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1986/78. Dolerite weathering at Runnymede.

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Abstract

A site near Runnymede should be suitable as a disposal site for chemical wastes, with some precautions. These will include the installation of a drain around the disposal area to about one metre depth. As well, the clay on the bottom and sides of the pits will require remoulding and compacting. It may be necessary to add bentonite clay in this process to reduce the permeability to a very low figure. The seven boreholes drilled nearby should be sufficient to monitor any movement of chemicals from the disposal area.

INTRODUCTION

An investigation has been undertaken into the depth of weathering of dolerite in the Runnymede area to determine whether it is suited to development as a site for the disposal of chemical wastes. The area is situated some four kilometres south of Runnymede and is within a State Forest (fig. 1). The investigation has included a seismic survey at one location (undertaken by P. C. Stevenson), test pits dug with a backhoe at a number of locations, and the drilling of seven holes in the area most favoured as a disposal site from the previous work.

FAVOURED CONDITIONS FOR A DISPOSAL SITE (TOPOGRAPHICAL AND GEOLOGICAL)

An important factor that needs to be considered when choosing a disposal site is that it should be isolated from inhabited areas. This is largely to protect against significant contamination of water supplies at the point of use, whether underground or surface water. It would be the aim in selecting a site to ensure, as far as possible, that the dumped material does not migrate away from the site by water transport. In the unforeseen event that some migration from the site did occur, it should be detected at nearby monitoring points and remedial measures would be taken to prevent further movement from the dumping enclosure. In some cases it might be difficult to control the material that has already left the site. However, the danger to water users will be decreased with distance from the site by dilution. From a very remote site the dilution (and chemical alteration) would almost certainly be to such an extent that the contamination is undetectable, let alone dangerous, at the point of use in most cases.

So that the chemicals are retained in the dumping enclosure, the material in which they are placed must have a low permeability. The most common naturally-occurring material with these properties is clay and, in southern Tasmania, the most likely rock units that could provide suitable clay zones are Tertiary age sediments, shale bands in Triassic rocks, and weathered zones in Jurassic dolerite. Tertiary sediments including clay bands usually occur in valleys, and although they attain considerable thicknesses, and from this point of view are very attractive, they are often in agricultural areas and are therefore not particularly remote from habitation and water use. Triassic shales tend to occur on the sides of slopes or in valley floors because of their low resistance to weathering. Again they are usually in agricultural areas. Dolerite, which covers large areas of south-east Tasmania, is generally resistant to weathering and occupies much of the higher ground. Dolerite often produces a rocky soil which is not

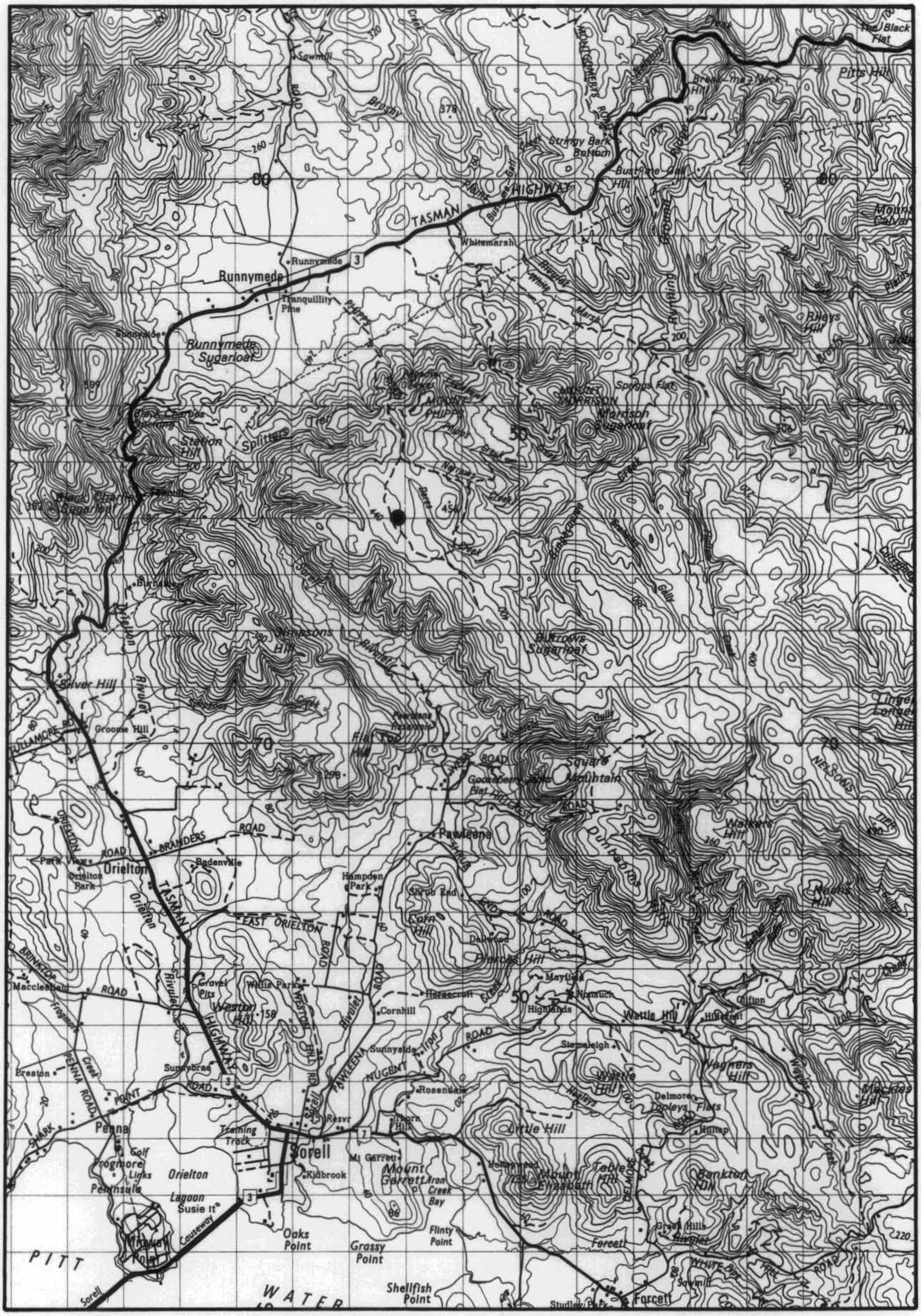

Figure 1. *Location of area under study*

5 cm

much used for agriculture except for rough grazing. Occasionally, on top of flat ridges of dolerite, relatively deeply weathered zones are known to develop in localised areas and these sometimes consist dominantly of clay. Dolerite bedrock can have quite low permeability where fractures are widely spaced and closed.

Ridge tops have small catchment areas so that water involved in rainstorms is more easily controlled than, say, in a valley. Elevated land is therefore favoured over low-lying land.

From the above it is apparent that a favourable site in southern Tasmania would be an elevated location underlain by weathered dolerite. Various locations were inspected, several with the above conditions, but rejected because of other factors such as poor access, before investigations began in a remote area in a State Forest a few kilometres south of Runnymede.

SEISMIC SURVEY

The seismic survey consisted of three spreads of 12 geophones and was undertaken in the northern part of the area examined (fig. 2). The results indicated a considerable depth to relatively unweathered rock, and it appeared likely that weathered material would occur to much deeper levels than required for the disposal site (P. C. Stevenson pers. comm.).

TEST PITS

Twenty-one test pits at a number of locations over a distance of about 500 m near an access road were dug to varying depths to examine the depth of weathering and the ease of excavation of the dolerite (fig. 2). Logs of the test pits are given in Appendix 1. Although the dolerite is deeply weathered at the many locations examined, unweathered kernels of dolerite of varying size and of varying concentration are scattered throughout the clayey material. In many locations the kernels were too concentrated to allow the pits to be dug to the required depth of about 2.5-3.0 m. In an occasional pit there was little difficulty in excavating to three metres but when nearby pits were attempted, the situation was different. This applied in the area of the seismic survey where eight test pits were attempted (Pits 1-4, 9-12) and only one (Pit 2) was relatively easy to dig. Continuous unweathered rock was not encountered in any of the pits, but the concentration of kernels in clay became too high. Only one area appeared to have the potential for sufficient clayey material over a wide enough area, and this is the location where Pits 5 to 8 were dug. With persistence, it should be possible to excavate trenches of the appropriate size.

GROUNDWATER IN TEST PITS

Some seepage was present in many of the pits and of those in the area favoured for development outlined above, Pits 7 and 8 had considerable amounts. Most of the water appeared to enter the pits from about one metre depth, although small seepages occurred towards the base of Hole 7. The seepages often entered the pits by way of tube-like channels. It is not known how these develop, but they may be where tree roots were once located.

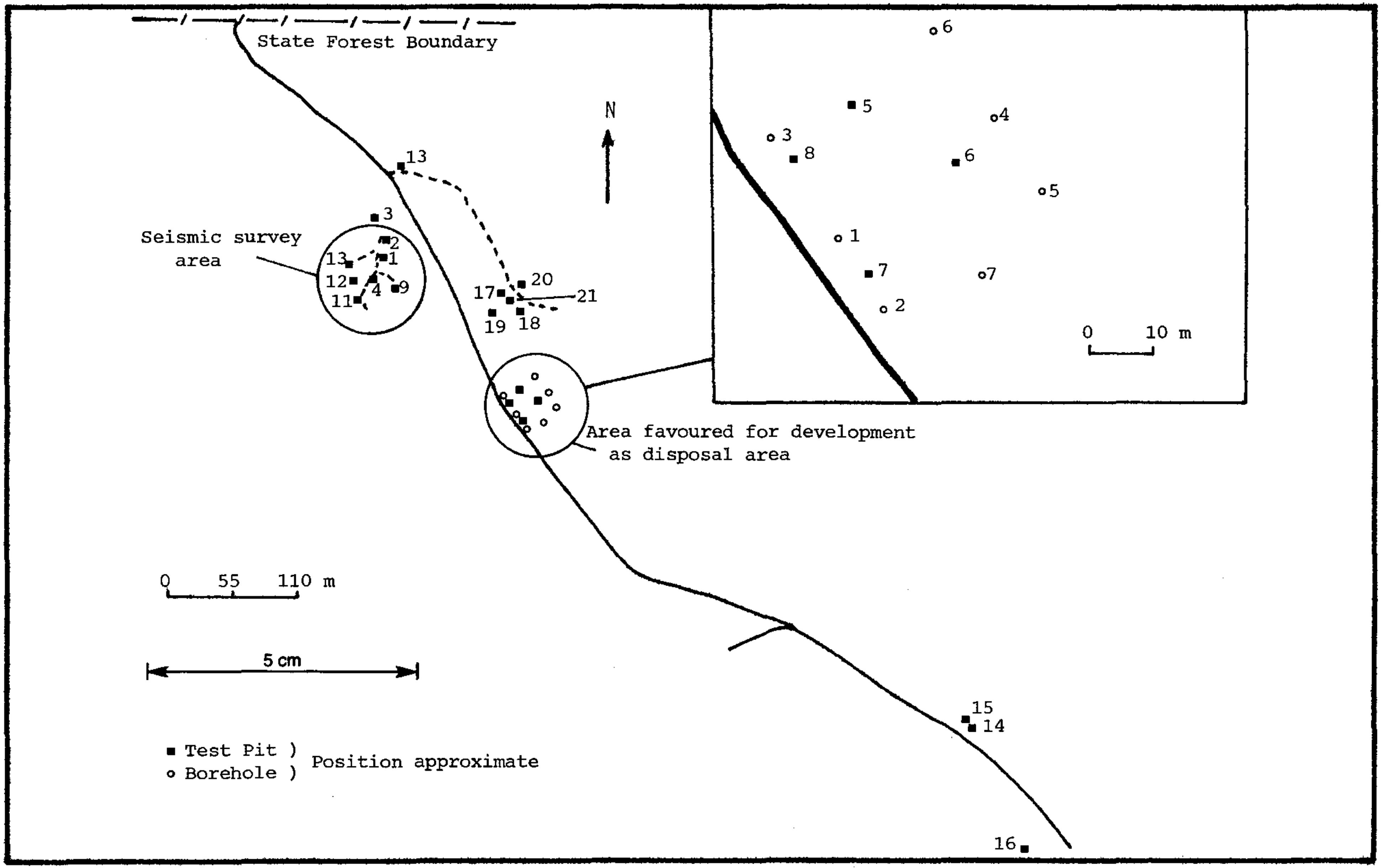

Figure 2. *Possible disposal area, Runnymede*

GROUNDWATER IN BORES

Seven bores about 175 mm in diameter have been drilled to monitor any movement of chemical waste from the dumping area (fig. 3). Five bores were shallow, being only to hard bedrock, while two were much deeper (Hole 1 to 50 m and Hole 4 to 40 m). The water table is quite shallow in all of these, including the deep bores that penetrate the largely unweathered dolerite. A large proportion of the water in each case appears to have been struck in less weathered dolerite just above unweathered rock. The shallow standing-water levels for Holes 1 and 4 (the deep bores) suggests that the unweathered rock has very low permeability. The driller indicated that no extra water was obtained while drilling these deeper holes, and this supports a low permeability for the lower levels. Each of the shallow bores has been cased with slotted PVC casing surrounded by crushed rock. The two deeper bores are only cased to bedrock with steel casing.

Permeabilities have been determined using the auger hole test method as described in Todd (1980). This method involves the pumping out of the hole and monitoring the water level changes with time. As well, short pump tests were conducted on the bores regarded as having the largest water yields when drilled (Holes 1, 4 and 6). Both the pumping and recovery stages were monitored. Calculations of transmissivity (T) and permeability (K) have been made using a modified Theis formula. The conditions that are required for the application of the Theis method are probably not present for these tests even in an approximate form, and the results obtained using the auger hole method are regarded as being by far the most reliable. Even these are probably only approximate average figures.

The calculated permeabilities are given in Appendix 3. Permeabilities calculated using the Theis method are much higher, and this is no doubt due to the relative shortness of the tests as well as to the considerable proportion of water pumped being stored in the bore before pumping began, compared to the total amount of water pumped during the test. Variations in pumping rate also contributed to the unreliability of the results. Several values for permeability for particular bores are given, and these are calculations at various stages of recovery in the auger hole method. The two values in the Theis method are from the pumping stage and recovery stage.

The standing water level in the bores fluctuates a little and measurements taken on two occasions are given below:

	17.4.87	*20.7.87*
Hole 1	2.03 m	1.12 m
Hole 2	2.22 m	1.08 m
Hole 3	1.73 m	0.47 m
Hole 4	2.14 m	0.50 m
Hole 5	2.19 m	1.85 m
Hole 6	2.29 m	0.77 m
Hole 7	2.54 m	2.24 m

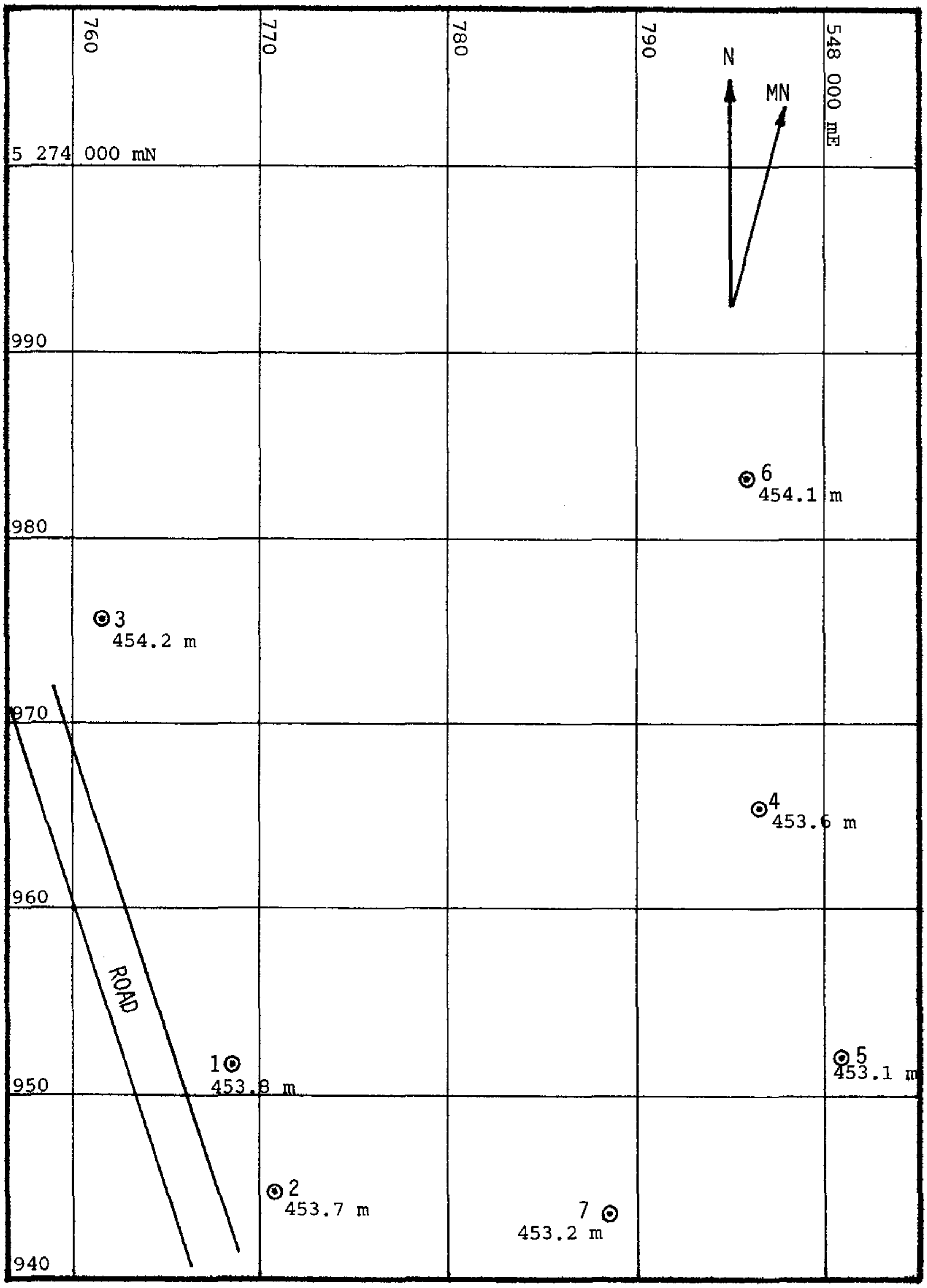

Figure 3. *Runnymede Disposal Area - Location of boreholes*

5 cm

CONCLUSIONS

The investigations show that there is a surface layer up to about 2.5-3.0 m thick consisting largely of clay derived from the weathering of dolerite. There will be varying quantities of unweathered dolerite kernels in the clay but it is likely that it will be possible to excavate pits in it. The surface layer is underlain by a layer of less weathered dolerite, and largely unweathered dolerite occurs at about 5-7 m (fig. 4).

Some seepage occurs in the more clayey surface layer but the lower part of the less weathered zone just above solid rock is likely to have the greater permeability. The two deep bores show that the unweathered dolerite has a probable low permeability.

Although some seepage is present within the clayey material it is likely that the permeability can be reduced to a very small figure by remoulding and compacting a layer 100-200 mm thick on the base and sides of the pits. This may be sufficient on its own to ensure negligible outflow from the pits but if not, bentonite clay could be mixed with the remoulded material. The bentonite, on becoming wet, would expand and largely close any voids in the naturally-occurring dolerite-derived clay, thus reducing the permeability in the same way that bentonite is used in the sealing of leaking dams. It will be necessary to prevent seepage to the less weathered zone above hard bedrock.

A drain should be constructed around the site to aid in preventing surface and near-surface seepage from entering the disposal area. This drain should be to about one metre or more in depth.

The surface of the disposal area should be made as impermeable as possible to prevent rainwater falling directly on it seeping underground.

The seven bores should be sufficient to determine whether any of the dumped material is leaving the area by groundwater transport. However in the event that significant contamination is observed in these nearby holes (regarded as a slight possibility only), more remote holes (100 or more metres distant) should be installed to monitor the extent of the movement while remedial measures are taken.

From the above it can be concluded that the site largely fulfills or can be made to fulfill the necessary conditions for a disposal site. It is remote from known water bores, being over 4 km from the nearest known bore. There is an accumulation of clay over bedrock from which it should be possible to develop sealed pits in which to dump waste materials. Whether the pits are dug directly below the existing surface or whether the soil is mounded and pits dug into the elevated surface will depend partly on the control of the water table by the drainage system. Because of the elevated nature of the site it should be relatively easy to control surface runoff with drains.

REFERENCE

TODD, D. K. 1980. *Groundwater hydrology (second edition)*. Wiley : New York.

[19 November 1986]

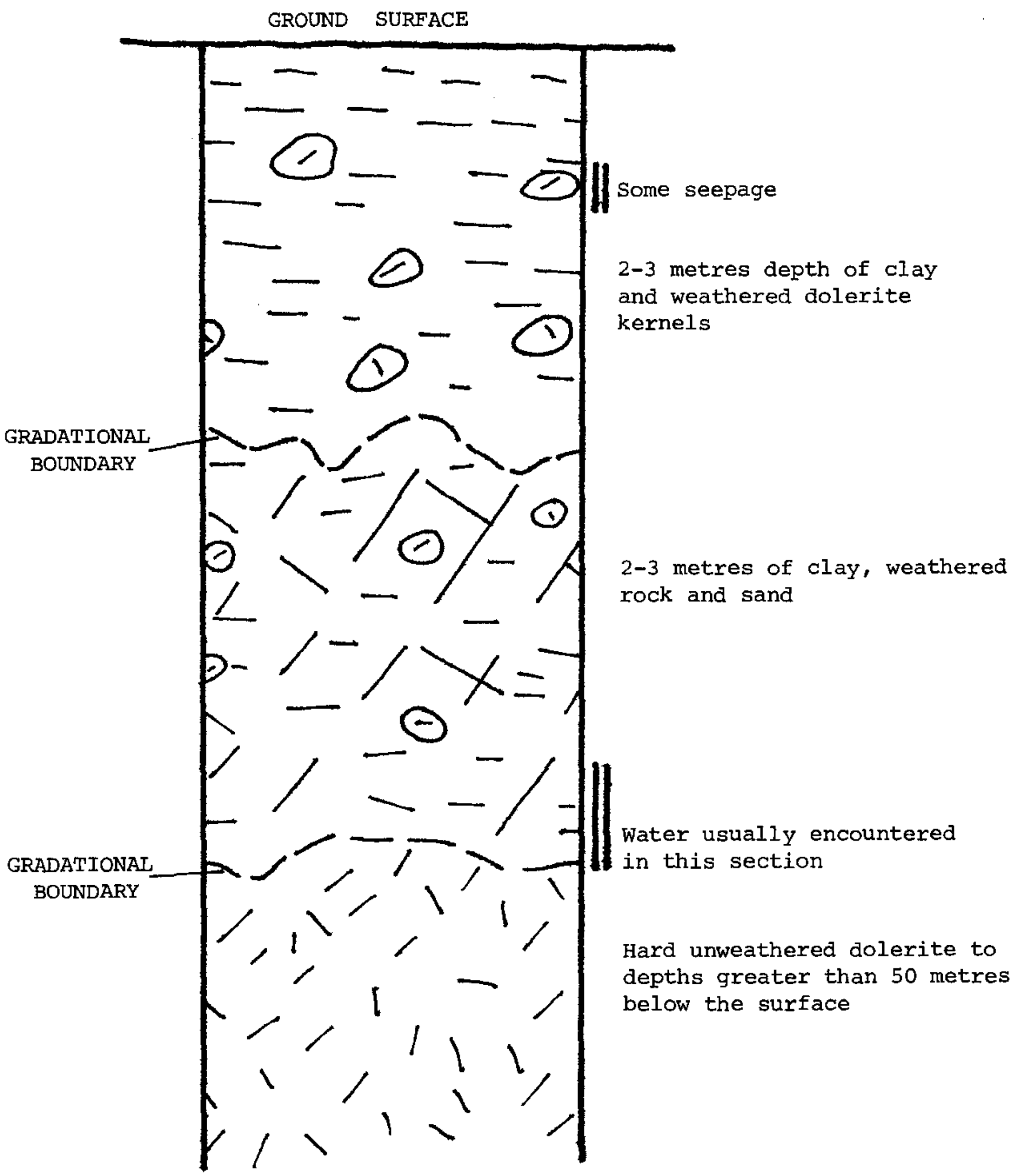

Figure 4. *Diagrammatic section below proposed disposal site*

APPENDIX 1

Logs of test pits

PIT 1

Depth (m)	*Description*
0 -0.3	Light brown to reddish clay soil, varies in thickness to 0.6 m.
0.3-1.0	Grey plastic clay with little dolerite texture, some brown mottling.
1.0-1.6	Brown and grey mottled clay, dolerite texture obvious, large boulders of unweathered dolerite in base of pit and further digging difficult.

Some seepage entered pit from base of soil layer.

PIT 2

Depth (m)	*Description*
0 -0.4	Brown clayey silty soil.
0.4-1.4	Lighter brown plastic clay shows some fracturing, towards bottom becomes mottled with grey clay; no obvious dolerite texture.
1.4-3.5	Grey and brown (iron-rich) clay with variable indication of dolerite texture but becoming more obvious with depth. Occasional large unweathered dolerite kernels throughout.

General seepage into pit from about 2.6 m to base of pit. About 0.3 m depth of water 5 hours after pit completed. About 0.6 m depth of water (estimated 200 litres) after 20 hours.

PIT 3

Depth (m)	*Description*
0 -0.3	Mainly bark.
0.3-0.8	Brown plastic clay, little dolerite texture.
0.8-1.7	Brown and grey clay, texture after dolerite becoming more obvious with depth. Unweathered zone at the base prevented further digging.

Seepage near surface on western corner.
Small seepage at base on eastern end - on top of rock.

PIT 4

Depth (m)	*Description*
0 -0.2	Brown clayey soil
0.2-0.8	Light brown plastic clay, finely fissured with little obvious dolerite texture.
0.8-1.2	Grey and brown mottled clay dolerite texture more obvious. A large unweathered kernel at the base of the pit prevented further digging.

Seepage from base of soil layer.

PIT 5 - Southern area

Depth (m)	*Description*
0 -0.5	Dark brown clay soil and disturbed clay.
0.5-0.9	Hard brown clay with little dolerite texture together with large dolerite boulders.
0.9-2.5	Grey-brown and red mottled clay with obvious dolerite texture (iron-rich parts and leached parts).

Seepage from topsoil but relatively dry at the base.

PIT 6

Depth (m)	*Description*
0 -0.3	Brown soil and disturbed clay.
0.3-0.6	Mainly brown clay, some dolerite texture, some unweathered kernels.
0.6-1.6	Grey and brown mottled clay, dolerite texture obvious. Unweathered kernels prevented further digging.

Some seepage near surface but relatively dry at the base.

PIT 7

Depth (m)	*Description*
0 -0.4	Dark brown clay soil and disturbed material.
0.4-1.0	Mottled red and brown clay, a little dolerite texture showing.
1.0-3.2	Grey and red mottled clay/weathered dolerite, some zones slightly harder but no unweathered kernels.

Strong seepage around pit at 1-1.2 m depth (about 4 *l*/min) often from holes in the clay. Occasional small spurts of water from near base.

PIT 8

Depth (m)	*Description*
0 -0.8	Brown soil and clay with dolerite boulders, variable depth.
0.8-2.7	Brown, red and grey mottled weathered dolerite clay, some unweathered kernels, base of pit wedge shaped because of abundant hard areas.

Substantial seepage at base of soil layer with about 4 *l*/min from one seepage on eastern end and about 2.3 *l*/min from another on south side, with others around pit. Within 10 minutes of completion, an estimated 180-230 litres had entered the pit.

PIT 9

Only 0.6 deep - wide area of rock at base of pit.

PIT 10

Depth (m)	*Description*
0 -0.5	Brown clay with dolerite boulders.
0.5-1.7	Blue and grey mottled clay with dolerite texture, numerous dolerite boulders. Hole became constricted and further digging prevented.

Seepage at interface between the two materials, only fairly minor.

PIT 11

Depth (m)	*Description*
0 -0.3	Brown clay soil.
0.3-0.8	Brown clay with iron oxide pisoliths, fairly soft, plastic.
0.8-1.2	Light blue-grey clay, fairly soft plastic, some indication of dolerite texture.
1.2-1.7	Brown and light grey mottled clay, dolerite texture obvious, unweathered centres becoming common, prevented digging.

Slight seepage in top layer, bottom relatively dry.

PIT 12

Depth (m)	*Description*
0 -0.4	Brown clay soil and boulders.
0.4-0.9	Brown and grey mottled clay followed by blue-grey plastic clay.
0.9-1.0	Weathered dolerite passing into unweathered kernels, not possible to dig further.

Some seepage from topsoil.

PIT 13

Only 0.6 m dug, broken dolerite in base of hole.

PIT 14

Only about 0.6 m before rock prevented digging.

PIT 15

Depth (m)	*Description*
0 -0.4	Brown clay soil, wet.
0.4-0.8	Brown and dark grey mottled fissured clay, little dolerite texture.
0.8-1.4	Clay with dolerite texture and unweathered kernels, eventually too hard to dig.

Seepage coming from base of soil.

PIT 16

Depth (m)	*Description*
0 -0.3	Brown loose soil.
0.3-1.1	Blue-grey plastic clay with dolerite boulders.
1.1-2.1	Weathered dolerite, clay and boulders, difficult digging.

No seepages.

PIT 17

Depth (m)	*Description*
0 -0.1	Brown soil.
0.1-0.75	Light brown and grey mottled clay.
0.75-2.8	Grey and brown mottled clay, brown areas iron rich and harder, some showing onion skin weathering. Dolerite texture. Large dolerite kernel at 1.2 m.

A little seepage from about 1 m depth. Minor seepage at 2.2 m depth.

PIT 18

Depth (m)	*Description*
0 -0.3	Brown soil, clayey.
0.3-1.0	Clay and dolerite boulders, became too hard to dig.

PIT 19

Depth (m)	*Description*
0 -0.4	Loose brown clay soil.
0.4-1.2	Weathered dolerite and boulders, becoming too hard to dig.

PIT 20

Depth (m)	*Description*
0 -0.4	Brown soil.
0.4-0.8	Blue-grey plastic clay.
0.8-1.2	Weathered dolerite and boulders, too hard to dig.

PIT 21

Depth (m)	*Description*
0 -0.2	Brown clay soil.
0.2-0.8	Mainly brown clay, plastic fissured, occasional dolerite boulders.
0.8-2.6	Brown and grey mottled clay and deeply weathered dolerite, shows igneous texture.

Strong seepage from about 0.8 m level at various points around pit. 2.3-4 *l*/min.

APPENDIX 2

Boreholes - Drillers Logs

HOLE 1

Depth (m)	*Description*
0 -2.45	Clay
2.45-3.60	Broken dolerite
3.60-4.70	Hard dolerite
4.70-5.0	Dolerite and water
5.00-50.00	Dolerite

About 4 *l*/min of water.

HOLE 2

Depth (m)	*Description*
0 -2.5	Clay
2.50-5.50	Dolerite

HOLE 3

Depth (m)	*Description*
0 -3.5	Clay
3.5 -	Dolerite

HOLE 4

Depth (m)	*Description*
0 -0.8	Clay
0.8 -3.5	Broken rock, water
3.5 -6.0	Dolerite, harder
6.0 -8.2	Broken dolerite, water
8.2 -40.00	Harder dolerite

About 7.5 *l*/min of water.

HOLE 5

Depth (m)	*Description*
0 -1.6	Clay and broken rock
1.6 -6.0	Decomposed dolerite
6.0 -7.0	Dolerite

HOLE 6

Depth (m)	*Description*
0 -1.8	Clay
2.10-5.50	Decomposed dolerite
5.50-6.00	Dolerite

HOLE 7

Depth (m)	*Description*
0 -1.8	Clay and broken rock
1.8 -6.0	Decomposed dolerite
6.0 -7.0	Dolerite

APPENDIX 3

Permeability Calculations

HOLE 1

Auger Hole Type Analysis (*m/day*)	*Modified Theis* (*m/day*)
5.1×10^{-5}	0.13
	0.11

HOLE 2

Auger Hole Type Analysis (*m/day*)	*Modified Theis* (*m/day*)
4.0×10^{-5}	

HOLE 3

Auger Hole Type Analysis (*m/day*)	*Modified Theis* (*m/day*)
1.5×10^{-4}	
5.8×10^{-5}	
4.5×10^{-5}	

HOLE 4

Auger Hole Type Analysis (*m/day*)	*Modified Theis* (*m/day*)
6.9×10^{-5}	0.036
4.2×10^{-5}	0.012

HOLE 5

Auger Hole Type Analysis (*m/day*)	*Modified Theis* (*m/day*)
1.3×10^{-5}	
2.3×10^{-5}	

HOLE 6

Auger Hole Type Analysis (*m/day*)	*Modified Theis* (*m/day*)
4.2×10^{-4}	0.04
2.7×10^{-4}	0.028
3.0×10^{-4}	

HOLE 7

Auger Hole Type Analysis (m/day)	*Modified Theis (m/day)*
2.4×10^{-5}	
8.4×10^{-6}	

Values in the 10^{-3} to 10^{-5} m/day range are low to very low.
Values in the 10^{-1} to 10^{-2} m/day range are moderate to low.

Source - D. K. Todd (1980)

Holes 2 and 3 have been deepened to about 5 m from 2.5-3 m since these tests were undertaken.