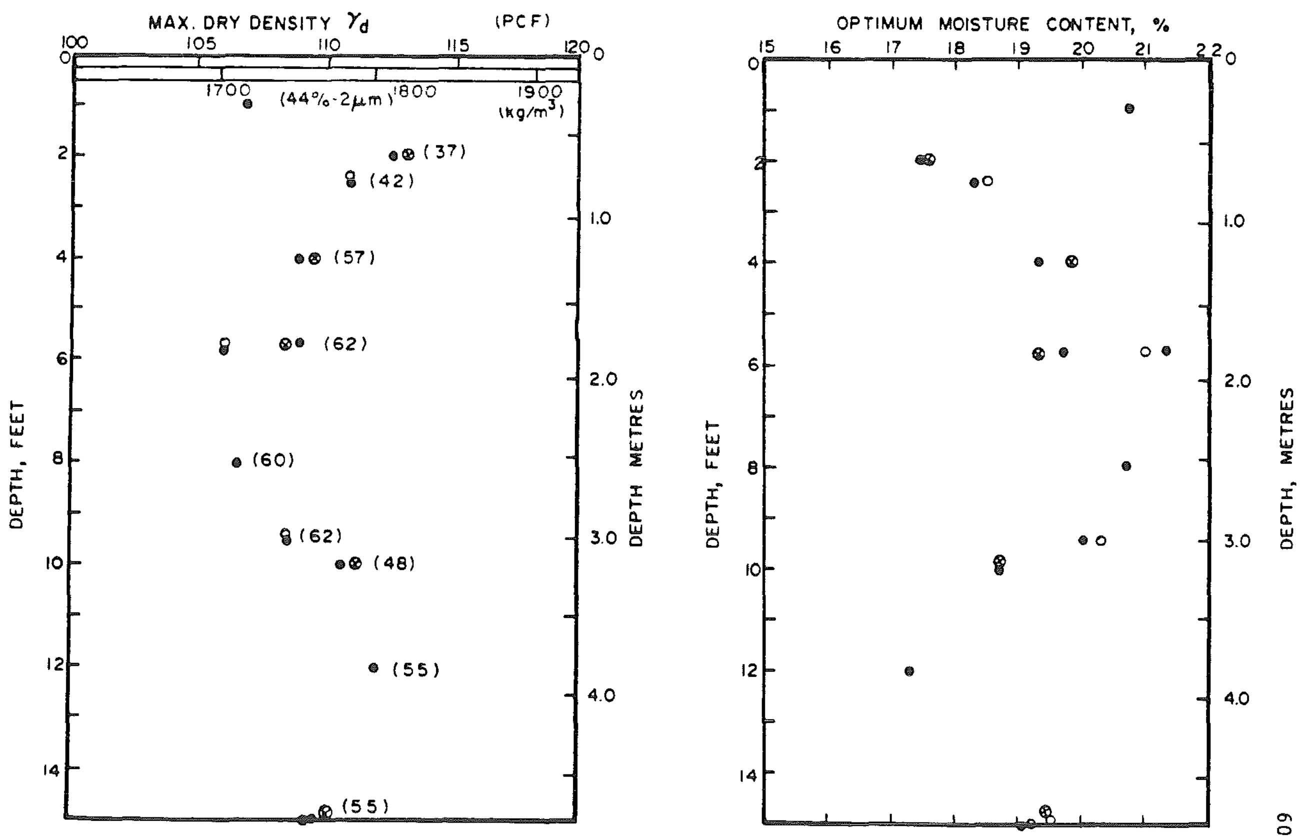
Carbonate leaching at the Glencoe site is incomplete, and although some depletion occurs to the 3 ft. (0.9 m) depth, there is still 10 percent carbonate in the soil at 1 ft. (0.3 m) directly below the topsoil. *Total carbonate* runs 19 to 20 percent for the till with slightly more in the redeposition zone between 3 and 8 ft. (0.9 and 2.4 m). It is significant that there is nearly four times as much calcite as dolomite in this till. This shows it to be similar to the Warwick till but different from the upper till at Sarnia, which is dolomite rich (Quigley and Ogunbadejo, 1975).

The K_2O profile in Figure 25 shows an increase from about 4.0 to 4.5 between the 1 and 9 ft. (0.3 and 2.7 m) depths. It is believed that this increase reflects the increase in clay content shown in Figure 23 and not potassium depletion due to weathering.

Glycol retention values for the $-2\mu m$ fraction increase from 45 to 90 mg/g between the 12 and 1 ft. (3.6 and 0.3 m) depths. As before, these reflect the increased swelling clay towards the surface. The glycol values given for the potassium treated clay are about one half of those for the untreated clay. This indicates a smectite with pronounced collapse characteristics, such as a low charge vermiculite.

6.2/ Compaction-Strength-Depth Relationships

The compaction data are presented in Figure 26; it is immediately evident that the trend of decreasing γ_d (max) noted at Sarnia and Warwick is not clear for this site. Between 12 and 6 ft. (3.6 and 1.8 m), γ_d (max) does decrease from about 112 pcf to 107 pcf (1790 to 1710 kg/m³), and this probably does reflect the increasing smectite content shown by the weathering index curve. The rapid increase



● AIR DRIED BEFORE COMPACTION ○ NEVER DRIED BEFORE COMPACTION
⊗ PROCTOR COMPACTION (AIR DRIED)

Figure 26/Maximum Dry Density and Optimum Moisture vs Depth, Glencoe Clay Crust

in γ_d (max) above 6 ft. (1.8 m) probably results from the decreasing clay content shown in Figure 23, a factor that masks the opposite effects of increasing smectite.

Although most of the points plotted in Figure 26 represent Harvard miniature compaction results, five standard Proctor tests are also plotted. They are nearly identical in value to the Harvard miniature test results, indicating the feasibility of using the latter test in this study program.

Unconfined compression test results for samples from 2, 4, 6, 10 and 15 ft. (0.6, 1.2, 1.8, 3.0 and 4.6 m) are presented in Figures 27 to 31 inclusive. In all plots the unconfined strength decreases both wet and dry of optimum. This is in contrast to the Sarnia data, where, within the moisture range tested, the dry soils were stronger than those compacted at optimum. The stress-strain curves are typical of compacted soils, with the driest soils yielding much more brittle behavior than the wet soils. It is perhaps significant that the strongest soils (i.e. those compacted at or close to optimum) did not yield stress-strain curves as steep as weaker soils compacted dry of optimum.

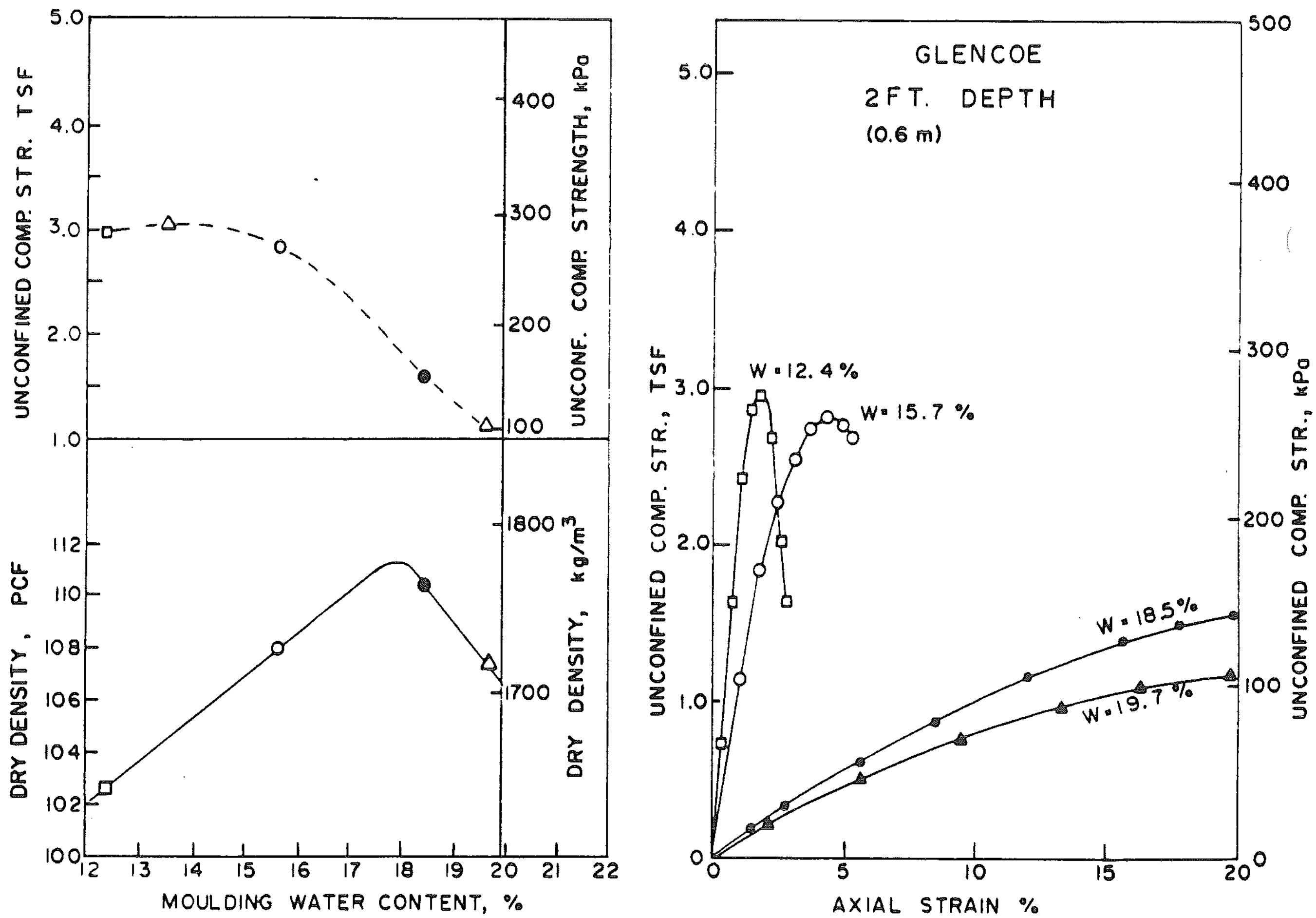


Figure 27/Compaction-Strength, Summary Plots, SA G-B2, 2 Ft. (0.6 m) Depth, Glencoe

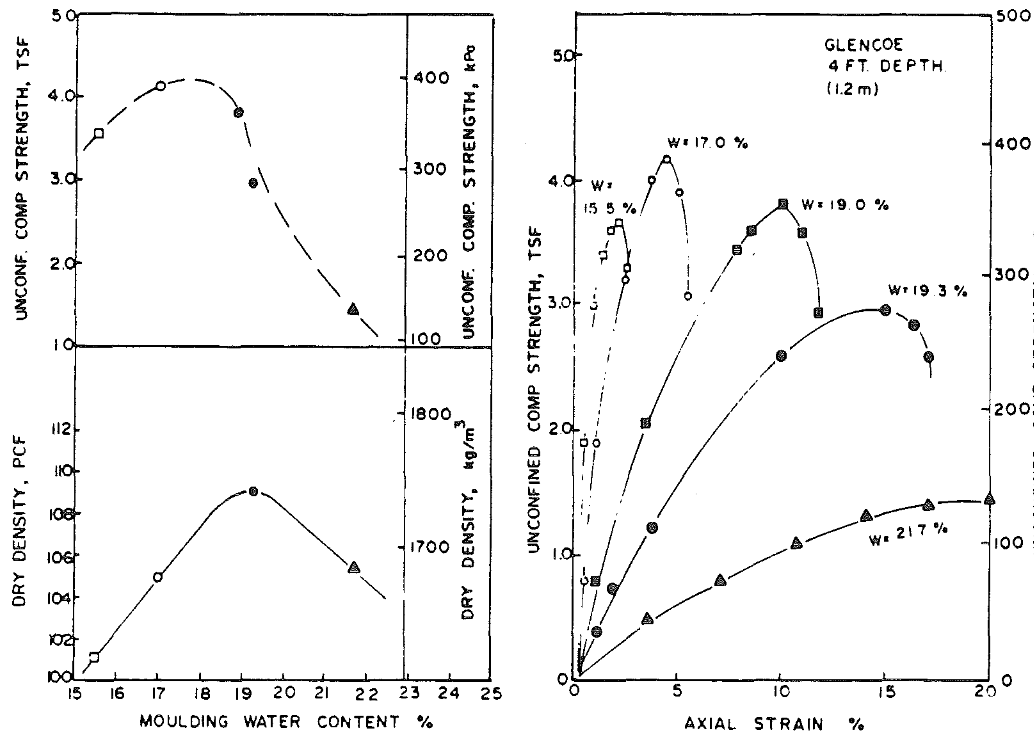


Figure 28/Compaction-Strength Summary Plots, SA G-B4, 4 Ft. (1.2 m) Depth, Glencoe

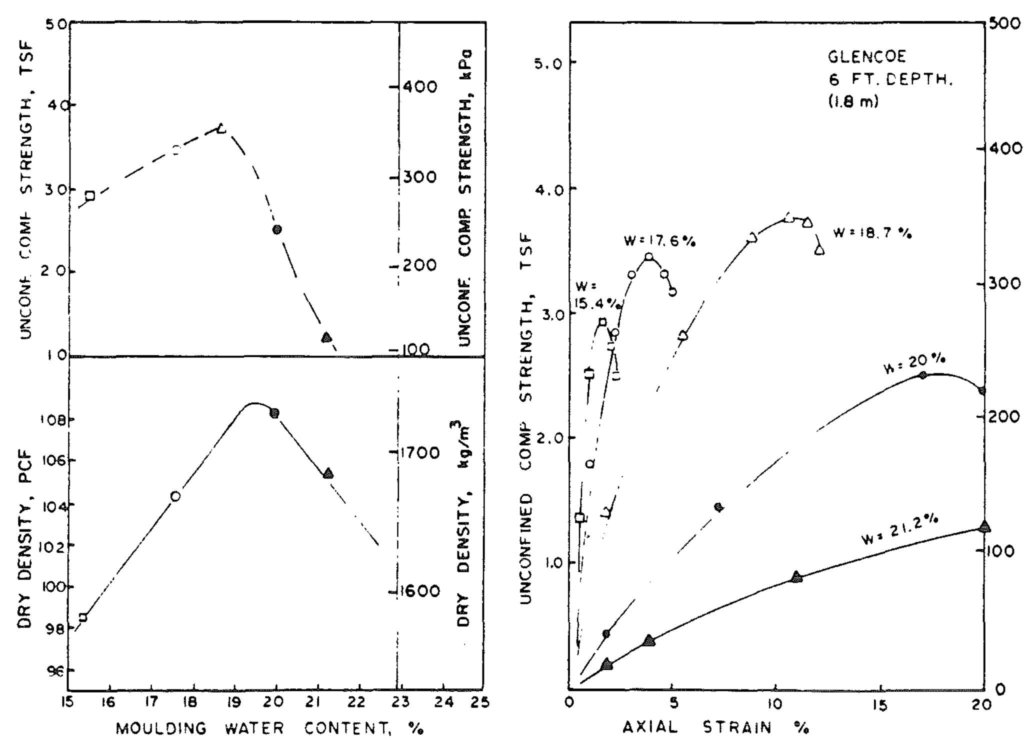


Figure 29/Compaction-Strength Summary Plots, SA G-B5, 6 Ft. (1.8 m) Depth, Glencoe

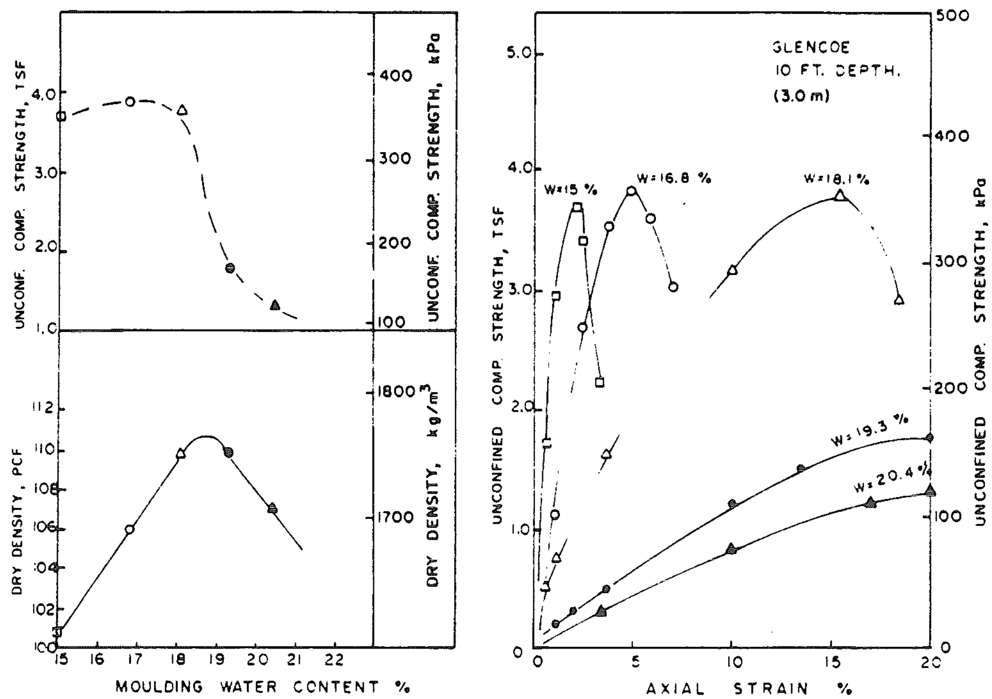


Figure 30/Compaction-Strength Summary Plots, SA G-B7, 10 Ft. (3.0 m) Depth, Glencoe

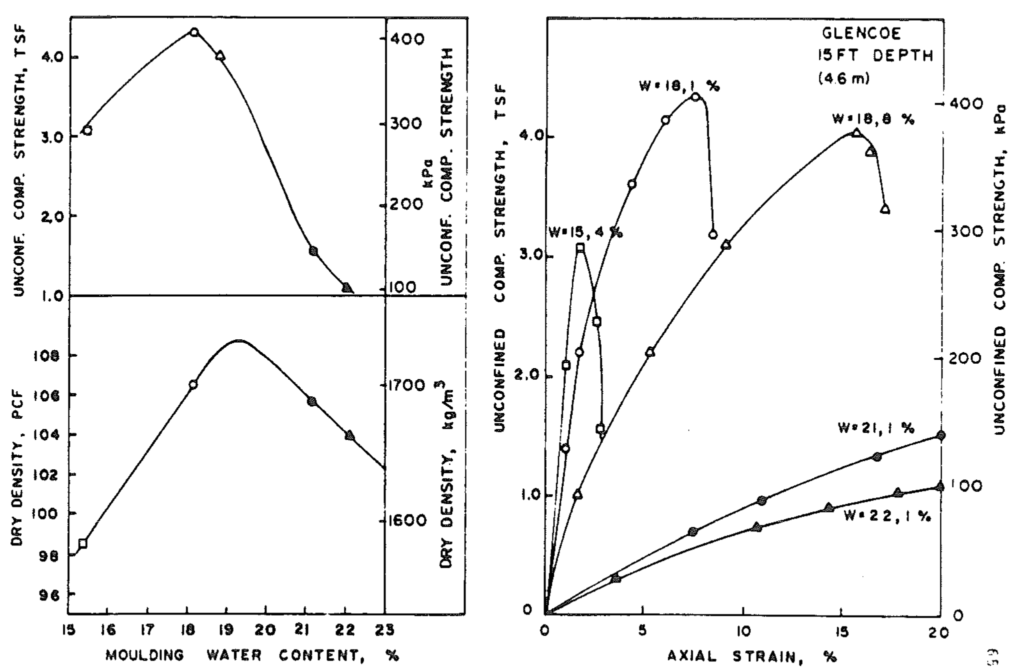


Figure 31/Compaction-Strength Summary Plots, SA G-5, 15 Ft. (4.5 m) Depth, Glencoe

In Figure 32 the optimum moisture contents (Harvard miniature and Proctor) for the Glencoe soils are compared with the plastic limit values. For all practical purposes the two values are identical except in the upper 4 ft. (1.2 m) of the deposit, where the weathering index is highest; the greatest amount of smectite occurs; and, w_{opt} is 2 or 3 percent less than the plastic limit.

6.3/ Swell Potential Studies

Considerable effort was devoted to understanding the swelling characteristics of the Glencoe soils. In addition to calculating and measuring the swell of the actual soil, tests were carried out on the clay fraction in an attempt to identify more closely the real and potential influence of the near surface swelling clays.

In Figure 33 measured and calculated swell potentials, S and activity, Ac, are plotted for the actual, untreated soil. Although the activity increases regularly towards the surface, the calculated swell potential decreases somewhat towards the surface, indicating the predominating influence of decreasing clay content in spite of increasing activity. The measured values, on the other hand, increase regularly from about 1 percent at 10 ft. (3.0 m) to 4 percent at the 2 ft. (0.6 m) depth. Once again, these values are quite low, probably due mainly to the high carbonate content of the soils.

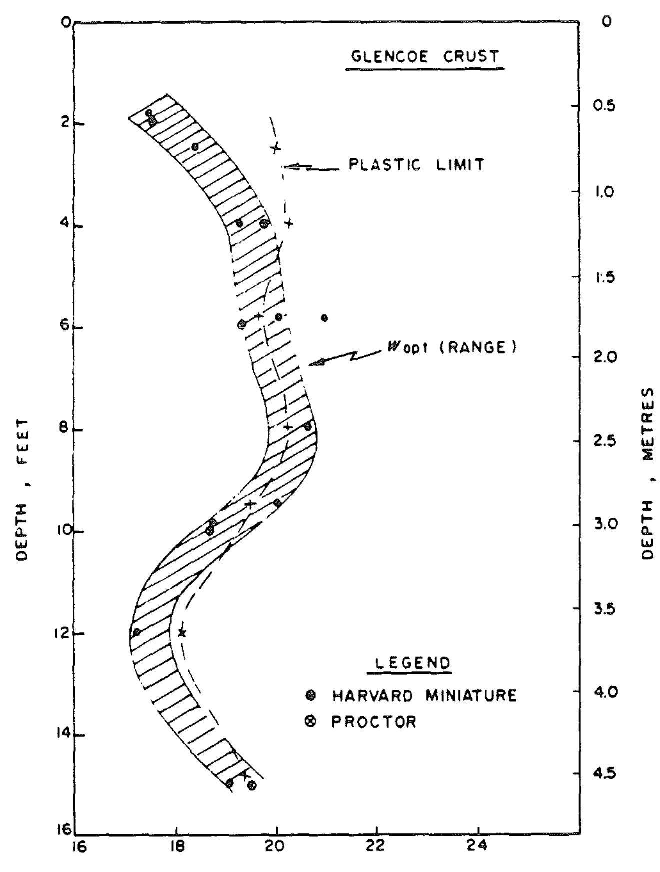


Figure 32/Optimum Moisture Content and Plastic Limit vs Depth, Glencoe Clay Crust

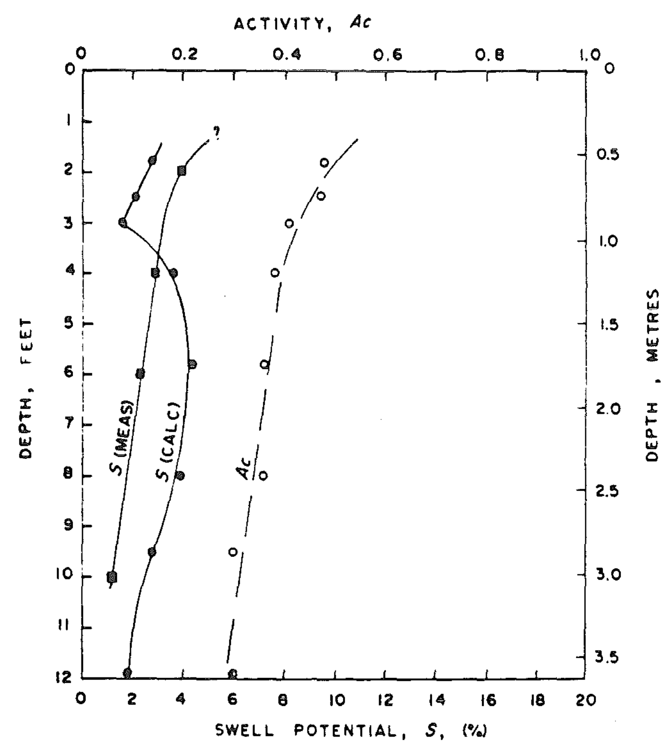


Figure 33/Activity and Swell Potential, Glencoe Soils

In Figure 34 calculated swell potential plots for hypothetical soils assumed to contain 60 and 100 percent clay are presented. Near surface soils with 60 percent clay have calculated swell potentials of up to 8 percent and those with 100 percent clay, up to 45 percent. By fractionating the soil to obtain the clay size fraction, the validity of this latter value may be checked as shown in Figure 35.

The $< 2\mu m$ soils with and without carbonate yielded identical amounts of swell of 3 percent at the 10 ft. (3.0 m) depth, increasing to 8 percent at the 2 ft. (0.6 m) depth. These values are surprisingly low since they are only twice that of the actual soil. This limited swell (compared to the 40 percent shown in Figure 34) is related to both the type of smectite and the absorbed cations. The smectite is derived from high charge chlorite and although this high charge is greatly reduced by oxidation weathering, it is probably still fairly high. The resultant smectite will have expansion characteristics somewhere between that of montmorillonite and vermiculite. Extreme collapse upon K^+ saturation confirmed this. The Ca^{++}, Mg^{++} cation regime adsorbed on the clays also inhibits swelling, even when carbonate is totally absent.

An attempt was made to measure the maximum possible swell potential by homoionizing the $< 2\mu m$ soil in sodium prior to swell and washing out the excess salt. The resultant swell is now much greater: 14 percent for the 10 ft. (3.0 m) sample and 24 percent for the 2 ft. (0.6 m) sample. This is still somewhat low compared to the calculated values; however, this is not surprising since Seed et al, 1962, used different types of soil to establish their swell potential equations. Also in view of the preliminary nature of this work, no rigid control was taken to ensure low pore fluid salinity in this testing series.

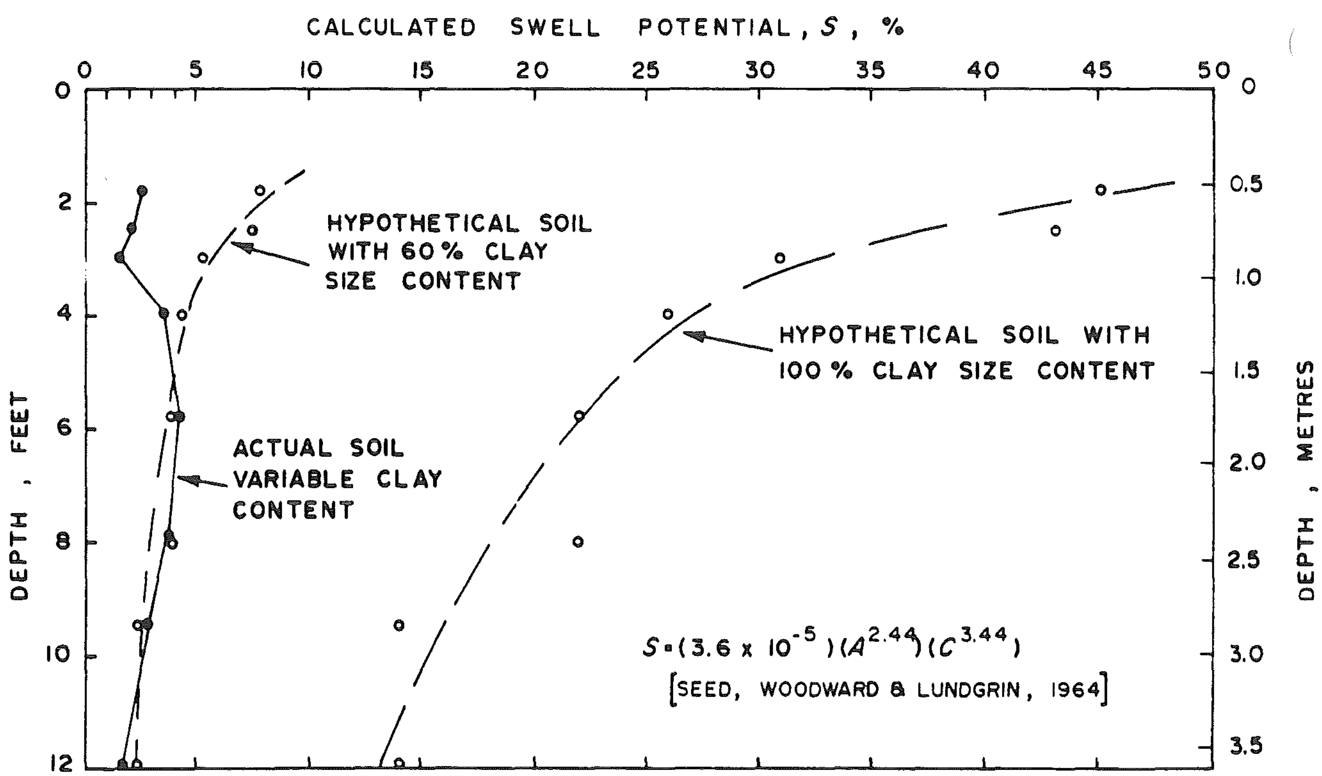


Figure 34/Calculated Swell Potentials for Actual and Hypothetical Glencoe Area Soils

The results of preliminary compaction testing done to determine the optimum moisture content of the $< 2\,\mu m$ samples before swell testing are given in Figures 36 and 37. The effects of increasing swelling clay towards surface are evident in these plots; the samples from the 2 ft. (0.6 m) depth yield a γ_d (max) of about 90 pcf (1400 kg/m³) compared to 95 to 97 pcf (1520 to 1550 kg/m³) for the 10 ft. (3.0 m) samples.

The percent swell versus log time curves are plotted in Figures 38 and 39. The soils with Ca^{++}, Mg^{++} as the dominant adsorbed cations generally have swelled nearly completely in 24 hours (Figure 39), whereas the Na^{+} clays continued to swell even after five or six days.

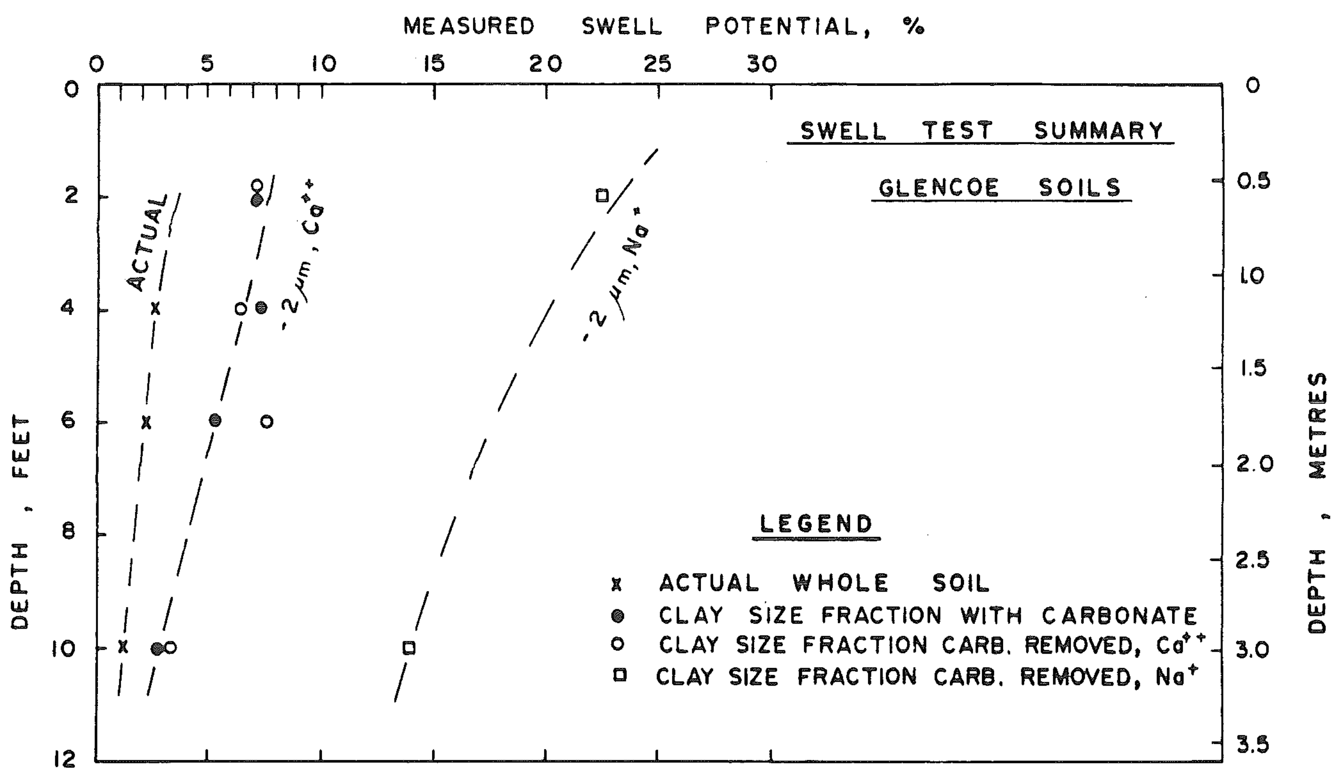


Figure 35/Measured Swell Potentials for Actual and Fractionated Glencoe Soils

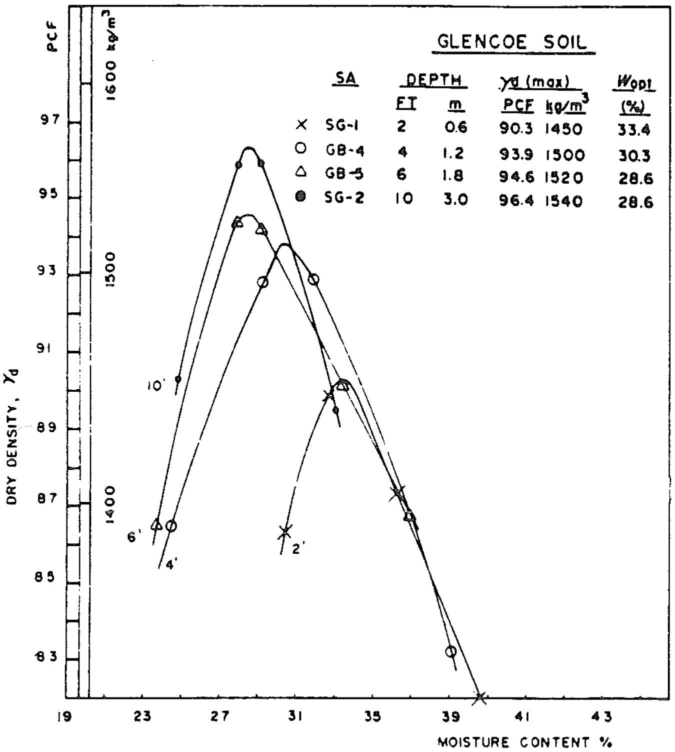


Figure 36/Compaction Results Used to Determine Optimum Condition for Swell Tests, Glencoe Soils, < 2 μm Carbonate Removed Ca^{++} Flocc'd

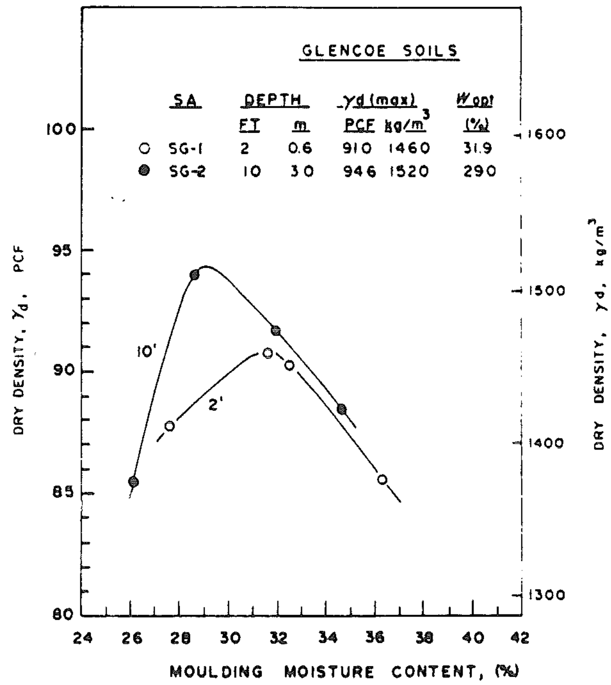


Figure 37/Compaction Results Used to Determine Optimum Condition for Swell Tests, Glencoe Soils, < 2 μm Carbonates Removed, Homoionic Na^+

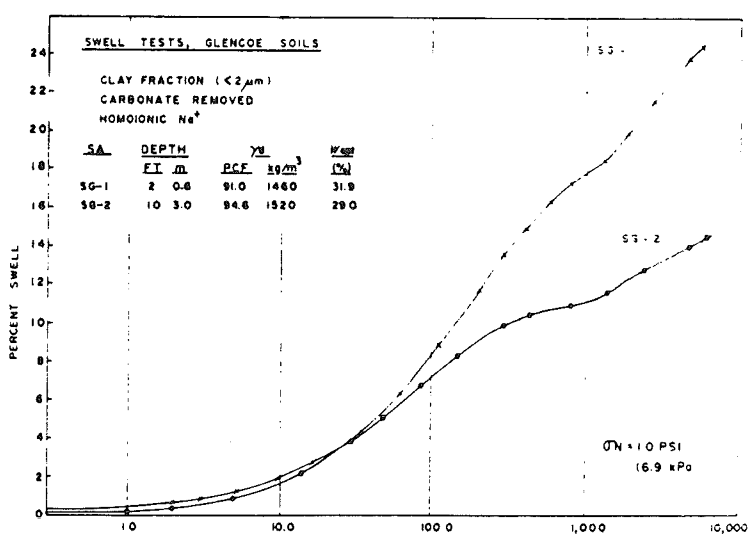


Figure 38/Swelling vs Time Curves, Glencoe Soils, Carbonate Removed, < 2 μm Fraction, Homoionic Na^+

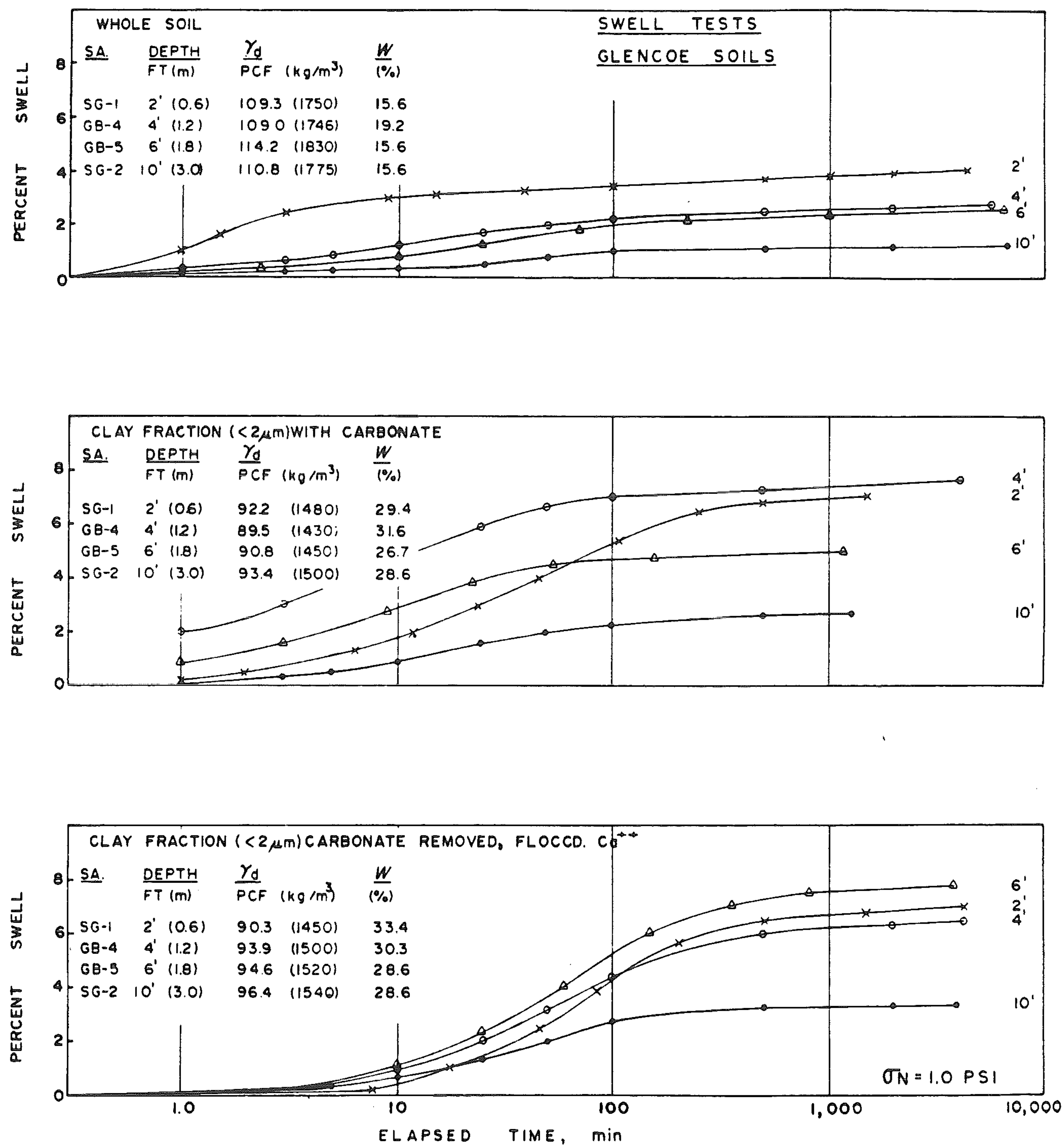


Figure 39/Swelling vs Time Curves, Glencoe Soils, Treated and Compacted As Indicated

7/Discussion

The mineralogical and compaction testing program carried out on soil samples from Sarnia, Warwick and Glencoe, Ontario, has shown that long-term surficial weathering has produced a similar set of changes in the mineralogy and compaction behavior of crustal soils at each location.

The soils at each location consist of a silty clay till believed to have been of water-laid origin. At Sarnia the till on which the crust has developed is known to be dolomite rich (Quigley and Ogunbadejo, 1975), even though the near surface results in this report show nearly equal amounts of calcite and dolomite (Table 3, Appendix II). At Warwick and Glencoe the tills are richer in calcite than dolomite and thus represent a different till sheet.

Alteration of chlorite to smectite by oxidation weathering occurs at all three locations, indicating the presence of an unstable chlorite in all three tills. The depth of oxidation is dependent on the depth of present and past ground water levels. At both Glencoe and Sarnia brown oxidized soil extends to a depth of at least 15 ft. (4.6 m) compared to only 6 ft. (1.8 m) at Warwick. Near the surface, where oxidation has been most intense, much of the original chlorite has altered to smectite (up to 15 percent Sarnia), whereas at depth little smectite is present (2 or 3 percent).

Downward leaching of rain and meltwaters has removed some of the surface carbonates and redeposited them at depth. It is interesting that dissolved dolomite tends to redeposit as calcite, so that at Sarnia the original dolomite rich till now contains about an equal mixture of calcite and dolomite in the 6 ft. (1.8 m) section studied.

These two factors (smectite formation and carbonate depletion) are believed to be the main controls on the variations in compaction properties of soils excavated from various depths in the crust. At all sites γ_d (max) decreases towards the surface and the corresponding optimum moisture content increases. The amount of decrease varies from only 5 pcf (80 kg/m^3) at Warwick to 15 pcf (240 kg/m^3) at Sarnia. Borrow materials extracted from various depths in the crust and placed in the same embankment should therefore be expected to exhibit large variations in density due to the complex moisture and mineralogical variations. The stiffness or elastic modulus of the soils is also highly variable as shown by the stress-strain curves, so that surface deflection measurements would likewise vary greatly depending on the depth from which any particular subgrade soil was excavated. Test sections of highway could conceivably yield highly variable information of little constructive value unless great care was taken in mineralogical control of the borrow soils.

Swell potential measurements indicate that the closer soils are to the surface, the greater is their tendency to swell. Near surface swell potentials as high as 25 percent are technically possible for clays homoionized in Na^+. Fortunately the soils are carbonate rich except close to the surface, and the adsorbed Ca^{++}, Mg^{++} cation regime greatly impedes swelling below about the 2 ft. (0.6 m) depth. Above this depth (but below the topsoil), swell potentials as high as 6 percent were measured (Sarnia).

Ogunbadejo and Quigley, 1974, reported differences in γ_d (max) of up to 8 pcf (130 kg/m^3) for air-dried and never-dried surface soils at Sarnia. These tests were run as Proctor tests and are believed to be valid even though the Harvard miniature tests performed at Sarnia as part of this test program showed much lesser variations due to drying. The test procedures are much different: The Proctor test uses dynamic impact compaction while the miniature test uses the kneading compaction.

The X-ray weathering index combined with careful determination of soil activity and soil carbonates seem to be the most useful indicators of potential variations in compaction-strength behavior. Compaction tests themselves may not illustrate the behavioral trends because of textural variations. This was shown clearly by the data from Glencoe and, to a certain extent, by the data from Warwick.

Dykes, high embankments and river banks constructed from or cut into crustal soils should exhibit large variations in residual friction angles similar to the 10° variation noted for Sarnia. Although not directly connected with this study, the related problems of increased swelling near the surface, slaking and sloughing of dried and re-wet soils, and variable friction angles all suggest that erosion of river dykes and banks at highway crossings may be significantly related to the weathering processes discussed in this report.

Preliminary soil-cement experiments were carried out on Glencoe soils early in the investigation and are presented in Appendix III. They were deferred in favor of detailed mineralogical studies since they could not be interpreted at the time. It is now believed that a meaningful and potentially valuable soil-cement study could be initiated.

8/Conclusions

This study has concerned itself with the compaction properties of weathered crustal clay soils between London and Sarnia in southwestern Ontario. The major observations and conclusions are as follows:

1. Desiccation, oxidation and leaching have produced a very stiff to hard brown surface crust on the clay deposits of southwestern Ontario. Carbonate has been depleted or removed from the upper 1 to 3 ft. (0.3 to 0.9 m) and soil chlorites have been extensively altered to smectite swelling clay, especially near the surface.
2. The X-ray weathering index, glycol retentions and soil activity values increase towards the surface, reflecting the increase in smectite, especially at the Sarnia site, where weathering is deepest and most intense.
3. The increased smectite towards the surface results in a regional trend of decreasing γ_d (max) towards the surface with corresponding increases in w_{opt}. At Sarnia, γ_d (max) decreased from 120 to 105 pcf (1920 to 1680 kg/m^3) between the 6 and 1 ft. (1.8 and 0.3 m) depths, the greatest variation of the three sites.
4. Calculated swell potentials of the compacted soils vary from nil at depth for unweathered soils to 12 percent at the surface for the weathered soils. Measured values of swell potential were about half of these values, reaching a maximum of 6 percent for surface soils at Sarnia. Abundant carbonate in the soils inhibits the swelling, which was observed to be much greater when carbonate free and homoionized in Na^+.
5. The large variation in compaction and stress-strain behavior as a result of mineral variations should make highway test section studies difficult to interpret.
6. Preliminary soil-cement studies indicate that cement stabilization is feasible in southwestern Ontario, subject to recommended further research to establish the mineralogical controls on rate and amount of strength gain.

9 / Acknowledgements

The work presented in this report was performed by graduate students and technical staff at the University of Western Ontario. The assistance of Messrs. G. Lusk, L. DiNardo and W. T. Bou deserve special mention.

Special thanks are extended to the City of Sarnia and to Ekfrid township for permission to enter their landfill sites for sampling purposes.

The work was carried out in accordance with a letter of authorization from Mr. P. Smith, Director of the Engineering Research and Development Branch, and monitored in technical content by Mr. A. Rutka, Manager, Geotechnical Office.

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11/Appendices I, II, III
Appendix I/Methods of Analysis

Since most of the test procedures used for the project are well-known, only brief descriptions are presented here.

1.1/Soil Classification

Determination of grain size using seive and hydrometer methods and Atterberg limit and specific gravity tests were conducted using standard test procedures found in such laboratory manuals as Lambe, 1951 or Bowles, 1970. The limits were run on the −40 mesh fraction of the soils as normally required. Since most soils contained little or no +40 mesh material, the procedure normally involved manual removal of the pebbles only.

1.2/Mineralogical and Chemical Analyses

X-ray diffraction analyses were carried out using a G.E. diffractometer and Cu$k\alpha$ radiation generated at 50 kv and 15 mA. X-ray plates were prepared by centrifugation onto porous ceramic disks to produce a highly oriented clay specimen. The clays were X-rayed wet (expanded), air-dried (ADPO) and glycolated (GPO).

The weathering index was defined as the ratio of the 1.4 to 1.5 nm peak to the 0.7 nm peak for either wet or glycolated samples. Although this is a nonlinear relationship, since the 0.7 nm chlorite peak decreases as the 1.4 to 1.5 nm smectite peak increases towards the surface, it provides a useful, quick, visual indication of the increase in swelling clay towards surface.

Carbonate analyses were carried out using the chittick apparatus and the methods of Dreimanis, 1962. This approach is useful since it gives good values for total carbonate and approximate values for contained calcite and dolomite.

Glycol retention values were performed using the method of Martin, 1955. Since glycol adsorbs on clays in a layer about two molecules thick, the glycol retention is a useful indicator of surface area and hence of increased swelling clay towards the surface.

Potassium analyses were carried out using X-ray fluoresence techniques and a Phillips vacuum unit. The unknowns were compared to known samples for quantitative estimation of percent K_2O.

1.3/Compaction-Strength Tests

The bulk of the compaction tests were performed using a Harvard miniature compaction device described by Wilson, 1950. The compaction is a kneading procedure using a spring mounted rod. All miniature tests were conducted using a 40 lb. (178 N) spring and 20 tamps per layer on five layers within the small mould. This procedure gives compaction results similar to standard Proctor results for the Glencoe soils.

The unconfined compression tests were run directly on the miniature compaction samples, which measured 2.816 inches (71.53 mm) in length and 1.312 inches (33.32 mm) in diameter. The volume of the mould is 0.0022 of a cubic foot, so that the soil weight in grams of a compacted sample is numerically equal to its unit weight in pounds/cubic foot.

1.4/Swell Potential Measurements

Measurements of swell potential were carried out on thin disks of soil taken from a specially fabricated, split, Harvard miniature mould. The height to diameter ratio of the disks was 1:4, and a normal loading of 1 psi was applied during swelling as recommended by Seed, Woodward and Lundgren, 1962. Distilled water was used in the reservoir for all swelling tests.

1.5/Removal of Soil Carbonate and Homoionization

Soil carbonates were removed for certain swell tests by digestion in HCl at pH 4 to 4.5. Lower pH values are known to attack soil chlorites and smectites, the important components of the test soils under study.

Homoionization involved washing the clays in strong solutions of $CaCl_2$ or NaCl about five times, then washing out the excess salt to 10^{-3}M concentration. The soils were then dried in preparation for compaction.

Appendix II / Tables of Test Data

This Appendix includes Tables 1-5/ Sarnia; Tables 6-10/ Warwick; and, Tables 11-18/ Glencoe. The data tabulations are presented in the units in which the tests were run and have not been converted to SI units (this Appendix only).

Table 1/List of Samples, Sarnia

Depth Scale	Profile A Drainage Ditch
0	S-Topsoil (0.4')
1	S-A1 (1') Bulk
2	S-A2 (2')
3	S-A3 (3') Bulk
4	S-A4 (4')
5	S-A5 (5')
6	S-A6 (6') Bulk
7	

Table 2/Atterberg Limits and Activity, Sarnia Soils

Sample Number	Depth Feet	Specific Gravity	Liquid Limit %	Plastic Limit %	Plasticity Index I_p	Clay Size %	Activity I_p—(%<2 μm^{-9})
S-Topsoil	0.4	—	—	—	—		—
S-A1	1	2.71	53	21	32	42	0.97
S-A2	2		45	18	27	37	0.96
S-A3	3	2.76	38	18	20	32	0.87
S-A4	4		32	17	15	30	0.71
S-A5	5		24	14	10	27	0.56
S-A6	6	2.76	23	14	9	29	0.45

Table 3/Chemical Test Results, Sarnia, Profile A

Sample Number	Depth Feet	Carbonates			Glycol Retention mg/g Untreated, <2μm	Weathering Index 14°A:7°A (X-ray) (1.4 to 0.5 nm)
		Dolmite	Calcite	Total		
Topsoil	0.41				88	
S-A1	1	1.3	0.2	1.5	101	3 2
S-A2	2	13 2	3.0	16.2	66	1 7
S-A3	3	13.9	3.7	17.6	95	1 7
S-A4	4	11 4	13.0	24.4	64	1.6
S-A5	5	15.0	12.1	27.1	54	1.3
S-A6	6	14.1	14.0	28.1	53	1.3

Table 4/Harvard Miniature Compaction Results, Sarnia, Profile A, Drainage Ditch

Sample Number	Depth Feet	Max. Dry Density, γ_d pcf		Optimum Moisture Content, w_{opt} %		Clay/Size %
		Air-Dried	Never-Dried	Air-Dried	Never-Dried	
S-A1	1 0	106.0	104.5	20.5	21.5	42
S-A3	3.0	114.0	115.0	16.5	15.7	32
S-A6	6.0	121.5	118.8	14 2	15 0	29

Table 5/Calculated Swell Potentials*, Sarnia

SAMPLE NUMBER	DEPTH FEET	ACTIVITY Ac	PERCENT CLAY, C	SWELL POTENTIAL, S, %
S-A1	1	0.97	42	12.8
S-A2	2	0.96	37	8.1
S-A3	3	0.87	32	3.9
S-A4	4	0.71	30	1.9
S-A5	5	0.56	27	0.7
S-A6	6	0.45	29	0.6

*Swell Potential = $(3.6 \times 10^{-5})\ (Ac^{2.44})\ (C^{3.44})$

Table 6/List of Samples, Warwick

Depth Scale Feet	Profile A Borrow Pit	Profile B Road Cut
0		
	W-1 (0.5′)	W-B1a (0.5′)
1		
	W-2 (1.5′) Bulk	W-B1b (1.2′)
2	W-3 (2′)	W-B2 (1.8′)
		W-B3 (2.5′)
3		
	W-4 (3.5′) Bulk	W-B4 (3.3′)
4		W-B5 (3.8′)
5	W-5 (4.8′)	W-B6 (4.8′)
6		W-B7 (6.0′)
	W-6 (6.3′) Bulk	
7		
	W-7 (~8.5′) Bulk	
8		W-B8 (8.7′)
9		
10		
11		
12		

Table 7/Atterberg Limits and Activity, Warwick Soils, Profiles A and B

Sample Number	Depth Feet	Specific Gravity	Liquid Limit %	Plastic Limit %	Plasticity Index	Clay Size %	Activity I_p (%<2μm^{-9})
Borrow Pit, Profile A							
W-1	0.5	2.78					
W-2	1.5		43	20	23	52	0.70
W-3	2.0						
W-4	3.5	2.64?	34	21	13	53	0.30
W-5	4.8		32	19	13	37	0.46
W-6	6.3		25	18	7	30	0.33
W-7	~8.5	2.78	32	22	10	53	0.23
Road Cut, Profile B							
W-B1a	0.5		41	23	18	43	0.53
W-B1b	1.2	2.78	37	21	16	41	0.50
W-B2	1.8		38	20	18	42	0.55
W-B3	2.5		38	20	18	51	0.43
W-B4	3.3		39	22	17	55	0.37
W-B5	3.8	2.70	30	18	12	32	(0.52)?
W-B6	4.8		35	20	15	44	0.43
W-B7	6.0		37	20	17	48	0.44
W-B8	8.7	2.74	20	13	7	20	(0.64)?

Table 8/Chemical Test Results, Warwick, Profiles A and B

Sample Number	Depth Feet	Carbonates, % Whole Soil			Glycol Ret'N mg/g Untreated $<2\mu m$	Weathering Index 14°A:7°A (X-ray) (1.4 to 0.7 nm)
		Dolomite	Calcite	Total		
Profile A						
W-1	0.5	1.5	0.6	2.1		1.7
W-2	1.5	8.1	10.0	18.1	74	1.5
W-3	2.0	4.6	14.0	18.6		1.3
W-4	3.5	15.4(?)	13.2	28.6	64	1.2
W-5	4.8	5.1	13.0	18.1	51	0.7
W-6	6.3	7.9	15.7	23.6	49	0.35
W-7	8.5	8.7	11.4	20.1	42	0.25
Profile B						
W-B1a	0.5	4.4	4.2	8.6		1.42
W-B1b	1.2	6.7	12.3	19.0	107	1.0
W-B2	1.8	4.4	14.9	19.3	58.1	0.94
W-B3	2.5	7.9	11.6	19.5	56.1	0.92
W-B4	3.3	6.7	14.2	20.9	55.5	1.14
W-B5	3.8	7.4	11.0	18.4	54.3	0.80
W-B6	4.8	7.9	13.5	21.4	58.3	0.66
W-B7	6.0	7.4	9.3	16.7	58.1	0.86
W-B8	8.7	9.6	11.2	20.8	28	0.35

Table 9/Harvard Miniature Compaction Results, Warwick, Profile A, Borrow Pit

Sample Number	Depth Feet	Max. Dry Density, γ_d, pcf		Optimum Moisture Content, w_{opt} %		Clay Size %
		Air-Dried	Never-Dried	Air-Dried	Never-Dried	
W-2	1.5	107.5	106.6	19.5	20.3	52
W-4	3.5	108.6	107.5	19.7	20.5	53
W-5	4.8	110.0	–	19.1	–	
W-6	6.3	116.5	117.2	15.5	15.2	30
W-7	~8.5	111.5	111.4	18.5	18.6	53

Table 10/Calculated Swell Potentials*, Warwick Profiles A and B

SAMPLE NUMBER	DEPTH FEET	ACTIVITY *Ac*	PERCENT CLAY, *C*	SWELL POTENTIAL *S*, %
Profile A				
W-2	1.5	0.70	52	12.0
W-4	3.5	0.30	53	1.6
W-5	4.8	0.46	37	1.3
W-6	6.3	0.33	30	0.3
W-7	8.5	0.23	53	0.8 ?
Profile B				
W-B1a	0.5	0.53	43	3.2
W-B1b	1.2	0.50	41	2.3
W-B2	1.8	0.55	42	3.2
W-B3	2.5	0.43	51	3.4
W-B4	3.3	0.37	55	3.1
W-B5	3.8	0.52	32	2.6
W-B6	4.8	0.43	44	2.0
W-B7	6.0	0.44	48	2.9
W-B8	8.7	0.64	20	0.4

Swell Potential, $S = (3.6 \times 10^{-5})(Ac^{2.44})(C^{3.44})$

Table 11/List of Samples, Glencoe Crust

Depth Scale Feet	Profile A	Profile B
0		
1		G-B1 (1′)
	G-1a (1.75′)	
2		G-B2 (2′) Bulk
	G-1b (2.5′) Bulk	
3	G-2 (3′)	G-B3 (3′)
4		G-B4 (4′) Bulk
5		
6	G-3 (5.75′)	G-B5 (5.75′) Bulk
7		
8		G-B6 (8′)
9		
	G-4 (9.5′)	
10		G-B7 (10′) Bulk
11		
12		G-B8 (12′)
13		
14		
15	G-5 (~15′) Bulk	

Table 13/Comparison: Plastic Limit and Optimum Moisture for Compaction

Sample Number	Depth Feet	Plastic Limit %	Optimum Moisture, w_{opt} %	
			Miniature	Proctor
G-B2	2	—	—	17.6
G-1b	2.5	20.0	18.4	—
G-B4	4	20.3	19.3	19.8
G-3	5.8	19.7	21.1	—
G-B5	6	—	—	19.3
G-B6	8	20.3	20.7	—
G-4	9.5	19.5	20.1	—
G-B7	10	—	—	18.7
G-B8	12	18.1	17.3	—
G-5	15	19.4	19.3	19.5

Table 12/Atterberg Limits and Activity, Glencoe Soils

Sample Number	Depth Feet	Liquid Limit %	Plastic Limit %	Plasticity Index	Clay Size %	Activity I_p / (%<2 μm —9)
G-1a	1.8	37.4	20.2	17.2	44	0.48
G-1b	2.5	35.4	20.0	15.4	42	0.47
G-2	3	30.6	17.0	13.6	42	0.41
G-B4	4	38.4	20.3	18.1	57	0.38
G-3	5.8	38.7	19.7	19.0	62	0.36
G-B6	8	38.8	20.3	18.5	60	0.36
G-4	9.5	35.5	19.5	16.0	62	0.30
G-B8	12	32.0	18.1	13.9	55	0.30
G-5	15	36.0	19.4 ?	16.6	55	0.36

Table 14/Chemical Test Results

Sample Number	Depth Feet	Carbonates % Whole Soil			Insolubles % Whole Soil	*Glycol Retention mg/g		*K_2O %
		Dolomite	Calcite	Total		Untreated	Homo K^-	
G-B1	1					88	41	4.1
G-1a	1.8	2.9	12.1	15.0	47	82	46	4.0
G-1b	2.5	2.0	8.7	10.7	47	97	51	4.3
G-2	3	5.6	14.9	20.5	35	81	39	4.0
G-B4	4					66	34	4.2
G-3	5.8	4.5	13.7	18.2	41	62	32	4.2
G-B6	8.0					63	35	4.4
G-4	9.5	4.0	16.6	20.6	35	60	28	4.2
G-B8	12					43	27	5.2
G-5	12	4.4	15.4	19.8	35	45	28	4.6

Run on <2 μm soil fraction.

Table 15/Harvard Miniature Compaction Results, Glencoe Soils

Sample Number	*Depth Feet	Max. Dry Density, γ_d, p.c.f.		Optimum Moisture Content, w_{opt} %		Clay Size %
		Air-Dried	Never-Dried	Air-Dried	Never-Dried	
G-B1	1.0	106.8	—	20.7	—	44
G-B2	2.0	112.7 (2)	—	17.5 (2)	—	37
G-1b	2.5	111.0	110.8	18.3	18.5	42
G-B4	4.0	109.2	—	19.3	—	57
G-3	5.8	106.2	106.0	21.3	21.0	62
G-B5	5.8	109.0	—	19.7	—	—
G-B6	8.0	106.4	—	20.7	—	60
G-4	9.5	108.6	108.5	20.0	20.3	62
G-B7	10.0	110.6	—	18.7	—	48
G-B8	12.0	112.2	—	17.3	—	55
G-5	~15.0	109.6 (2)	109.3	19.1 (2)	19.5	55

**Depth below disturbed surface of soil. See rough profile, Figure 3.*
(2) Average of two tests.

Table 16/Proctor Compaction Results, Glencoe Soils

Sample Number	Depth ft.	Max. Dry Density γ_d, p.c.f.	Opt. Moisture Content w_{opt} %
G-B2	2	113.5	17.6
G-B4	4	109.5	19.8
G-B5	6	108.5	19.3
G-B7	10	111.5	18.7
G-5	15	110.5	19.5

Table 17/Calculated Swell Potentials* Glencoe

Sample No.	Depth Ft.	Activity Ac	Calc. S,% Actual Soil	Calc. S,%** 60% <2 μm	Calc. S,%*** 100% <2 μm
G-1a	1.8	0.48	2.7	7.9	45
G-1b	2.5	0.47	2.2	7.5	43
G-2	3.0	0.41	1.6	5.3	31
G-B4	4.0	0.38	3.7	4.4	26
G-3	5.8	0.36	4.4	3.9	22
G-B6	8	0.36	3.9	3.9	22
G-4	9.5	0.30	2.8	2.5	14
G-B8	12	0.30	1.8	2.5	14

Table 18/Measured Swell Potentials*, Glencoe

Sample No.	Depth Ft.	Meas. S, % Actual Soil	Meas. S, % C = 100% (With carbonate)	Meas. S, % C = 100%, Ca^{++} (Carb. removed)	Meas. S, % C = 100%, Na^{-} (Carb. removed)
SG-1	2	3.9	7.0	7.0	~24
G-B4	4	2.7	7.4	6.4	~24
G-B5	6	2.2	5.0	7.7	—
SG-2	10	1.2	2.6	3.3	~14

**$S = (3.6 \times 10^{-5})(Ac^{2.44})(C^{2.44})$*
***C = 60%*
****C = 100%*

Appendix III/Preliminary Soil Cement Experiments

A vast amount of literature exists on the subject of lime and cement stablization of soils. Of major importance is the clay mineralogy of the soils and the availability of amorphous silica to react with lime to produce strong cementing agents. The silica may come from amorphous constituents in the soil; from the more soluble clay minerals themselves; or, from additives added with the lime or cement.

In southwestern Ontario the clay mineralogy varies with depth as a result of oxidation weathering and smectite formation as discussed in this report. Soil-cement or soil-lime reactions should therefore be extremely dependent on the depth from which the study-soil is extracted. For example, abundant smectite in the carbonate deficient surface soils could delay soil-cement stabilization reactions compared to deeper soils. If, however, the silica component of the smectite is relatively soluble at a cement paste pH of 13, the final strength could well be greater than that of the deeper, carbonate-rich soils.

Two sets of preliminary soil-cement experiments were run on Glencoe soils as shown in Figure 40. An increase in strength of at least tenfold develops as a result of adding 5 percent cement to the soil mixes; therefore, it is inferred that cement stabilization is definitely feasible in southwestern Ontario.

The near surface soil containing the greater amount of smectite produced 7-day and 28-day strengths greater than the deeper soil. It cannot be certain whether this difference is due to the lesser clay size fraction of the surface soil [35 percent $<2\,\mu m$ at 2 ft. (0.6 m) compared to 48 percent at 10 ft. (3.0 m)] or due to greater mineral solubility and faster reaction chemistry of the mineral components. These particular tests, run early in the testing program, were terminated pending detailed study of the mineralogy and related compaction properties at all three test sites.

Now that the mineralogical-compaction relationships have been established, it is believed that a meaningful and potentially valuable soil-cement study could be initiated.

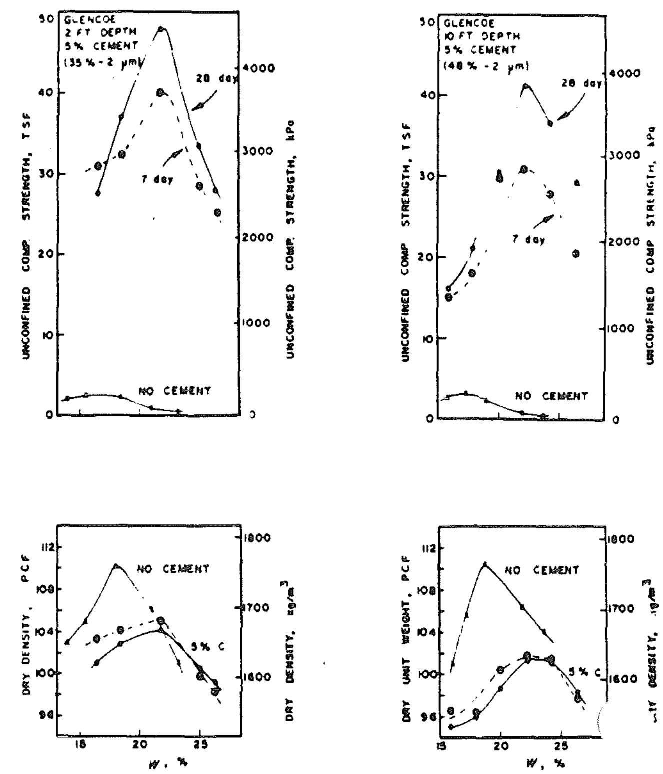


Figure 40/Preliminary Soil-Cement Studies on Glencoe Soils from Depths of 2 and 10 Ft. (0.6 m and 3.0 m)

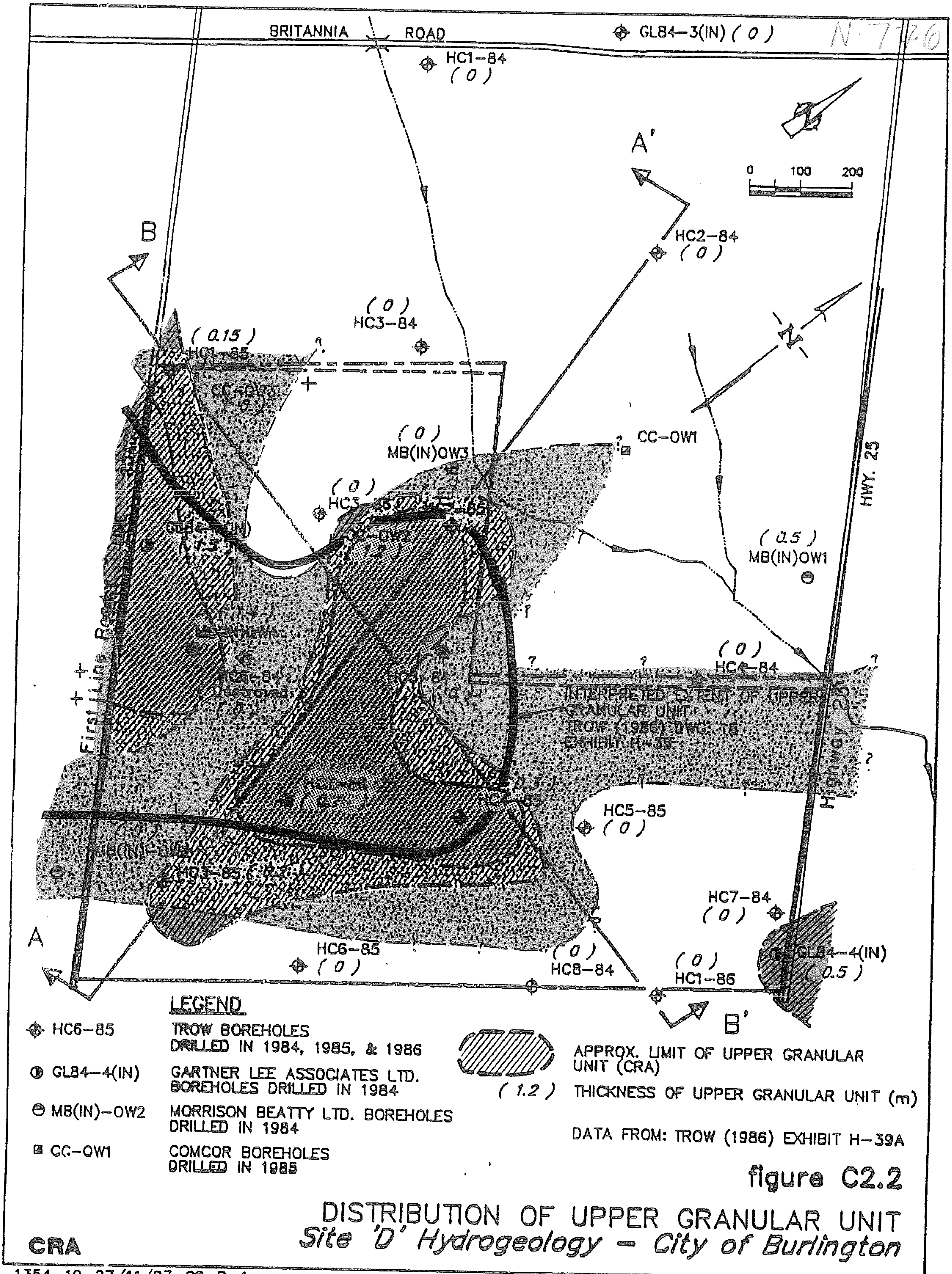
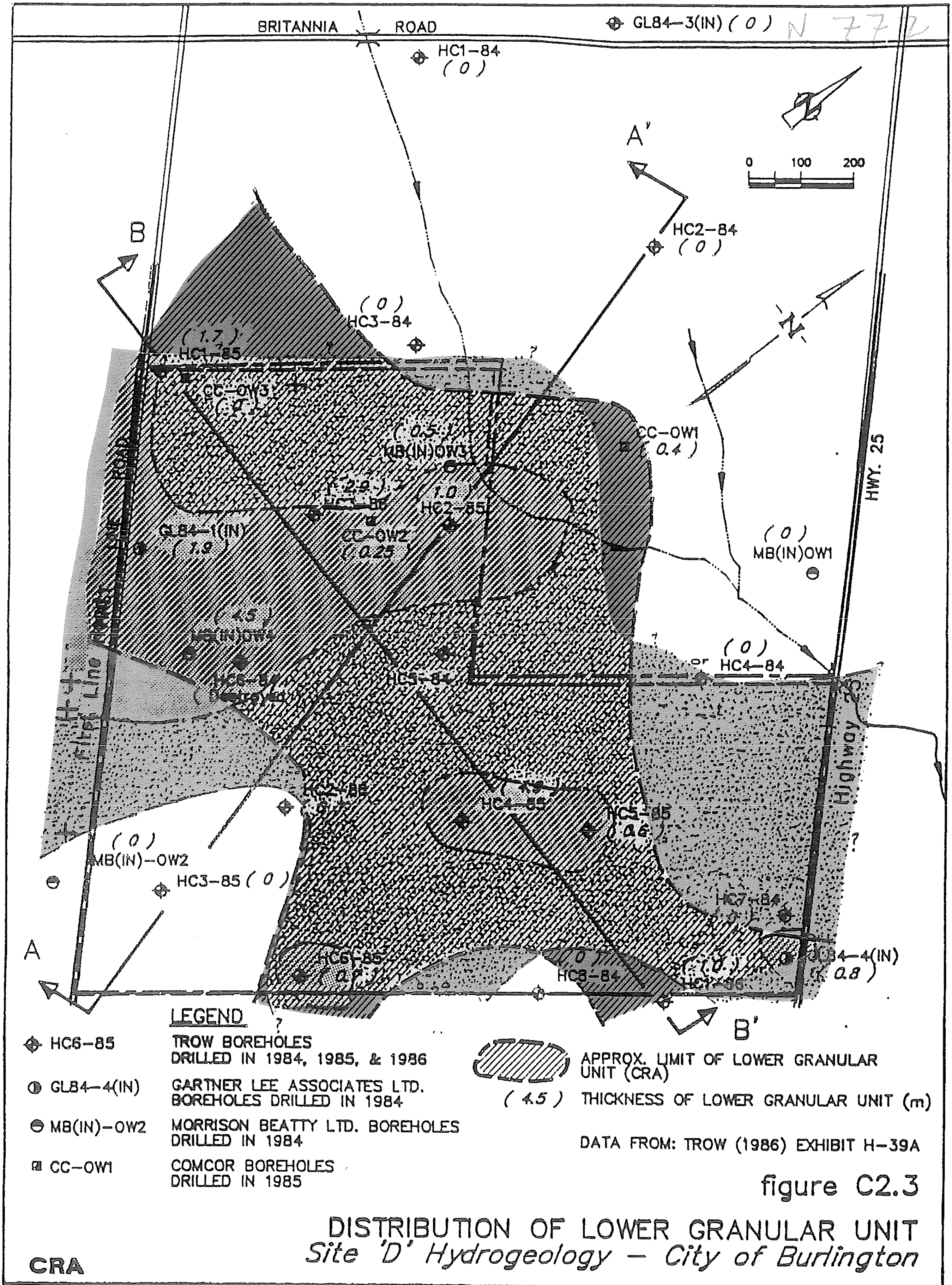


FIGURE 6 : EXTENT OF UPPER GRANULAR UNIT
SITE D, MILTON

Scale 1:10 000 approx. Borehole Locations from HCL Dwgs 2, 5



1354-10-27/11/87-29-D-1

FIGURE 8 . EXTENT OF LOWER GRANULAR UNIT
SITE D, MILTON

Scale 1:10 000 approx. Borehole Locations from HCL Dwgs 2,5

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N-778

CRA
Consulting Engineers

CONESTOGA-ROVERS & ASSOCIATES LIMITED
651 Colby Drive,
Waterloo, Ontario, Canada N2V 1C2
(519) 884-0510

May 8, 1984

Reference No. 1354

10/84 Leary

Mr. Bob Leach
Gartner Lee Associates Limited
Toronto-Buttonville Airport
Armadale Building, Suite 10
Markham, Ontario
L3P 3J9

Dear Bob:

Re: Review of Burlington Landfill Site, Application For Continued Use, Volume 2, Hydrogeology March 1984

On behalf of the City of Burlington, Conestoga-Rovers & Associates Limited (CRA) has been retained through Ecoplans Limited (ECP) to review Volume 2, Burlington Landfill Site Application for Continued Use, March 1984. This report specifically deals with geologic and hydrogeologic aspects of the Burlington Landfill Site and the proposed expansion. The report was prepared for M.M. Dillon Limited (MMD) by Gartner Lee Associates Limited (GL).

CRA has now completed our review, and would like to present the following comments and/or raise the following questions pertaining to the report in question.

1) GEOLOGY

Through review of the Volume 2 report and other various reports on the Burlington Landfill Site and adjacent areas, we are in general concurrence with the geology as interpreted and presented in the report by GL.

2) GENERAL HYDROGEOLOGY

CRA is in general concurrence with the hydrogeology of the site as presented by GL. This would include general groundwater flow direction, and permeability calculations. Some minor clarification is required as to interpretation of groundwater contours in areas where monitoring data is not available, however none of these clarifications should change the major hydrogeologic assessment of the site as presented.

cont'd .....

3) GROUNDWATER MONITORING AND CHEMISTRY

A number of questions have been raised after review of the groundwater monitoring and chemistry results and the interpretations made on these results as presented in the Volume 2 report. The following presents a point form summary of areas where CRA feels further review ad clarifications are required.

- Well Construction - Further information than is provided in the report should be provided to determine well construction and installation techniques, and verification of proper functioning of the wells, especially the well seals.

- Well Development and Sampling - Inadequate information has been supplied in the report as to whether the wells were developed and stabilized hydraulically and chemically before detailed sampling was performed. Little information is provided as to how or how many times wells were bailed to see it they obtained chemical equilibrium. No mention has been made in the Volume 2 report as to how it was ensured the wells were at chemical equilibrium before sampling.

  Exact detailed sampling techniques have also not been outlined in the Volume 2 report. Numerous well piezometer chemical data shows that they may not have reached equilibrium at selected wells.

- Background Water Chemistry - No definition of background water chemistry or range in chemistry results have been summarized in the Volume 2 report. This makes it difficult to compare downgradient results with background.

  The depths, soil units and location of background wells also make comparison of some downgradient well chemistry, with background chemistry difficult.

- Statistical Analysis - No mention has been made in the Volume 2 report of the statistical significance of the

cont'd .....

chemical data. This is important to see if, based on the amounts of data used, differences in chemistry from background to downgradient wells are significantly different.

- Leachate Plume Interpretation and Attenuation - Based on the chemical data as contained in the Volume 2 report, CRA believes it is impractical to make a definitive conclusion as to the existence or non-existence of a leachate plume and apparent attenuation capacities of the underlying shale at the Burlington Landfill Site.

  It is understood however, that there may be more data and information on the leachate plume that CRA has not been a party to at this time, and we look forward to discussing this and the above mentioned points with you further at our meeting of May 9, 1984.

Yours very truly,

CONESTOGA-ROVERS & ASSOCIATES LIMITED

Anthony J. Crutcher, P. Eng.

AJC:dp

c.c. City of Burlington

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N 779

Gartner
Lee
Associates Limited

Consulting
Engineering
Geologists and
Hydrogeologists

Toronto - Buttonville Airport ■ Markham, Ontario ■ L3P 3J9 ■ 416-477-8400
Telex - 06-986278

May 10, 1984.

M.M. Dillon Limited,
47 Sheppard Avenue East,
Box 1850, Station 'A',
Willowdale, Ontario.
M2N 6H5

Attention: Mr. W. F. Wells, P.Eng.

Dear Sirs:

Re: Burlington Landfill Monitoring
May 9, 1984 Technical Meeting

A meeting was held on May 9th, 1984 at the office of Gartner Lee Associates Limited, Markham, Ontario. The following technical representatives involved in the Burlington Landfill - Continued Use Environmental Protection Act Hearing were in attendance: Mr. R. Leech and Mr. R. Dickin (Gartner Lee Associates Limited); Mr. L. Parsons (Ministry of the Environment); Mr. A. Crutcher and Mr. W. Graziani (Conestoga-Rovers Ltd.) and Mr. K. Ridley (Monenco).

Technical information concerning the monitoring program was discussed in detail. Concern was expressed that the existing ground water monitors are not suitable for collecting samples for trace organic analyses.

The existing monitors were designed and installed to collect general water quality samples and measure ground water levels.

/cont'd.

They were not designed for collecting trace organic samples. PVC glue was used to construct the existing monitors and recent research has shown the organic chemicals can leach from the glue into ground water.

Agreement was reached between all parties in attendance to recommend to his client the carrying out of a phased program to better define the existing extent of ground water contamination at this site. This approach includes the use of trace organics as indicators of ground water contamination. The first phase of this program is as follows:

(1) A nest of ground water monitors will be established to determine background water quality for organic analysis. Each monitor will be set in a separate borehole to ensure integrity of well seals. Boreholes will be a minimum of 127 mm diameter and 51 mm ID threaded PVC pipe will be used to construct the monitor. No PVC glue will be used in monitor construction. The boreholes will be drilled without using drilling water or mud, to avoid introducing any foreign fluids.

(2) A second nest of ground water monitors will be installed downgradient of the toe of the landfill. These monitors will be located at a suitable location where contaminated ground water should be encountered. The drilling and construction of the monitors will be the same as the background nest described in (1) above.

(3) During development of the monitors constructed in (1) and (2) above, field chemistry measurements will be made to ensure chemical stability. All field information including water levels will be fully documented. Only following complete development will ground water samples be collected for detailed laboratory analysis.

Based on the results of this first phase, the need for

/cont'd.

additional monitoring, both on and off-site will be assessed.

In addition to the above phase, it was recognized that further work would be required to establish representative chemistry for the landfill leachate. Sampling of the leachate during dry seasonal conditions was agreed to by all technical representatives present as is currently proposed in the existing monitoring program.

Finally, it was recommended by all present that a technical committee be established to review the monitoring program. This committee would consist of technical representatives of the Region of Halton, the City of Burlington and the Ministry of the Environment. Recommendations from this committee would be incorporated into the monitoring program.

We trust that the above information will be useful for the present Environmental Protection Act hearing on the Burlington Landfill continued use proposal. We feel that this technical co-operation by all parties is a positive step for defining and resolving key technical issues.

Yours very truly,

GARTNER LEE ASSOCIATES LIMITED

R.E.J. Leech, B.Sc., M.Eng.Sc.,
Senior Hydrogeologist, Principal.

REJL:dc

c.c. Mr. G. Woodburn - Region of Halton
Mr. D. Hodgson - Osler, Hoskin and Harcourt

N

SWM-34-84 MAY 28 1984

N780

CONESTOGA-ROVERS & ASSOCIATES LIMITED
651 Colby Drive,
Waterloo, Ontario, Canada N2V 1C2
(519) 884-0510

Consulting Engineers

May 11, 1984

Reference No. 1354

M.H.B.
S.P.
COPY TO:

Mr. Michael H. Boggs
Chief Administrative Officer
Corporation of the City of Burlington
P.O. Box 5013
426 Brant Street
Burlington, Ontario
L7R 3Z6

Dear Mike:

Re: Burlington Landfill Expansion's Hydrogeologic Investigation Consultants Meeting, May 9, 1984

On May 8, 1984, Conestoga-Rovers & Associates Limited (CRA) attended a meeting on behalf of the City of Burlington to discuss various technical matters in regards to the Volume II, Burlington Landfill Site Application for Continued Use, March 1984. This meeting was held with Gartner Lee Associates Limited (GL) technical representatives for the Regional Municipality of Halton at the Gartner Lee offices. Also in attendance at the meeting were representatives of the Ontario Ministry of the Environment (MOE) and a technical representative on behalf of CELA, from Montreal Engineering Company Ltd. (MEC).

Topics of discussion generally followed the format as given in CRA's May 8th letter to GL, copied on the City of Burlington. This letter has been enclosed with this correspondence

The majority of discussion revolved around groundwater monitoring and chemistry results as presented in the Volume II report, and the design and implementation of a monitoring program as suggested earlier by CRA in the May 2 meeting with Halton Region.

In summary, it was agreed by all parties that:

- present monitoring wells as installed are not appropriate for the detailed organic analysis which is anticipated to be required for further plume definition and shale attenuation capacity calculation.

cont'd .....

SWM-34-84

CONESTOGA-ROVERS & ASSOCIATES LIMITED
Consulting Engineers

- Well development and checking for chemical stability of groundwater was not carried out before sampling and analysis was done as presented in the Volume II report. Therefore, earlier time period quality results in many wells as presented in the Volume II report are suspect, and it is not certain that all wells have reached chemical equilibrium.

- No definition of background chemistry had been presented in the report partly because of the varying chemical data, and the uncertainty that water being measured upgradient of the site is the same type water being measured downgradient of the site. A good background definition of the groundwater is required to identify the plume and shale attenuation capacities.

- Based on the chemistry as presented in the report, it is impractical to define the leachate plume and/or the shale attenuation capacity and that a new monitoring program should be developed based on the present understanding of the site and its inherent poor background groundwater quality to further access the leachate plume and shale attenuation capacities.

- The new monitoring program would be a phased program somewhat similar to the program suggested by CRA at the May 2nd meeting. This program would entail the installation of new wells that would be constructed for organic analysis and installed in singular boreholes to eliminate potential seal problems. These wells would also be drilled dry (i.e. no drilling water would be used).

- A committee would be formed with technical representatives of all parties to oversee the proposed program, borehole locations, well construction and installation, sampling and analysis procedures to ensure meaningful results are obtained. The committee would include representatives from the MOE, City of Burlington, the Region, and possibly CELA and Dr. Cherry.

Should you have any questions on the above, please feel free to contact us.

Yours truly,

CONESTOGA-ROVERS & ASSOCIATES LIMITED

Anthony J. Crutcher, P. Eng.

WG:dp
Encl.

Consulting Engineers

N 781

CONESTOGA-ROVERS & ASSOCIATES LIMITED
651 Colby Drive,
Waterloo, Ontario, Canada N2V 1C2
(519) 884-0510

December 13, 1984

Reference No. 1354

Mr. Michael H. Boggs,
Chief Administrative Officer
Corporation of the City of Burlington
P.O. BOX 5013
426 Brant Street
Burlington, Ontario
L7R 3Z6

Dear Mr. Boggs:

Re: Review of "Draft" Burlington Regional Landfill Site Monitoring Program - Terms of Reference

On November 28, 1984, Conestoga-Rovers & Associates Limited (CRA) was requested by the Burlington Solid Waste Management Committee (SWMC) through Ecoplans Ltd. to review and comment on the above referenced draft Terms of Reference. The letter of authorization for this work is enclosed in Appendix A. This draft report was prepared by Gartner Lee Associates Ltd. (GLA) for the Regional Municipality of Halton in fulfillment of Condition #3 as set forth in the Provisional Certificate of Approval No. A210102, for expansion of the Burlington Landfill site.

The following comments are offered on the Draft Landfill Site Monitoring Program, Terms of Reference as prepared by GLA.

1.0 HYDROGEOLOGIC DATA BASE

As noted by GLA in the draft terms of reference a considerable hydrogeologic data base exists. However, as noted in the Burlington Landfill Expansion hearings the hydrochemical data for site groundwater impact assessment is limited.

2.0 LANDFILL AREA WELL SEALING

Wells have been identified by GLA which need sealing before landfilling can take place in the immediate area. These wells are shown on Plan 1 in the draft Terms of Reference. No specific information on sealing techniques is given in the draft Terms of Reference. The specifics of the intended sealing techniques should be provided.

continued....

It is suggested at minimum that these wells be over augered to the base of the tills in the proposed landfilling area and then cement/bentonite grout tremied to the proposed landfill base contour elevation in this area.

3.0 TRACE ORGANIC WELL INSTALLATION

The concept of specially constructed wells to allow for the analysis of groundwater trace organic compounds for leachate plume definition, has been agreed to by all parties at the recent hearing.

The all stainless steel well construction proposed by GLA, is adequate for organic monitoring purposes. The use of steam cleaning alone, is not considered an adequate pipe cleaning procedure to ensure that pipe manufacturing process oils or greases are removed before installation. The pipe should first be cleaned with an appropriate solvent rinse to ensure these materials are removed, and then steam cleaned before installation.

Other alternative well materials would be suitable for organic monitoring in addition to the stainless steel installations. These would include:

1. Steel pipe with stainless steel screen, adequately cleaned.
2. Rigid, threaded, Schedule 80 PVC pipe properly cleaned.

The use of bentonite for sealing of the proposed wells is considered inadequate. It is difficult to ensure that such seals are homogeneous and continuous, and that upper water is not leaking through the seals to the screen. It is recommended that a cement/bentonite grout be used for the seal installation. The grout should be tremied into the borehole annulus to the surface. A bentonite seal should be used between the screen pack and grout. This seal is placed to ensure no mixing of the grout with the screen pack.

When using an air rotary method for drilling, it should be recognized that there is a possibility that "oil blow by" can occur with the air compressor. This could possibly inject trace amounts of oil into the organic nest installations. Precautions should be taken to ensure that "oil blow by" does not occur.

continued....

These precautions should include:

- installation of an inline air filter on the discharge air line from the compressor, to trap oil particles in the compressed air,
- ensuring that the compressor is in good operational order.
- analysis of an air sample from the compressor for organics (especially hydrocarbons) before borehole installation.

4.0 TRACE ORGANIC WELL LOCATIONS

GLA has proposed two organic well installations, one upgradient and one downgradient of the existing landfill. These are shown on the GLA Plan 1. The upgradient well is to serve for background conditions, and the downgradient well for assessment of the viability of trace organic monitoring to delineate the leachate plume.

CRA believes that two new well nest installations alone are insufficient. An additional two trace organic wells nests should be installed. One of these additional well nests would replace well nest #17 on the landfill southern property boundary, by the north service road. The second additional organic well nest should be located at an appropriate location west of the landfill property. This location should have a similar ground elevation as the monitoring nests on the southern portion of the landfill.

The replacement well nest #17 should be installed, as this location is important in evaluating plume extent, and possible offsite impact.

The second well nest located off of the landfill property would provide background chemical data. This background data would be compared to chemical data obtained from wells on the southern portion of the landfill property, to evaluate the extent of leachate contamination.

The upgradient well proposed by GLA in the northern (till) landfill area would give adequate background chemistry data for groundwater in the till/shale environment, but not for the exposed weathered shale/shale environment in the southern

continued....

landfill area. This southern area is different geologically (i.e. no significant upper till mantle) and is more likely to be influenced by deeper regional groundwater flows than the northern area. The southern area therefore needs an independent background chemistry well located in a similar hyrogeologic environment, so valid comparisons can be made on the extent of leachate contamination.

This southern area background well should be located off landfill property. It would be difficult to locate a well where it was certain that no leachate had impacted the groundwater in the southern portion of the landfill property.

These two proposed additional trace organic well nests, should have monitor installations placed in suitable formations. CRA would suggest placement of one monitor in the weathered fractured shale zone, and one into the more competent shale beneath the fractured shale zone for each well nest.

These additional well nests should be constructed at minimum to the standards as discussed in Section 3.0 of this letter report.

5.0 GROUNDWATER SAMPLING PROCEDURES

All wells to be monitored should be bailed until three consecutive, relatively stable readings of pH, conductivity and chloride are obtained. The monitoring of only conductivity to determine chemical equilibrium as proposed by GLA is not sufficient. Conductivity is a "gross" parameter, and could be misleading, when determining well equilibration. This is due to the highly minearlized state of the area groundwater.

PH is a good indicator to ensure that the well installation is purged of well installation contamination, and is clean. Chloride is a good additional check parameter. Relatively stable readings of chloride combined with the pH and conductivity readings give a better indication of well equilibration than just conductivity alone.

continued....

It is also often helpful to take recovery measurements during the well development process to ensure that the wells are operating properly, and are being developed.

After the wells have equilibrated a detailed analysis can be conducted. A minimum one well volume (preferably three volumes, if possible) should be removed before a sample is taken for analysis for any subsequent sampling after the well equilibration process is completed.

6.0 GROUNDWATER MONITORING/PLUME DELINEATION PROGRAM

GLA has proposed a groundwater monitoring program which would used a phase aproach to plume delineation, and leachate impact on area groundwater in the draft terms of reference. The first phase would be to study the viability of using trace organics for plume deliniation, and the chemical equilibration of all oberservations wells as shown of plan 1 of the draft terms. With this proposal it would take at minimum 1 year before results are achieved.

CRA generally concurs with the phased approach, but would suggest that the first phase be compressed, and modified to give answers to the basic questions that are required to develop an efficient and orderly longer term groundwater monitoring and plume deliniation program.

The proposed work schedule would consist of an initial six month program that would be composed of the following steps.

1) Immediate installation (spring 1985) of the four proposed trace organic well nests to the specifications as outlined in Section 3.0 of this letter report.

2) The development of these four new nests, and development of existing monitoring nests 13 and 16, as outlined in Section 5.0 of this letter report.

3) Sampling of all the developed monitor nests as listed in point 2), twice. All of the developed wells would be analyzed for general chemistry and would include the following parameters; pH, conductivity, chlorides, hardness, alkalinity, nitrogen (TKN, NH_3), dissolved organic carbon (DOC), chemical oxygen demand (DOC), and

continued....

major anion, and cation species so that a charge balance can be calculated.

The new trace monitor well nests should be analyzed for trace organics in addition to general chemistry. GLA has proposed that the trace organics analyzed at each of the new well nest follow the EPA priority pollutant list (PPL) CRA would suggest the use of the EPA Hazardous Substance List (HSL) (plus total phenols) which is a more current list of environmentally significant pollutants. This list has generally superceded the PPL and is somewhat more comprehensive.

4) A report at the end of the six month well installation, equilibration and sampling work program outlining the results of the work schedule. The report should be able to answer the following questions:

i) Can trace organic analysis, general chemistry data, or a combination of both enable the measurement of the impact of, landfill leachate on the area groundwater.

ii) What organics, general chemistry, or combination can be used most effectively to monitor the plume movement?

iii) Has the plume extended past the landfill site property boundary?

iv) Does leachate impact groundwater quality, and is it significant?

v) Can the existing wells be chemically equilibrated in this hydrogeologic regime, and what is the best method of developing and monitoring for chemical equilibrium?

vi) It is worth trying to develop the remaining monitors for sampling and chemical analysis on-site given the results of the six month program?

Given the answers to these questions, the groundwater monitoring and plume delineation program can then be designed and planned for the long term to take advantage of the initial experience gained in the proposed shorter six month program.

continued....

7.0 SURFACE WATER MONITORING

The surface water monitoring program as proposed by GLA in the draft Terms of Reference, would be adequate in determining an impact on nearby surface water courses from the Burlington Landfill operation.

It would be helpful however, to know how the stream flow measurements will be taken, and the subsequent accuracy of the flow estimates. The flow measurements are important when determining impact. They are used to determine contaminant mass loadings to surface water courses from the landfilling operation.

When discussing potential impacts to the surface water streams, priority should be given to mass loadings, not just in stream contaminant concentration. Mass loading provides an accurate method of determining the impact of landfilling operations on the surface water courses.

8.0 LEACHATE CHEMISTRY CHARACTERIZATION

GLA has proposed the use of a sample and analysis of leachate from the leachate collection system for leachate characterization. A sample from this location may be diluted and not truly representative.

CRA would therefore suggest the collection of an additional sample from the standpipe at OW11A-II for analysis and comparison of this sample to the leachate collection system sample.

CRA would also suggest that the samples be analyzed for the parameters as listed in the EPA HSL (plus total phenols) as well as for the parameters as listed by GLA on table 1 for leachate characterization in the draft terms of reference. This would give a cross check to ensure that any organics found in the trace organic well nests are found in and are due to leachate from the Burlington Landfill site operation.

Sampling and analysis should be conducted at least twice for each proposed leachate monitoring point and correspond to the timing as proposed in Section 6.0 of this letter report, for the proposed initial hyrogeologic program.

continued....

9.0 CONTINGENCY PLAN

The contingency plans should be made available to the City of Burlington for review and comment when they are completed.

10.0 REPORTING

GLA has proposed a yearly groundwater monitoring report. CRA believes that this would not be sufficient for the early groundwater monitoring, and plume deliniation program.

The first report on the findings of the initial proposed program should be completed at the completion of the tasks as outlined in Section 6.0 (ie. approximately six months). Reports on the groundwater monitoring and plume deliniation program should then be prepared and presented as each further step of the program is devised and is completed.

Each report should summarize and comment on the results of the previous phase and make recomendations, as to the procedure to be implemented for the next phase of the program. Each report should be reviewed by the City of Burlington before it is finalized.

Once the plume studies are completed, and the groundwater monitoring program has been adequately standardized to the satisfaction of all parties concerned, the yearly reporting schedule as outlined by GLA in the draft terms should be adequate.

It is recommended that the City of Burlington be given an opportunity to comment on the revised terms of reference for the monitoring program prior to finalizing.

Should you have any questions and or comments on the above letter report, please feel free to contact us.

Yours truly,

CONESTOGA-ROVERS & ASSOCIATES LIMITED

Walter Graziani

Walter Graziani, P. Eng. Anthony J. Crutcher, P. Eng
/mm
Encl.

N

N 782

TY OF BURLINGTON

DATE March 25, 1985

MOVED Alderman Pugsley

SECONDED Alderman Whyte

SWM-17-85 **CITY'S RESPONSE TO WALKER WRIGHT YOUNG ASSOCIATES PHASE 2 STAGE 2C REPORT**

WHEREAS the principal recommendation of the Draft Environmental Assessment Study Phase 2 Stage 2C Report prepared by Walker Wright Young Associates Ltd., namely, that the Escarpment Site F in Burlington "be selected as the preferred site for landfill in Halton", is based on incomplete information and inadequate analysis;

AND WHEREAS, should the Region's EA submission identify the undertaking as landfill at one preferred site, it would risk having to conduct another Landfill EA Study were the EA Board to not approve the undertaking as submitted;

AND WHEREAS, in the opinion of the City's professional consultants, a close review of the information available to Walker Wright Young Associates Ltd., within a more systematic and more reliable framework for comparatively evaluating the six candidate sites, demonstrates conclusively:

(1) that none of the six sites, including the Escarpment Site, is clearly preferable to all of the others and
(2) that Sites A and D, form a very tight grouping as "most preferred" sites, with Site E and Escarpment Site F being close "second most preferred" sites;

THEREFORE BE IT RESOLVED THAT the Region of

SWM-17-85 (Continued)

AND FURTHER THAT a meeting be held on April 1, 1985 at 7:00 p.m. at Aldershot High School to present the City's position on this matter to members of the public.

N 783

EM-34-86

Ministry of the Environment | Ministère de l'Environnement | Central Region | Région du Centre

Ontario

Suite 401
1235 Trafalgar Road
Oakville, Ontario
L6H 3P1
416/844-5747
416/822-2566

Bureau 401
1235, chemin Trafalgar
Oakville (Ontario)
L6H 3P1
416/844-5747
416/822-2566

February 28, 1986

HAND DELIVERED

APPENDIX 1 TO CAO 29/86

The Corporation of the
City of Burlington
P. O. Box 5013
426 Brant Street
Burlington, Ontario
L7R 3Z6

Attention: Mr. Michael Boggs, CAO

Dear Mr. Boggs:

RE: Bayview Park Landfill Site, City of Burlington,
Conceptual Design Report, January 30, 1986

Ministry staff have reviewed the Conceptual Design Report, submitted January 31/86, for a leachate and transmission collection system.

The design presented in the report is at the conceptual level and provided the Ministry with helpful information towards production of your final design. We will require a response to the following questions in your final design:

General Comments

1. The Ministry of the Environment [illegible]

It was confirmed in an earlier telephone discussion between myself and Walt Graziani that the comments in the conceptual report on Page 6 and 7, relating to the requirements for a collection system on the eastern side of the site, do not apply to the area discussed above.

For the benefit of the City, I would like to reiterate the Ministry's immediate and long term objectives:

1. Our intermediate objective is to ensure the elimination of surface water contamination caused by the leachate seeps.

2. Our longer term objective is to determine the fate of leachate infiltration from the landfill into the regional groundwater flow regime and identify the necessity for additional mitigation.

The following comments specifically address matters relating to hydrogeology and engineering. If you have questions concerning any of these matters, please contact, respectively, Ms. Irmi Pawlowski (965-4120) or Mr. D. F. Carr, P. Eng. (965-6975):

Hydrogeology:

Discussion and some details on the technical aspects for the conceptual design of the leachate collection system are lacking. Would you please address the following examples:

1. The identification of the elevation of the invert of the leachate drains.

2. The applicability of the "tunnel" drain formula specifically to this site, including the hydraulic calculations based on preliminary sections.

3. The individual seep flow rates and their significance with respect to the final design of the leachate sump and collection drains.

4. The management and disposal of any contaminated water and soils during construction.

5. Construction worker information, safety and protection.

6. The evaluation and maintenance of system performance.

7. There are a few additional issues requiring clarification which Ms. Pawlowski would like to discuss directly with your consultants, please have them contact her at their earliest convenience.

Engineering:

1. On Page 10 of the report it indicates that the total groundwater flow rate for the drain systems will be in the order of 119 litres per minute. On the following page Table 2.2 indicates unit drain flows in imperial gallons per minute and a total flow of 118.6 litres per minute. On page 11 of the report, the total design flow rate for the collection system is indicated to be in the order of 164 litres per minute. The three numbers are contradictory and should be clarified in the report.

2. As any leachate from the landfill site will ultimately be discharged to an existing municipal sewer, the existing municipal sewer should be checked for:

   (a) is the sewer material suitable for handling the proposed leachate and

   (b) is there capacity in the receiving sewer to accept the additional flow, both under present (committed) and future (fully utilized) conditions? This should be checked by the consultant.

3. It is quite obvious that methane gas will be present in the area of all the leachate sumps or will gain access into the leachate sump itself. As such, the leachate sumps should be made explosion proof (this includes the pumping units themselves and any associated electrical equipment within the sump). For the same reason, any sump control panels should be located remote from the sumps; otherwise they too will have to be made explosion proof.

4. It is stated in the report that the groundwater is at or near the ground surface. In this case, all the pumping sumps should be checked for uplift and have the necessary weight to prevent this under a high groundwater condition.

5. On page 22 of the report it indicates that a vent pipe will prevent any overflowing of leachate from the sump in the event of a pumping system failure. This is not considered adequate and we would request that a high leachate level in the sumps be alarmed via a high water "fail safe" type alarm which is transmitted to a manned centre.

6. How is the alignment and stability of the collection sewer to be maintained in the refuse as shown in Figure 5.4 of the report?

7. As indicated in the report, this is a very conceptual design and, as such, approvals will provide more detailed comments on the specific design when the final drawings, specifications and engineers report are submitted at the final design stage. For example, the proposed pump capacity from each sump is not indicated, neither is the size of the proposed forcemain, minimum forcemain velocities, sump volume, etc.

...P/4

EM-34-86

This concludes the Ministry's comments on the Conceptual Report. If your consultants have questions on any of the general issues in this review, they may contact me directly.

In order to facilitate a prompt Ministry review of the detailed design expected April 14/86, please send copies of the detailed submissions directly to the following parties by courier:

Ms. I. R. Pawlowski, Hydrogeologist, Technology Assessment Section, Waste Management Branch (1 copy)

Mr. D. F. Carr, P. Eng., Sr. Approvals Eng., Central-Southeastern Regions, Environmental Approvals Section (1 copy)

L. F. Parsons, Planning Co-ordinator, Halton-Peel District (address above (2 copies)

Also, would you please ensure that both Regional representatives and National Sewer Pipe Limited promptly receive copies when available.

If I can be of further assistance, please do not hesitate to contact me. I appreciate your co-operation.

Yours truly,

L. F. Parsons
Planning Co-ordinator
Halton-Peel District

LFP:cm

cc: Anthony J. Crutcher, P. Eng., Conestoga Rovers & Associates Ltd.
Mr. R. S. Christensen, National Sewer Pipe
Mr. D. Perlin, Regional Municipality of Halton
G. Nelson
B. Singh
G. Mierzynski
I. R. Pawlowski
D. F. Carr
J. Dulny

N/784

CITY OF BURLINGTON

DATE April 7, 1986

MOVED Alderman Mulkewich

SECONDED Alderman Savoline

EM-35-86

EXPROPRIATION OF LAND FOR THE LEACHATE COLLECTION SYSTEM AND BUFFER LAND REQUIREMENT AT THE BAYVIEW PARK LANDFILL SITE

THAT the application of The Corporation of the City of Burlington to the Council of the said City attached hereto for approval to expropriate land described as all and singular Part of Lot 3, Concession 2, and Part of Lots 2 and 3 Concession 1, formerly in the Township of East Flamborough, now in the City of Burlington, in the Regional Municipality of Halton, designated as PARTS 1, 2, 3, 4 and 5 on a preliminary, proposed plan of expropriation prepared by the City of Burlington, Department of Public Works - Survey Section, dated March 21,1986,

For the following purposes:

1. to collect and prevent leachate-contaminated groundwater seepage from the Bayview Landfill Site from flowing overland and entering the Indian Creek system;

2. to collect contaminated groundwater at the Landfill Site margins and prevent these contaminated waters from discharging into Indian Creek;

3. to install leachate collection systems, access roads, contingency groundwater cut-off walls and to provide down gradient attenuation/treatment zones;

4. to provide long-term access to the leachate collection system including access roads and contingency groundwater cut-off walls for maintenance and monitoring;

5. to provide buffer zones for installation of the leachate collection systems, access roads, contingency groundwater cut-off walls and down gradient attenuation/treatment zones; and

6. to bring adjacent lands upon which refuse encroaches under the ownership of the City.

For the following reasons:

1. to control leachate discharge to the surface water from surface seepage and shallow groundwater flow; and

2. to provide increased buffer zones down gradient of the Bayview Landfill Site to permit natural attenuation and treatment of contaminants in shallow and deep groundwater.

.../2

EM-35-86 (Continued)

Be received, and the City Solicitor be directed to sign Form 2 and the said Form to be served and published in accordance with the Expropriation Act, R.S.O. 1980 c. 148, as amended;

and that the Director of Public Works be authorized to retain an appraiser to prepare a report as to the compensation payable to the owners of the said lands pursuant to the Expropriation Act, R.S.O., 1980 c. 148, as amended, the cost to be charged to the Capital Works in Progress Account Number 111-0070-7141. File: 760-04-1 & 575-15-10-1

CERTIFIED A TRUE COPY

CITY CLERK

CARRIED "R.L. Bird" - MAYOR

Page 2 of 2 pages.

K TUER

N 785

REGIONAL MUNICIPALITY OF HALTON

Report to The Chairman and Members of the Solid Waste Management Committee

From The Director of Public Works

Date 1986 04 12

Report No. PW.131/86

Re: Halton's Comments - Review of Conceptual Design Report, Leachate Collection System and Buffer Land Requirements, Closed Bayview Park Landfill Site Burlington

RECOMMENDATION

1. THAT the City of Burlington be advised that Halton has no objection to the alignment set out in preferred option 1(a) of the Conceptual Design Report, Leachate Collection Systems, Closed Bayview Park Landfill Site Burlington. i.e. King Road Gravity Sewer With Underground Crossing of Highway 403, as the preferred collection system option for leachate from the closed Bayview Park Landfill Site.

2. THAT the City of Burlington be advised that Halton has no objection to the acquisition by the City of Burlington of all of Zones A and B and up to 50 metres of the northerly portion of Zone C, adjacent to the southeast side of Bayview Park to enable the installation of the Toe-Drain Collection System concerned.

3. THAT the City of Burlington be advised that Halton considers it unnecessary to acquire any more lands in Zone C than is required for the installation of the Toe Drain Collection System (i.e. up to 50 metres of the northerly portion) until after the Toe Drain Collection System has been installed and an extensive monitoring program

undertaken to evaluate the Toe Drain Systems effectiveness AND until after the landfill approvals process respecting Halton's Long Term Landfill Component is completed.

4. THAT the City of Burlington be advised that Halton has no objection to the receipt of the Bayview leachate at the Skyway Water Pollution Control Plant for treatment unless and until unforeseen operational problems arise in the future at the Skyway Water Pollution Control Plant requiring discontinuance of acceptance of Bayview leachate at the Plant.

5. THAT the City of Burlington be advised that it will be permitted to discharge the leachate collected into the Halton sanitary sewer system on King Road subject to the following conditions and as previously agreed in 1984 with no Special Discharge Fees under the Sewer Use By-law having to be paid:

(a) THAT a metering device is installed by the City at its expense on their gravity leachate system at or near the edge of Bayview Park lands to enable a record to be kept of the amount of leachate discharged and for the purpose of charging the City the normal sewer surcharge.

(b) THAT the City pays the normal sewer surcharge fees.

(c) THAT the discharge is in accordance with Halton Sewer Use By-law No. 97-79 or successors to this by-law as much as reasonably possible but with Halton Council being able to permit the City from time to time as may be required to discharge in excess of the by-law limits as may be established from time to time.

(d) THAT the City carries out an ongoing program of analysis of leachate being discharged from time to time into Halton's sanitary sewer system with copies of all test results being forwarded to Halton Region, Industrial Waste Section, as and when available.

(e) THAT the proposed leachate collection pipe as set out in Option 1(a), from where it enters the right-of-way on King Road from Bayview Park to where it connects with the existing King Road sanitary sewer south of Highway 403, must be designed and constructed at the City's expense to Regional standards and specifications, since it will be located on a road allowance.

6.(a) THAT prior to the commencement of construction of the proposed leachate collection system, appropriate agreement(s) be entered into between the City of Burlington and the Regional Municipality of Halton encompassing the permission and terms and conditions set out in Recommendation No. 5 above.

(b) THAT the agreement(s) mentioned above be drafted by the Regional Solicitor and that the Regional Solicitor be authorized to prepare the necessary by-law(s) permitting execution of the agreement(s) when same are ready for execution.

REPORT

In Report PW.80/86, staff advised of the intent of the City of Burlington to "clean up" its leachate problem at the closed Bayview Park Landfill in Burlington and the receipt of the Conceptual Design Report, Leachate Collection System and Buffer Land Requirements, Bayview Landfill Site, City of Burlington, related thereto, as prepared for the City by Conestoga-Rovers & Associates (CRA). Staff, subject to receipt of the final report from Pollutech on Bayview leachate treatability and toxicology impact, were to provide comments on the conceptual report for the April 14, 1986 Solid Waste Management Committee.

Field sampling for the Leachate Treatability and Toxicology Impact Study took longer than anticipated which has resulted in delaying Pollutech's final report. Pollutech has made every effort to meet our April 14th deadline but their final report will not be available until April 18th. They have, however, provided us with a verbal report of their results, and based on this information, we are still proceeding with staff's report to committee.

We met with the City and CRA staff on March 27, 1986. At this meeting, Halton staff were given a set of draft construction drawings for review. These drawings were based on the Option 1A concept as described in the conceptual design report under review. Halton staff have reviewed both the report and drawings. Further, Hydrology Consultants were asked to review the conceptual report and provide verbal comments to us.

On April 11, 1986 we received for review the Detailed Design Report for the Leachate Collection System and Surface Drainage Improvements. However, staff, at the time of preparing this report had not had time to review the report or accompanying drawings.

In report PW.80/86 Halton staff advise that there were five key issues which would be addressed in our review of CRA's reports, namely:

1. Hydraulic impact on the sanitary sewer system, either on King Road and southerly, or the North Service Road westerly and southerly.

2. Bayview leachate treatability and toxicology impact.

3. Sewer system ownership and operation for pumping stations, sewer mains, forcemains, and Highway 403 crossing.

4. Parameters for preparation of Special Discharge Agreement, including sewer use charges for discharge of leachate into Halton's sanitary sewer system.

5. Impact of proposed remedial measures on the development of proposed Site F for Halton's new landfill.

<u>Hydraulic Impact - Sanitary Sewer System</u>

CRA have estimated that the maximum flow from the leachate collection system, following initial construction, will be in the order of 164 L/m (36 gpm) and that in time, due to the effects of dewatering, the flow rate will be reduced to 47 L/m (10 gpm). Our Engineering Services Division have reviewed those flows to determine the downstream impact on Halton's sanitary sewer system and advise that these flows will have no significant impact on either the King Road sanitary sewermain system as proposed in Option 1(a) by CRA, or in the North Service Road system, as proposed in options 1(b), 1(b), 2, and 3.

Preferred Option - Leachate Collection System

Options 1(b), 2 and 3 require the construction of an intermediate pumping station and forcemain on the North Service Road whereas Option 1(a) provides for a gravity discharge to the sanitary sewer system without the requirement for pumping stations beyond the limits of Bayview Park. In light of the ongoing operating and maintenance costs for pumping stations, staff would suggest Option 1(a) is preferable. Further, Options 2 and 3 require the crossing of private lands, these being less desirable alignments. Option 1(a) and 1(b) provide alignments using public property. Option 1(a) also provides a potential for servicing future industrial areas on the north side of Highway 403 and the King Road area if the leachate collection pipe is also used as a "sanitary sewer" which it could be if designed and constructed as it should be to Regional standards and specifications.

Hydrology Consultants have reviewed the proposed toe drain and sump collection system. Hydrology acknowledge the need to control leachate at the Bayview site and feel that CRA's proposal Option (1A) has addressed that need.

CRA proposes a 200 mm diameter (8") pipe crossing under Highway 403 and connecting to our 450 mm (18") diameter sewer main on King Road which terminates just to the south of Highway 403. Engineering Services staff are currently reviewing their future servicing requirements in this area and may be suggesting an upgrading in size of the portion of pipe crossing under the Highway 403 to the North Service Road.

If oversizing is required this will be addressed in the agreement recommended between the Region and the City in accordance with accepted Regional procedures.

In summary, Halton staff have no objection to CRA's preferred Option 1(a) as the best approach to provide leachate collection for the closed Bayview Park Landfill and connection to Halton's sanitary sewer system.

Leachate Treatability and Toxilogical Impact

As to evaluating the CRA proposal's impact on Halton's sanitary sewer system and more particularly on our ability to treat the leachate and meet all discharge guidelines, Pollutech's preliminary data indicates the leachate meets all our by-law limits with respect to metals, BOD, and suspended solids. The only exception would be chlorides which, in view of the low volumes to be discharged, should not be a concern. Pollutech have, in fact, described the leachate as being not much different than an industrial sewage which would be readily accepted into our system. Further, Pollutech report they were unable to detect either PCBs or pesticides in the samples analyzed. This is both encouraging and surprising in view of early assumptions that the Bayview Park Landfill had been the prime source for alleged traces of these contaminants found in watercourse downstream of the site.

Pollutech have advised that they will be recommending in their report that Halton can accept the leachate from Bayview Park Closed Landfill for treatment at the Skyway Water Pollution Control Plant without the need for pre-treatment based on their samples tested and on the volumes set out in CRA's report.

Upon receipt, Pollutech's final report will be forwarded to the City of Burlington and their consultants.

Pollutech believe that Halton should require ongoing monitoring of the leachate discharged into the sanitary sewer system and Pollutech's report will recommend a monitoring/sampling program to meet that concern. Further, Halton will require that a flow meter be installed on the leachate discharge system to monitor quantities of leachate being discharged into Halton's system and to enable the City to be charged the normal sewer surcharge.

Land Requirements

Conestoga Rovers have proposed that additional lands surrounding Bayview Park will be required to carry out their proposed remedial measures. They have identified these lands as Zones A, B and C.

Zone A is a 30 m x 300 m area located on the northern portion of the west side of Bayview Park. CRA advise this area is required as it contains "refuse from previous disposal practices of the Bayview Landfill Site." and that the removal of this refuse would be technically difficult and economically impractical. Halton Staff has no objection to the acquisition of Zone A.

Zone B is located adjacent to the southerly half of the west side of Bayview Park and is approximately 50 m x 300 m. This area, according to the CRA report, is required in order to construct a leachate toe drain collection system to prevent leachate discharge into the adjacent creek system. Halton staff again has no objection to the acquisition of Zone B.

Zone C is located adjacent to the south side of Bayview Park and measures approximately 350 m x 450 m. According to CRA, this area is required primarily for the "Natural attenuation of continimates found in the deeper groundwater which discharges to the stream system south of the present Bayview property boundary and bypasses the proposed shallow groundwater collection system." Halton staff have received advice from Hydrology Consultants that the need for all of Zone C as a buffer zone is unproven as no information has been provided nor are we aware of any in previous reports that leachate is in fact discharging into this area. It is quite apparent that there are leachate seeps along the south side of Bayview Park and we would concur with the potential, without remedial measures, of these surface seeps discharging into the water courses in Zone C. However, the proposed remedial measures, i.e. toe drain collection system, should intercept these surface discharge points and thus should provide the major correction to the problem. In fact, these measures may be all that is necessary to satisfactorily address the problem considering Pollutech's comments on the quality of the leachate sampled.

Further, the City of Burlington advise that they will be carrying out a detailed monitoring program of the effectiveness of the toe-drain collection system and an investigation with regard to contamination of Zone C and that this investigation work will not be completed until 1987. Thus, the acquisition of all of Zone C at this time is unnecessary or at least premature. Further, we are advised that National Sewer Pipe, owners of Zone C, as well as A and B, will permit the City of Burlington and their consultants full access to this area to undertake the monitoring program. National Sewer Pipe advise at this time that they are not concerned by the potential contamination of this area and further, NSP are not going to do anything with this land until the landfill issue has been resolved.

Further, Halton's own plans regarding the development of a landfill site on NSP's lands, proposed Site F, if they go forward, could address concerns of off-site contamination from Bayview not collected by the toe drain collection system.

However, a portion of Zone C is required for the toe drain collection system and to obtain the area which contains refuse and also, land is required in order to construct the proposed leachate sumps. A strip of land to a maximum of 50 m in width on the southeastern limit of Bayview Park extending from Zone B through to King Road right-of-way should be more than sufficient to address the City's requirements at this time. The Ministry of the Environment in correspondence dated February 28, 1986 to the City of Burlington appear to have come to the same conclusion. In that letter the Ministry state: "The Ministry does not concur that all the land requirements associated with Area C can be supported at this time." The Ministry letter continues that "There are no data presented in either of these reports to substantiate the need for land as groundwater contamination attenuation/treatment zone downgradient. It may be that your monitoring program will demonstrate the need for this in future, however the need has not been demonstrated at this time."

System Design, Ownership and Operation

Staff would recommend that the portion of the leachate collection system to be constructed on Municipal and/or Provincial road allowances, i.e. the King Road portion, be designed and constructed to Regional standards and specifications with the cost to be borne by the City of Burlington. However, once constructed to Halton's standards and specifications, the system could be assumed by the Region and thereafter maintained by Halton if the City so requested. Any conditions for such assumption would best be considered and determined if such a request is ever made; so far no such request has been made. However, the collection portion of the proposed system, i.e. that portion located on Bayview Park or in adjacent properties to be acquired by the City, should in any case, remain under the jurisdiction of the City of Burlington. The City clearly has a responsibility to address the leachate problems from Bayview Park and thus has a mandate to ensure that the collection system is working effectively, whereas Halton's involvement is the treatment of the leachate when it is collected. Also, as time goes on, modifications to the collection system may be required, i.e. the construction of additional collection points or extension of toe drain system for which the City would be responsible and thus the system should remain under the City's ownership and control. Notwithstanding the above, the City should construct the sump and pumping system to Halton's standards. This is not only to ensure satisfactory performance of the system, but also to meet health and safety concerns of staff, whether they be staff of the City, Region or a private contractor who will be called upon to maintain and operate the system.

We will be reviewing the just received design reports and specifications and will forward our comments to CRA based on Regional standards and specifications.

Agreements and Sewer Surcharges

The City should be required to enter into a servicing agreement, typical to that of any development requiring sewer servicing by Halton. The agreement will address such issues as main sizing, standards to meet and servicing charges.

In report CAO.170/84 re Interim Waste Disposal Plan - Continuation Program at Burlington Landfill Site - Burlington's Conditional Support for the Continuation Program, Council approved that Halton "could accept leachate from Bayview Landfill Site if the leachate is treatable at the sewage treatment plant. Further, Regional staff stated that it would recommend that if the City proceeded to remedy its leachate problems at Bayview Park by wishing to connect to the sanitary sewer system, then, provided that the leachate is treatable at the sewage treatment plant, Regional staff would recommend that the hook up be at no cost to the City and that there be no treatment costs charged to the City for the treatment of the leachate at the Skyway Pollution Control Plant."

In light of the above Council approved recommendation, the City would be exempt from the Special Discharge Fees for example, high chlorides under the Sewer Use By-law and from permit and connection fees. The normal Sewer Surcharge would still be payable and depending on flows actually received, the sewer surcharge would normally be in the range of $9,000-$29,000 per annum.

Impact - Proposed Site F

CRA's recommended leachate collection system for Bayview Park, Option 1A, is compatable with and will not interfere with Halton's own proposed plans to use adjacent property for landfilling, proposed Site F. The acquistion of additional lands adjacent to the Park, i.e. Zones A and B and the northerly 50 metres of Zone C by the City will not affect Halton's ability to develop a landfill on Site F. In fact, as we have stated in the past, the development of a sanitary landfill on Site F with full leachate underdrain and collection system will complement any works proposed by the City for Bayview. If contamination of NSP lands is proven, capture of leachate by a collection system is a more positive method of dealing with the problem as opposed to the attenuation. The acquisition of any more lands in Zone C other than the northerly 50 metres could impact on matters related to Halton's possible use of Site F as a landfill such as approvals processes and costs and land costs. Thus, since the acquisition of any more lands in Zone C than is required for the installation and maintenance of the leachate collection system is unnecessary in any case until after the monitoring for a significant period of time of the effectiveness of the toe drain collection system, then there is no need for the City to acquire any more lands and potentially affect Halton's possible use of Site F as a landfill.

Respectfully submitted,

R.J. Moore, P.Eng.
Director of Public Works

JRM/sw

APPROVED BY C.A.O

THE REGIONAL MUNICIPALITY OF HALTON

RESOLUTION NO. ______

DATE April 23, 1986

Moved by: B. Clements

Seconded by: R. Bonnette

4. THAT the City of Burlington be advised that Halton has no objection to the receipt of the Bayview leachate at the Skyway Water Pollution Control Plan for treatment unless and until unforeseen operational problems arise in the future at the Skyway Water Pollution Control Plant requiring discontinuance of acceptance of Bayview leachate at the Plant.

5. THAT the City of Burlington be advised that it will be permitted to discharge the leachate collected into the Halton sanitary sewer system on King Road subject to the following conditions and as previously agreed in 1984 with no Special Discharge Fees under the Sewer Use By-law having to be paid.

(a) THAT a metering device is installed by the City at its expense on their gravity leachate system at or near the edge of Bayview Park lands to enable a record to be kept of the amount of leachate discharged and for the purpose of charging the City the <u>normal</u> sewer surcharge.

THE
REGIONAL
MUNICIPALITY
OF
HALTON

RESOLUTION NO. ______

DATE April 23, 1986

Moved by: B. Clements   Seconded by: R. Bonnette

(b) THAT the City pays the normal sewer surcharge fees.

(c) THAT the discharge is in accordance with Halton Sewer Use By-law No. 97-79 or successors to this by-law as much as reasonably possible but with Halton Council being able to permit the City from time to time as may be required to discharge in excess of the by-law limits as may be established from time to time.

(d) THAT the City carries out an ongoing program of analysis of leachate being discharged from time to time into Halton's sanitary sewer system with copies of all test results being forwarded to Halton Region, Industrial Waste Section, as and when available.

(e) THAT the proposed leachate collection pipe as set out in Option 1(a), from where it enters the right-of-way on King Road from Bayview Park to where it connects with the existing King Road sanitary sewer south of Highway 403, must be designed and constructed at the City's expense to Regional standards and specifications, since it will be located on a road allowance.

THE
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HALTON

RESOLUTION NO. ______

DATE April 23, 1986

Moved by: B. Clements Seconded by: R. Bonnette

6.(a) THAT prior to the commencement of construction of the proposed leachate collection system, appropriate agreement(s) be entered into between the City of Burlington and the Regional Municipality of Halton encompassing the permission and terms and conditions set out in Recommendation No. 5 above.

(b) THAT the agreement(s) mentioned above be drafted by the Regional Solicitor and that the Regional Solicitor be authorized to prepare the necessary by-law(s) permitting execution of the agreement(s) when same are ready for execution.

CERTIFIED A TRUE COPY
REGIONAL MUNICIPALITY OF HALTON
Acting Regional Clerk

N 786

THE REGIONAL MUNICIPALITY OF HALTON

RESOLUTION NO. ______

DATE April 23, 1986

Moved by: ____________________ Seconded by: ____________________

1. THAT the City of Burlington be advised that Halton has no objection to the alignment set out in preferred option 1(a) of the Conceptual Design Report, Leachate Collection Systems, Closed Bayview Park Landfill Site Burlington. i.e. King Road Gravity Sewer With Underground Crossing of Highway 403, as the preferred collection system option for leachate from the closed Bayview Park Landfill Site.

2. THAT the City of Burlington be advised that Halton has no objection to the acquisition by the City of Burlington of all of Zones A and B and up to 50 metres of the northerly portion of Zone C, adjacent to the southeast side of Bayview Park to enable the installation of the Toe-Drain Collection System concerned.

3. THAT the City of Burlington be advised that Halton considers it unnecessary to acquire any more lands in Zone C than is required for the installation of the Toe Drain Collection System (i.e. up to 50 metres of the northerly portion) until after the Toe Drain collection System has been installed and an extensive monitoring program undertaken to evaluate the Toe Drain System's effectiveness AND until after the landfill approvals process respecting Halton's Long Term Landfill Component is completed.

THE REGIONAL MUNICIPALITY OF HALTON

RESOLUTION NO. ______

DATE ______________

Moved by: ____________________ Seconded by: ____________________

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THE REGIONAL MUNICIPALITY OF HALTON

RESOLUTION NO. ______

DATE ______________

Moved by: ____________________ Seconded by: ____________________

(b) THAT the City pays the normal sewer surcharge fees.

(c) THAT the discharge is in accordance with Halton Sewer Use By-law No. 97-79 or successors to this by-law as much as reasonably possible but with Halton Council being able to permit the City from time to time as may be required to discharge in excess of the by-law limits as may be established from time to time.

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CERTIFIED A TRUE COPY
REGIONAL MUNICIPALITY OF HALTON
....
Regional Clerk

Be received, and the City Solicitor be directed to sign Form 2 and the said Form to be served and published in accordance with the Expropriation Act, R.S.O. 1980 c. 148, as amended;

and that the Director of Public Works be authorized to retain an appraiser to prepare a report as to the compensation payable to the owners of the said lands pursuant to the Expropriation Act, R.S.O., 1980 c. 148, as amended, the cost to be charged to the Capital Works in Progress Account Number 111-0070-7171;

and that Item EM-35-86 of the Report of the Environmental Management Committee passed by Council on April 14, 1986, be rescinded.

Carried "R.L.Bird" Mayor