

WOSSAC:36616  
631.4  
(410)

NORTH OF ENGLAND SOILS DISCUSSION GROUP MEETING

Reaseheath, Nantwich

5-7 September 1977

Triassic drift soils of the Cheshire Plain and their management

FIELD EXCURSION GUIDE

## Triassic drift soils of the Cheshire Plain

### Introduction

Cheshire is divided into four physical regions in each of which differences in geology, climate and relief result in different soil and vegetation patterns. These are the Pennines, the Plain, the Mid-Cheshire Ridge and the Wirral Peninsula. The excursion visits the southern part of the plain (see map), the largest and agriculturally the most important of these regions. It is a district of drift soils varying from those formed on fine loamy and clayey reddish tills, glaciolacustrine clays and alluvium to those on coarse glaciofluvial sands and gravels. The emphasis of the excursion however, will be on the fine loamy and clayey soils and their management for intensive livestock farming.

The morning will be spent examining soils formed on reddish glaciolacustrine drift and river alluvium, all of which have severe drainage problems due to their high clay content and flat low lying situation. A sequence of 4 profiles starting in an undrained unimproved area and ending in an intensively drained and well managed site will be seen during the course of the morning.

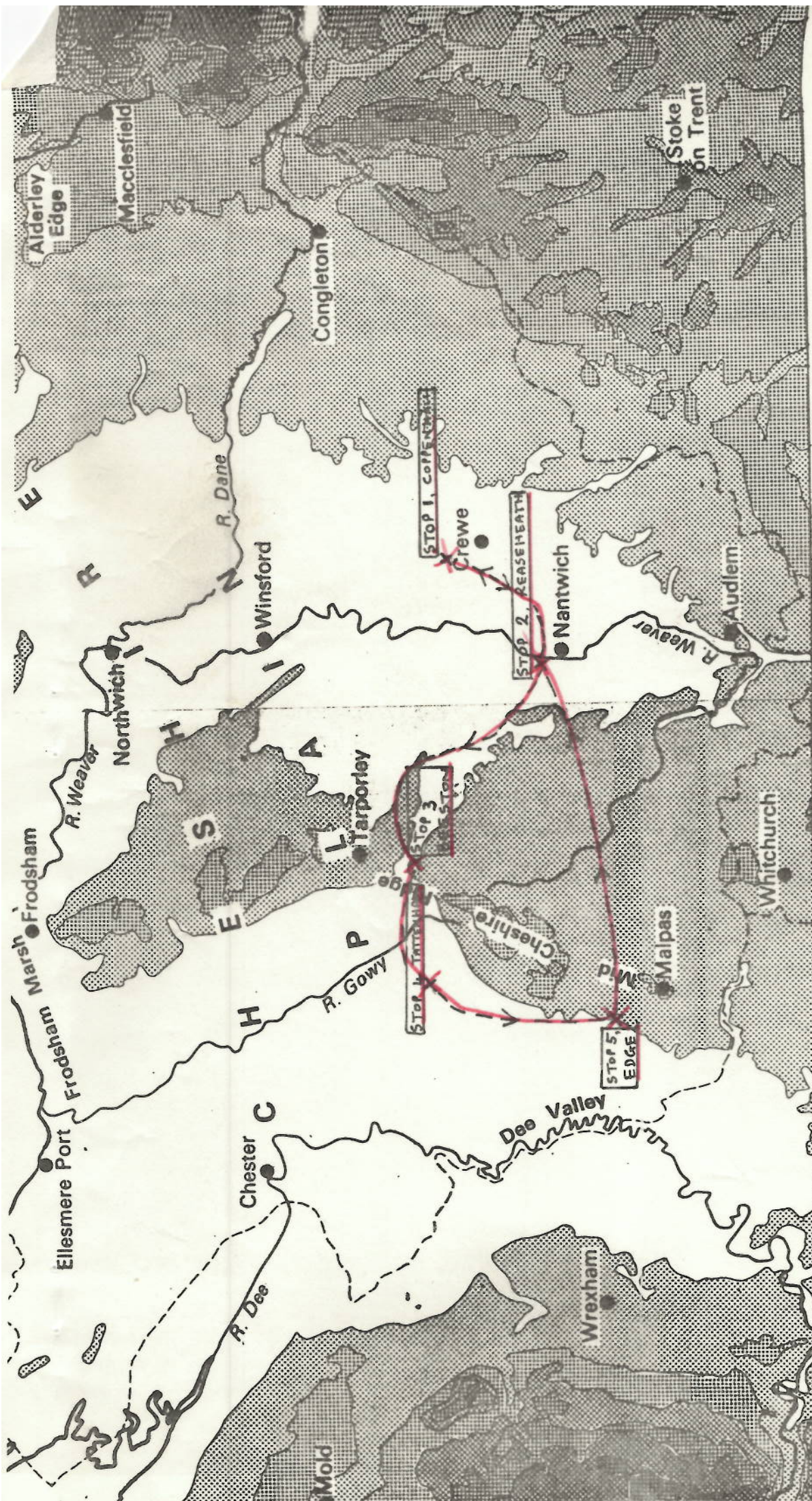
The afternoon programme is devoted to soils formed on reddish till. These are the most widespread in the county and a series of fine loamy and fine loamy over clayey profiles ranging from strongly to slightly gleyed will be seen.

To avoid examining these soils in isolation the relationship with adjoining map units and landscape features will be pointed out from time to time during the day. At lunch time the plain and Mid-Cheshire Ridge will be viewed from Beeston Castle Hill, a prominent crag of Triassic sandstone which affords views as far as the Pennines and Welsh mountains in clear conditions.

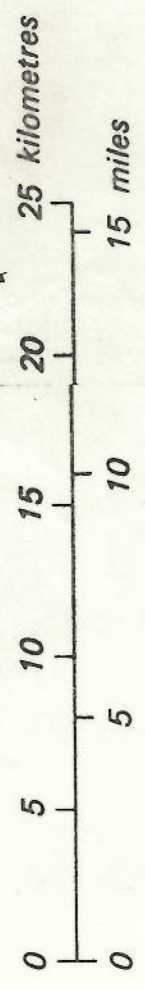
### Geological background

Much of Cheshire lies within a broad north-east to south-west trending basin of Permian and Triassic rocks extending from Lancashire to Shropshire. Older Carboniferous rocks occur at great depth beneath the Triassic strata, but are exposed only in the Pennines east of the Red Rock Fault where the Millstone Grit series forms the folded western limb of the Pennine anticline. Solid strata are rarely seen on the plain, most of which is covered by thick Pleistocene and Recent deposits. Extensive outcrops of the underlying red Triassic rocks occur only on the Mid-Cheshire Ridge. Elsewhere exposures of solid rock are restricted to isolated low hills, where red sandstone, or Keuper Marl protrudes through the surrounding glacial deposits, and to occasional stream sections. Although the soils of the plain are thus almost entirely formed in drift, the predominant reddish colour would suggest that much of the finer matrix material is fairly locally derived.

During the Pleistocene Cheshire was covered by ice sheets and a complex series of tills and glaciofluvial sands was laid down to give the subdivisions shown in Table 1. The general succession adopted by many workers of two distinct glaciations, represented by a lower and upper boulder clay separated by the Middle Sands and succeeded by a further period of sand deposition, is now thought to be an oversimplification. Evans and Arthurton (in Mitchell et al 1973) suggest that almost the whole succession, including some of the Middle Sands and Lower Boulder Clay, belongs to the late Devensian glaciation. This sequence termed



**EXCURSION ROUTE.**



- 0-200 ft  
0-61 m
- 200-400 ft  
61-122 m
- 400-600 ft  
122-183 m
- 600-800 ft  
183-244 m
- 800-1000 ft  
244-305 m
- 1000-1400 ft  
305-427 m
- > 1400 ft  
> 427 m

the Stockport Formation by Worsley (1967), is summarized in Table 1. The succession is difficult to follow as lenses of till often occur within the Middle Sands. Where these locally form the top of the sequence they can easily be mistaken for the Upper Boulder Clay. Similarly sand lenses occur within the till in many places.

Although the succession is one of the present problems of Pleistocene stratigraphy, the geological age of the sands and clays has no direct bearing on soil formation. As soil parent materials the glacial deposits can be grouped and described under the broad headings of tills, Head deposits and glaciofluvial sands. River terraces although strictly a separate deposit, merge with many of the late glacial and post-glacial sands. They form a similar parent material to the glacial sands and are grouped with them for this reason.

TABLE 1

Geological Succession of the Drift Deposits

Period and Systems	Stage or Series	Deposits	Lithology
Holocene or Recent	Flandrian	Alluvium (riverine, estuarine and marine)	Sand, gravel, silt and clay, sometimes with peat lenses
		River terrace	Sand, silt, gravel
		Hill peat	Eriophorum-Sphagnum peat
		Lowland peat	Reedswamp, fen-carr and Sphagnum peat
		Shirdley Hill Sand	Sand (blown)
		Lowland peat	Reedswamp, fen-carr and Sphagnum peat
		Fleistocene	Devensian (late)
Boulder clay/sand complex of the plain (Upper Boulder Clay or Stockport Formation, but includes some Middle Sands and some Lower Boulder Clay)	Reddish sands, gravels, silts and sandy clay to clay with Lake District erratics		
Head and boulder clay of the Pennines	Brown sands, gravels and sandy clay to clay with Pennine and Lake District erratics		
Devensian (middle and early)	Some Middle Sands, (Chelford Sands with included peats)		Brown and white sand
Wolstonian	Some Lower Boulder Clay of the plain		Reddish sandy clay to clay with Lake District erratics

## Tills

Tills and associated glaciolacustrine clays are one of the most important soil-forming materials in Cheshire. Much of the plain is formed entirely on them and they also extend on to the lower slopes of the Pennines. On the plain these are a reddish brown clay, clay loam or, more rarely, sandy clay loam derived largely from the underlying Keuper Marl, but often with beds and lenses of yellow and red sand. The thickness varies from less than 1 m (3 ft) where it feathers out on to the Mid-Cheshire Ridge to 72 m (237 ft) near Hooton in the Wirral.

Erratics are common, and in places abundant enough to form thin stony horizons in the till. The stones are nearly all from the Lake District and southern Scotland with the addition of occasional flint pebbles, suggesting the presence of chalk deposits in the Irish Sea, probably adjacent to those in Northern Ireland.

Soft concentrations of secondary calcium carbonate leached from the overlying horizons are common at a depth of 1-2 m (3-6 ft) in the till. In the 19th century, before cheap lime was available this material was dug out and spread over the surrounding fields to reduce acidity. This practice of marling had the additional benefit on sandy surface soils of increasing the moisture-holding capacity and fertility. The resulting ponds or marl pits are now a feature of the Cheshire landscape.

In some parts of the county, particularly in the south between Middlewich, Crewe and Audlem, and east of the Dee, there are large areas of reddish brown, sometimes finely laminated, obviously water-deposited clay. The physical properties of this material indicate that it has not been subjected to ice loading suggesting that it is connected with the Lake Lapworth system which covered much of Lancashire and Cheshire at the end of the Pleistocene.

## Glaciofluvial Sands and Terrace Deposits

The sands represent periods of glacial retreat during which water flowed from the melting ice sheets and deposited sand over the preceding till. They occur at several levels in the Pleistocene succession and merge, at the top, into Recent river terrace deposits. Sand deposits are scattered across the plain with large areas around Delamere Forest, to the south-east of Crewe and Nantwich, and in a broad eastern belt from Macclesfield southwards to the Staffordshire border near Alsager. As soil-forming materials glaciofluvial and terrace sands are second in importance to the tills.

The succession is extremely complex and although deposits such as the Gawsworth, Congleton and Chelford sands are distinct in their own areas, correlation across the county is uncertain. The Chelford Sand, a white deposit with a radiocarbon age from included peat of approximately 57000 years B.P. (Evans et al 1968), is generally considered to be the oldest deposit and passes into the overlying brown Congleton Sand. Both deposits are an important source of industrial sand. The Gawsworth Sand is thought to be of the same general age as the Middle Sands of Delamere Forest, which have been radiocarbon dated at about 28000 years B.P. (Boulton and Worsley 1965). The heavy mineralogy of the Congleton and Chelford Sands points to a derivation from the Millstone Grit. The sands also thin westwards away from the Pennines, suggesting that they are an outwash deposit laid down during periods of glacial retreat. In the west and south many of the later sand deposits form terminal moraines. These are associated by Foote and Whiteman (1966) with the Lake Lapworth system and its overflow channels through the Mid-Cheshire Ridge into the

*out of date  
now 60,000 BP  
revised*

*Not like  
cold - wind  
blown  
stream  
long period  
of time  
not natural*

Dee, which at that time flowed south into the Severn via the Ironbridge gorge.

The late glacial sands merge into river terrace sands which occur at various levels on the Dee, Weaver, Dane, Bollin and Mersey. The lithology of the deposits is generally similar to that of the glacial sands although pebbles and gravel lenses are more common.

The Shirdley Hill Sand is a windblown deposit formed by redistribution of the terrace sands around the Mersey and along the northern edge of the county.

### Alluvium

Riverine alluvium occurs on the floodplain of most streams and rivers and in some enclosed hollows where it is often associated with peat. In the lower reaches of the Dee and Mersey it passes into estuarine alluvium which has been sorted and deposited under tidal conditions and is often calcareous.

Riverine alluvium deposits wide enough to affect the farming pattern occur only on the larger rivers such as the Dane, Dee, Weaver, Bollin and Mersey. The material is sandy or coarse loamy on the river banks where there is often an indistinct levee, but becomes progressively finer textured away from the channel with clayey and fine loamy sediments being deposited along the edge of the floodplain farthest from the river. Along smaller streams texture usually reflects that of the glacial deposits within the immediate catchment. The alluvium in enclosed hollows is usually clay or silty clay. The thickness varies considerably and on the Weaver, a fairly typical Cheshire river, ranges from 1.5-6.0 m (5 to 20 ft). Riverbank exposures commonly show, 2.0-2.4 m (7 to 8 ft) of loamy sand or sandy loam, sometimes with faint laminations at depth, but this passes laterally into silty clay or clay. A feature of the Weaver exposures is the absence of stones and gravel seams, although a boring by the County Council near Nantwich showed peat and gravel at 3 m (10 ft).

River alluvium is important as a soil-forming material in the Dee valley near Farndon and along parts of the Weaver and Dane, but soils are mainly clayey or fine loamy and poorly drained, although some smaller areas of better drained sandy or coarse loamy soil occur along the river banks.

Estuarine alluvium occurs in the Dee estuary below Chester, most of which has been reclaimed for agriculture only within the last 150 years. A large area of salt marsh still remains west of Burton Point. The reclaimed areas extend up to the 25 ft contour, represented by a low cliff line which was cut when the sea-level rose at the end of the Pleistocene. The alluvium, which is at least 15 m (50 ft) thick near Shotton Steelworks, consists of a pale brown calcareous fine sand with darker silty lenses and laminae. Small scattered patches of silty clay also occur and can form the topsoil above sand deposited earlier.

In the Mersey estuary Frodsham marshes form an extensive area transitional between true estuarine and river conditions. Some fine sandy sediments are similar to those in the Dee estuary while other deposits of clay and clay over peat have more in common with the deposits in the lower reaches of the river valleys.

## Peat

Lowland peat deposits are scattered in hollows across the plain but are important only in the north around Warrington where raised mosses also occur. Some of the hollows are glacial features such as kettle holes while others may result from natural salt subsidence. The peats are of varying ages and pollen analyses suggest the presence of zone I deposits onwards (Birks 1965) indicating that the oldest peats are of late Devensian (late-glacial) rather than Flandrian (post-glacial) age.

## Climate

The climate of much of the Cheshire plain is transitional between the cool wet conditions of north-west England and the warmer drier weather of the West Midlands. Rainfall is fairly evenly distributed throughout the year. Of the average total of 735 mm (28.9 in) at Nantwich, a typical figure for the southern part of the plain which falls within the rain shadow of the Welsh mountains, 356 mm (14.0 in) falls in the six months from April to September and 379 mm (14.9 in) in the six winter months. October is normally the wettest month and the driest period is usually spring when east winds predominate. The average daily mean temperature is 9.2°C with a maximum mean in July and August of 16.5°C and a minimum in January of 2.5°C. The mean monthly temperature exceeds 5.5°C from about the end of March to the end of November, giving a growing season of approximately 240 days. Air frost can occur between October and May, but only rarely outside this period. Severe radiation frosts are common, particularly in January and February, a minimum temperature of -18°C being recorded at Nantwich in February 1969. Ground frosts are possible most of the year. Between 1962-69 for example, July was the only month at Reaseheath in which ground frost was never recorded.

Sunshine amounts are slightly below the average for the Midland counties, but somewhat higher than much of north-west England. Shrewsbury the nearest recording station with similar altitude and climatic factors has an average yearly sunshine total of 1356 hours.

## Itinerary

(Four profiles will be seen in the morning and four in the afternoon).

Depart from Reaseheath at approximately 0900.

After crossing the terraces and floodplain of the Weaver the route follows the A530 Middlewich road as far as Leighton Hospital, passing mainly over glaciolacustrine clays with pelo-stagnogley soils of the Crewe series. Small areas of coarser soil formed on the "Middle Sands" occur on some of the small valley sides. At Leighton the route turns east to reach the first stop by the Crewe-Glasgow railway at Moss Bridge. Although this low lying area, known as Warmingham Moss, may have been covered extensively by peat in the past, it is unlikely that there was ever any great thickness as the lack of drainage would tend to preserve any peat present. It is more likely to have always been a very poorly drained area with patches of peat within a generally humose top soil similar to the present situation.

STOF 1 Profile No. 1 Warmingham Series

Moss Bridge Farm, Coppenhall, Crewe.

This is a clayey argillic stagnohumic gley soil on reddish stoneless glaciolacustrine drift. In south Cheshire the series has been mapped only in this district immediately north of Crewe. It has also been recorded in the Doncaster area of South Yorkshire.

The black peaty or humose stoneless clay loam or clay Ahg horizon distinguishes the series from the greyish brown surface horizon of the associated Crewe series. The grey colours of the strongly gleyed Bg or Eg horizon below extend in places to a depth of 50 cm and contrast sharply with the black top soil. The gleying is usually much more pronounced than in the Crewe series. Below about 50 cm gleying becomes gradually less intense, the BCg horizon being a stoneless prismatic structured reddish brown or occasionally brown clay with grey structure faces and small white concretions of secondary calcium carbonate.

When suitably drained these are good grassland soils, but effective gravity drainage is often difficult due to very low gradients and surrounding higher ground. The LUC class would probably be 4ws. The area around this site is to be used very shortly for industrial development.

Profile No. 1

Grid reference: SJ 65/9785. N.B. Profile adjoins the one analysed, so some differences are to be expected.

Soil group: Stagnohumic gley soil.

Parent material: Glaciolacustrine clay.

Locality: 45 m (50 yds) W. of railway footbridge, Coppenhall.

Elevation: 52 m (170 ft) O.D.

Slope and aspect: level.

Land use: permanent grassland.

Horizons:

(cm)

- |                |  |
|----------------|--|
| 0-20<br>Ahg    | Very dark brown (10 YR 2/2) stoneless very friable peaty clay loam; weak medium subangular blocky and granular; extremely abundant fine fibrous roots; occasional earthworms; merging even boundary.   |
| 20-30<br>ABg   | Very dark grey (10 YR 3/1) stoneless slightly humose clay with common faint fine very dark greyish brown to dark yellowish brown (10 YR 3/2 to 3/4) mottles along root channels; strong medium prismatic common fine fibrous and a few small fleshy roots; rare earthworms; narrow irregular boundary. |
| 30-51<br>Bg    | Grey (5 Y 5/1) stoneless clay loam with common or many distinct medium dark yellowish brown (10 YR 4/4) mottles; strong coarse prismatic; common fine fibrous roots; merging even boundary.  |
| 51-102+<br>BCg | Brown (10 YR 4/3) stoneless clay with some sandy clay pockets; many distinct grey (10 YR 5/1) mottles on structure faces and old root channels; strong coarse prismatic; rare fine fibrous and very rare small woody roots.  |

Analyses

Horizon	Ahg	ABg	Bg	BCg	
Depth (cm)	0-20	20-30	30-51	51-102	
Sand	200 $\mu$ m-2 mm %	25.3	0.7	1.0	0.9
	60-200 $\mu$ m %	11.1	5.4	28.4	24.1
Silt	2-60 $\mu$ m %	29.1	27.3	32.0	32.6
Clay	<2 $\mu$ m %	34.6	66.6	38.5	42.2
Loss on ignition %	64.2	12.6	5.2	5.4	
pH in water (1:2.5)	4.7	5.1	5.5	6.2	
pH in 0.01M CaCl <sub>2</sub> (1:2.5)	4.1	4.5	4.9	5.7	
C %	32.7	3.7	0.8		
N %	1.73	0.30			
C/N	19	12			
C.E.C. (me/100 g)	100.7	37.8	17.5	19.7	

SWS.

Depart from Coppenhall approximately 1015.

Return to Reaseheath via the outward route.

*Grays  
Mechanics @ 75cm 20m  
spanning - backfill +  
pump for to dispersants -  
because of low lying situation*

STOP 2 Profile No. 2, Midelney series, Profile Nos. 3, 4 Crewe series  
Cheshire College of Agriculture, Reaseheath, Nantwich.

A wide variety of soils on clay, alluvium and sand occur on the College farm. Although there will be time only to examine those on clayey alluvium and glaciolacustrine clay, the distribution of adjoining soils will be pointed out and members are welcome to examine these in the evening. The first profile to be seen at the College is on the floodplain of the river Weaver.

Profile No. 2 Midelney series

This is a clayey over earthy peaty pelo-alluvial gley soil on interbedded riverine alluvium and peat. In Cheshire this soil is common on back swamps along the larger rivers such as the Dee, Weaver and Dane, where thin peat has formed under very wet conditions and been preserved by later accumulations of clayey alluvium. The series is also common in enclosed hollows and depressions where alluvium is associated with thick peat deposits, often as a peripheral zone around the peat.

The surface soil of mottled dark grey or dark greyish brown silty clay loam or sometimes clay loam is followed by a Bg horizon of brown strongly mottled stoneless clay. The 2Cg horizon of peat or peaty loam, usually

at a depth of 50-70 cm, is the main distinguishing feature and separates the series from the otherwise similar Compton series. In some profiles where peat occurs only in lenses it is followed by a 30g of dark grey clay or clay loam, but in many profiles peat continues to a considerable depth. Although the clay is derived from red till this colour is less common than in the Compton series, due to the stronger gleying associated with the peaty horizons. The Midelney series is a naturally fertile but acid soil which, although very wet in the winter months, is drought resistant and gives high yields of grass if fertilized and limed. The risk of flooding and fine texture prevent arable cropping. These factors downgrade the unit to LUC class 4ws.

Profile No. 2.

Grid reference: SJ 65/5240 N.B. The profile adjoins the one analysed, so some differences are to be expected.

Soil group: Alluvial gley soil.

Parent material: Alluvial clay over peat.

Locality: 640 m (700 yd) NNE of Beam Bridge, Nantwich.

Elevation: 35 m (110 ft) O.D.

Slope and aspect: level, backswamp depression.

Land use: permanent grass.

Horizons:

cm	
0-20 Ahg	Very dark greyish brown (10 YR 3/2) friable stoneless clay loam, moderate medium to coarse subangular blocky structure breaking to medium granular; fine and medium fissures common; moderate organic matter content; abundant fine fibrous roots; a few earthworms; narrow even boundary.
20-69 Bg	Brown to dark brown (7.5 YR 4/4) stoneless firm clay; fine distinct dark grey (5 YR 4/1) mottles common on root channels; some dark grey (5 YR 4/1) structure faces, particularly towards the base of the horizon; strong coarse prismatic structure; fine pores common along old root channels; a few fine fissures between structure faces; fine roots common; some charcoal fragments near base of horizon; earthworms rare; merging undulating boundary.
69-84 20g	Very dark greyish brown (10 YR 3/2) pseudo-fibrous humified peat and silty clay; some recognizable remains of reeds and wood; moderate thick platy structure; merging even boundary.
84+ 30g	Very dark grey (10 YR 3/1) slightly humose, stoneless clay loam with numerous pseudo-fibrous fragments and lenses

of peat; moderately developed medium to coarse blocky structure.

#### Analyses

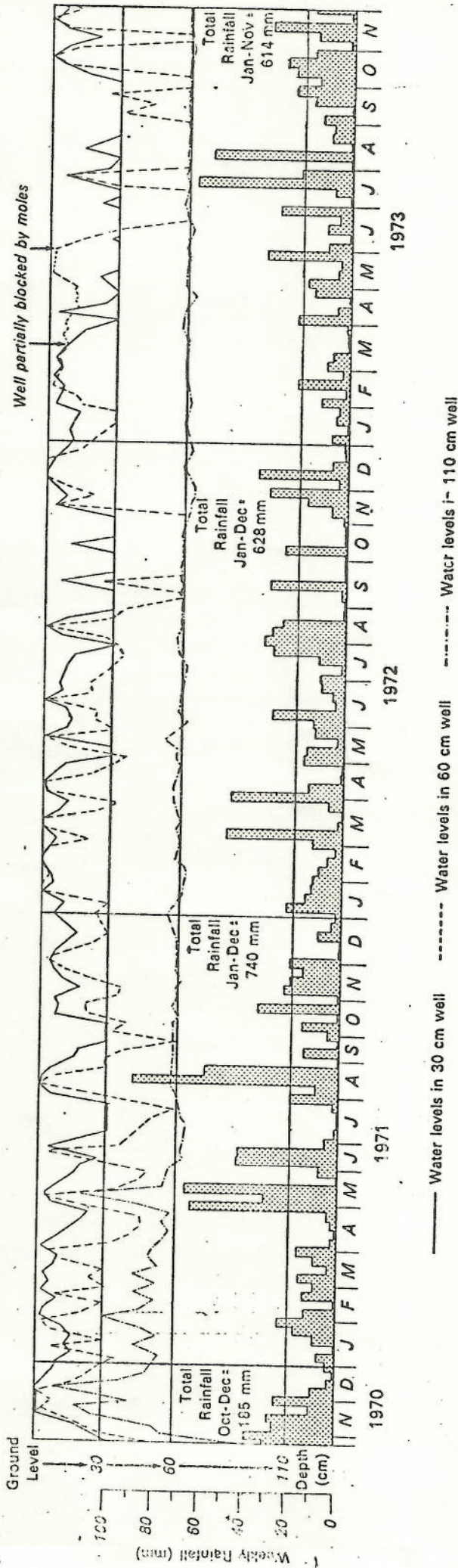
Horizon	Ahg	Bg	2Cg	3Cg
Depth (cm)	0-20	20-69	69-84	84+
Sand (200 $\mu$ m-2 mm %)	23	5	7	2
(60-200 $\mu$ m %)	20	6	7	25
Silt 2-60 $\mu$ m %	32	42	45	47
Clay <2 $\mu$ m %	25	47	41	26
Loss on ignition %	4.3	8.5	40.2	9.5
Organic carbon %			19.9	3.3
Nitrogen %			1.30	0.24
C/N			15	14
pH in water (1:2.5)	6.4	6.5	4.2	5.7
pH in 0.01M CaCl <sub>2</sub> (1:2.5)	6.0	5.9	4.1	5.6
C.E.C. (me/100 g)	23.6	30.4	71.6	23.5

#### Dip-well Water Levels

This site has no artificial drainage and the profile is waterlogged within 30 cm of the surface for much of the year. Only in summer is there any significant fall in the 30 cm well, with a tendency for the lowest levels to occur in August and September, although this could well be due to the particular rainfall distribution in the three recording years. Heavy rainfall is quickly reflected in the 30- and 60-cm wells, indicating a distinct surface water effect with water being held in the clayey horizons above the peat. Levels in the 110 cm well, however, are very uniform, apart from the first seven months of recording in 1970-71 when water movement into and out of the well could have been disturbed by the insertion techniques. Levels in this well would appear to be controlled by water-table movements which reflect the total annual rather than weekly rainfall.

The records show that this soil is in wetness class V and confirm that the gley colours in this profile are a reliable indication of soil drainage.

The last two profiles of the morning are on the adjoining gently undulating clay plain about 4.5 m (15 ft) above the river floodplain.



Water levels in relation to rainfall in profile 2, Middelney series.

### Profiles 3 and 4 Crewe Series

These profiles in adjoining fields illustrate that strongly developed gley colours are not necessarily a good indication of present soil drainage. The Crewe series is a clayey pelo-stagnogley soil on reddish stoneless glaciolacustrine drift. The profile is similar in colour to the Salop series (to be seen later), but has a much higher clay content and is stoneless throughout. Gleying is also more strongly developed and the series is perhaps best regarded as a finer textured wetter and stoneless equivalent of the Salop series. The Crewe series has also been described in Shropshire and Staffordshire.

The Ag horizon is a stoneless dark greyish brown clay, or rarely clay loam, above a grey stoneless clay Eg horizon. The latter is the zone of maximum waterlogging and usually occurs 20-30 cm under the surface. Below, gleying becomes gradually less intense, the Btg and BCg horizons being grey, mottled reddish grey and reddish brown stoneless clay or sometimes silty clay. The BCg horizon below is a stoneless prismatic structured reddish brown clay with small nodules and concretions of secondary calcium carbonate. The salient features are the distinct grey Eg horizon and the absence of stones. The absence of a black humose or peaty A horizon separates Crewe soils from the associated argillic stagnohumic gley soils of the Warmingham series.

Crewe soils are naturally very fertile and with suitable drainage are capable of high yields of grass. Phosphate may be deficient but is easily added in fertilizers which release it slowly over many years. The parent material is calcareous but surface horizons can become acidic enough to require occasional light dressings of lime. LUC class varies from 3-4ws depending on drainage and site.

#### Profile No. 3

Grid reference: SJ 65/4946  
Soil group: Stagnogley soil.  
Parent material: Glaciolacustrine clay.  
Locality: 0.7 km NE of Reaseheath Hall.  
Elevation: 38 m (125 ft) O.D.  
Slope and aspect: 2° E.  
Land use: Permanent grassland.

*20-30m spacing  
backfill to <sup>bottom</sup> 35m of surf.  
of subsoil / moles @  
1/2-3m intervals  
across lines of drains.*

This profile in an inadequately drained field has not been described, but is included so that the degree of gleying can be compared with that in profile 4 in the adjoining extensively drained field.

#### Profile No. 4

Grid reference: SJ 65/5346 N.B. The profile adjoins the one analysed so some differences are to be expected.  
Soil group: Stagnogley soil  
Parent material: Glaciolacustrine clay  
Locality: 0.8 km ( $\frac{1}{2}$  mile) NE of Reaseheath Hall.  
Elevation: 38 m (125 ft) O.D.  
Slope and aspect: level.  
Land use: ley used for paddock grazing.

Horizons:

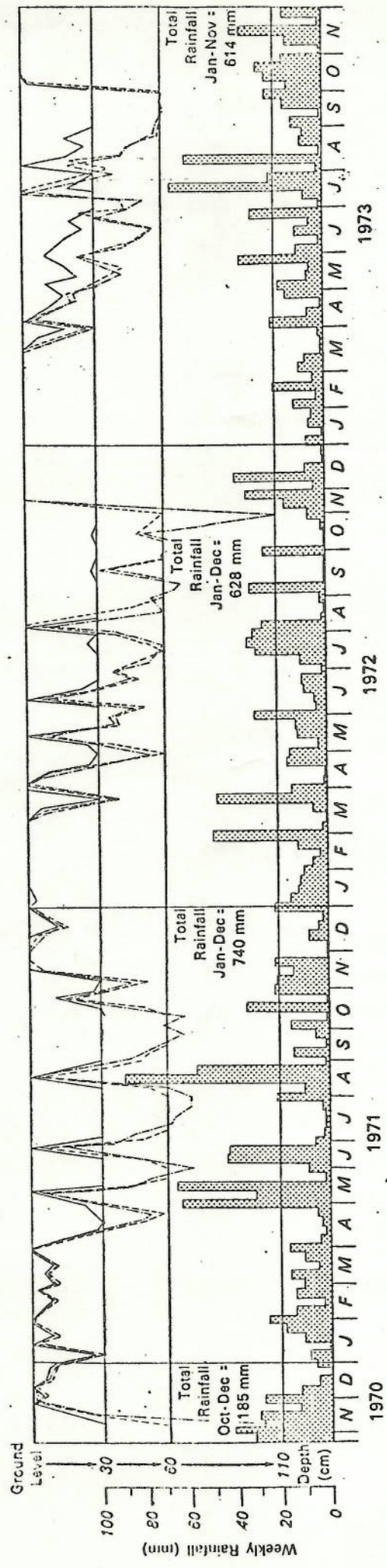
cm	
0-15 Ap <sub>g</sub>	Dark greyish brown (10 YR 4/2) stoneless clay, faint fine rusty mottling common; moderately developed medium sub-angular blocky and medium granular structure; firm; a few fine vertical fissures; moderate organic matter with abundant fine roots and some earthworms; sharp undulating boundary.
15-20 Ag	Brown to dark brown (10 YR 4/3) stoneless clay with many distinct fine to medium strong brown (7.5 YR 5/8) mottles; moderate medium angular blocky structure; firm; a few large vertical fissures containing material washed in from the overlying horizon; moderate organic matter; fine roots common; a few earthworms; narrow even boundary.
20-31 Bg/Eg	Grey (5 Y 5/1) stoneless clay; distinct or prominent fine to medium strong brown (7.5 YR 5/8) mottles common; medium angular to prismatic structure; a few medium vertical fissures; a few fine roots and earthworms; merging irregular boundary.
31-51 Btg	Brown to dark brown (7.5 YR 4/2) stoneless clay with distinct grey to light grey (5 Y 6/1) and strong brown (7.5 YR 5/8) mottles on structure faces and old root channels; strong coarse prismatic structure; firm or very firm; a few fine roots often following structure faces; old fine root channels abundant often giving broken peds a finely pored appearance; a few earthworms; merging irregular boundary.
51-71 BCg	Dark reddish grey (5 YR 4/2) stoneless clay with distinct grey (5 YR 5/1) mottling, mainly on structure faces and old root channels; strong coarse prismatic structure; firm; fine roots rare; old root channels common; rare earthworms; merging irregular boundary.
71- BCgk	Dark reddish brown (5 YR 3/3) slightly calcareous stoneless clay with large prominent grey (N5) mottles on structure faces; strong coarse prismatic structure; very firm; fine roots very rare; calcium carbonate common occurring as a white (10 YR 8/1) dendritic pattern and as very small concretions.

## Analyses

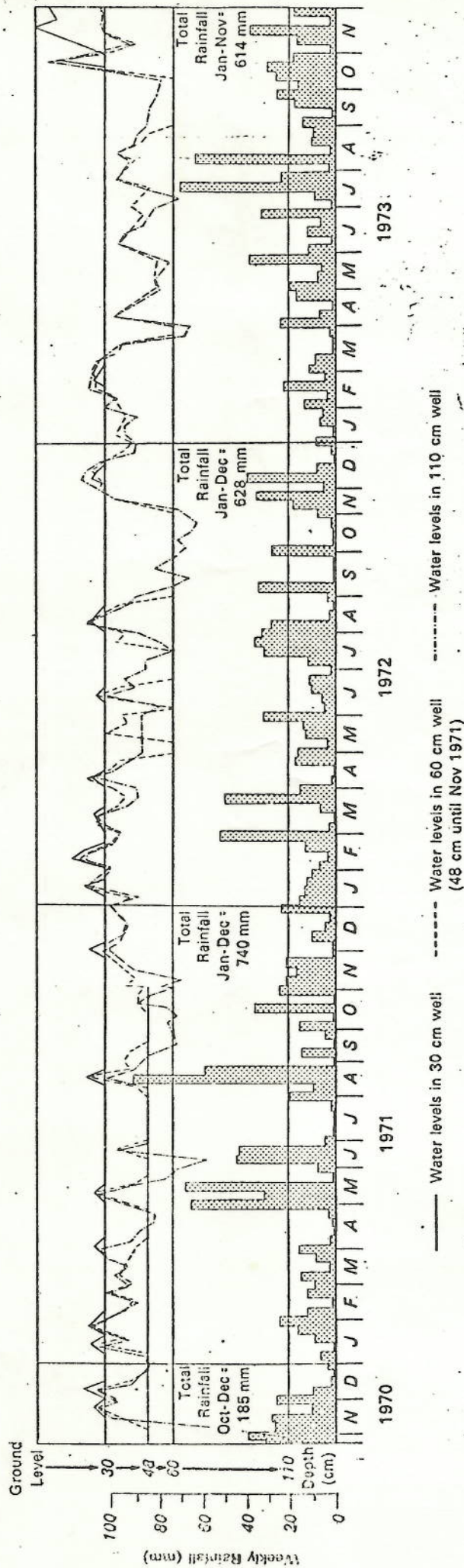
Horizon	Apg	Ag	Bg/Eg	Btg	BCg	BCgk
Depth (cm)	0-15	15-20	20-31	31-51	51-71	71+
Sand (200 $\mu$ m-2 mm %)	11	8	2			1
Sand (60-200 $\mu$ m %)	12	11	5	1	1	1
Silt 2-60 $\mu$ m %	34	35	37	24	31	33
Clay <2 $\mu$ m %	43	46	56	75	68	65
CaCO <sub>3</sub> equivalent %	0.5	nil	nil	nil	nil	9.9
Loss on ignition %	11.0	7.7	6.2	6.7	7.1	7.7
Organic carbon %	3.8					
pH in water (1:2.5)	6.9	7.1	7.0	7.4	7.7	8.2
pH in 0.01M CaCl <sub>2</sub> (1:2.5)	6.6	6.6	6.5	6.9	7.2	7.6
C.E.C. (me/100 g)	27.4		20.6	23.4		

## Dip-well water levels

The levels in Profile 3 in permanent pasture with little or no artificial drainage show that in most years the soil is waterlogged to the surface throughout the winter, and even in summer during wet spells. Levels in the 30-, 60- and 110 cm wells are almost identical when water is within 30 cm of the surface except for a slight tendency for levels to rise more quickly and be held for longer in the 30 cm well, perhaps indicating slight compaction within the surface horizon. Low evaporation in winter means that the soil remains waterlogged to the surface, even during rain-free periods, whereas levels fluctuate to a much greater extent and are closely related to individual falls of rain during the summer. The records indicate that this profile falls within wetness class V. Profile No. 4 is in a reseeded pasture, tile drained at 11 yd intervals and, although in a lower lying site than profile 3 the beneficial effects of underdrainage are immediately apparent. Waterlogging within 30 cm of the surface is much less common and restricted almost entirely to the winter months when it is severe only during a wet winter. Unlike the undrained profile which is quickly saturated even by isolated heavy rain-falls, fluctuations in this profile are less evident and occur mainly below the 30 cm level. Water levels in the 110 cm well occasionally rise above those in the 30- and 60 cm wells. This anomalous situation could be due to the well being further away from a drain. The effect of tile drainage is to improve the profile from wetness class V to IV. This will reduce poaching and allow the grazing season to be extended into October and early November, when undrained profiles are badly waterlogged. Although both profiles show marked gley morphology with strongly developed grey and yellow mottling, the tile-drained profile is more strongly gleyed, indicating that before drainage this profile was the wetter of the two.



Water levels in relation to rainfall in profile 3 (Crewe series), without adequate drainage.



Water levels in relation to rainfall in profile 4 (Crewe series), with artificial drainage.

Physical properties - (the terms used below are defined in the Appendix)

Physical measurements on profile No. 4 adjoining the dip wells in the tile-drained field show a moderately high available water capacity in the well-structured surface horizon but a low level in subsurface horizons where the clay content is higher. Retained water capacity is high throughout the profile, as would be expected in a clay soil with fine pores and air capacity moderately low and very low in the BCg horizon. Similar results were obtained from another profile (SJ 75/1935) and confirm that, although the Crewe series has a high water content, much subsoil water is held at high suctions and is not accessible to plants. Conversion of the available water to millimetres of water shows that in Profile SJ 65/5346 there is little more available than in the sandy Newport series. In a normal summer, available water exceeds the average maximum cumulative soil water deficit. In dry years the underlying water-table will tend to compensate and prevent severe deficits in the horizon above. Drought conditions are thus likely to be very rare in this soil.

---

Depart from Reaseheath at approximately 1200

The route joins the A51 Chester road at Burford traffic lights and passes over an undulating area of glaciofluvial sand between Hurleston and Barbridge. Beyond this point to the railway bridge at Calveley is an almost flat landscape of claciolacustrine clay. From Calveley to Tarporley traffic lights where the route turns south on to the A49 the surrounding country is mainly of sandy drift. The Triassic sandstone hills of the Mid-Cheshire Ridge can be seen to the left. About  $\frac{1}{2}$  mile beyond the traffic lights the A49 descends steeply into the Beeston Gap a melt-water channel which, at the end of the last glaciation, linked the ice-front west of the sandstone ridge with the Lake Lapworth system to the east. Sand deposits in this area are of considerable thickness and have been extensively quarried.

### STOP 3 Beeston Castle

Lunch will be taken at the Castle from where there are extensive views over the surrounding countryside.

Depart from Beeston at approximately 1345.

The route is round the northern side of the castle and across the western till plain to Tattenhall.

### STOP 4, Profile No. 5 - Clifton series - Tattenhall Hall - Tattenhall

Profile No. 5 is a fine loamy argillic stagnogley soil on reddish till of Triassic origin. The series covers much of the low lying area east and west of the Mid-Cheshire Ridge and is also widespread in Lancashire and Staffordshire.

The A horizon is a moderately structured mottled dark brown or very dark greyish brown sandy loam or sandy clay loam. The pale brown mottled Eg horizon is a slightly stony sandy clay loam. Below is a brown or reddish brown strongly structured and prominently mottled Btg horizon of clay loam or sandy clay loam containing significantly more clay as evidenced

by clay skins or concentrations of strongly oriented illuvial clay. The Cg horizon below is a coarse prismatic mottled reddish brown clay loam.

Stone content is usually slight but occasional pockets of gravel and small stones in the B horizon are of agricultural significance. Similarly lenses of sand derived from local Triassic sandstone and glaciofluvial deposits are common within the till.

The Clifton series is traditionally a grassland soil, mainly in permanent pasture, although on slightly better drained sites reseeding is practised and arable crops grown. In recent years there has also been a successful move towards market gardening on Clifton soils which indicates that with careful management a much wider range of crops could be grown. LUC class 3ws.

Profile No. 5

Grid reference: SJ 45/9183.

Soil group: stagnogley soils.

Parent material: reddish till.

Locality: 450 m NE of Tattenhall Hall, Tattenhall.

Elevation: 38 m (125 ft) O.D.

Slope and aspect: level.

Land use: permanent grassland.

Horizons:

cm	
0-18 Ap(g)	Dark brown (10 YR 3/3) friable sandy clay loam with common distinct fine and medium yellowish red (5 YR 5/6) mottles; slightly stony with small angular and rounded igneous pebbles; moderate medium subangular blocky breaking to fine subangular blocky and medium crumb; abundant fine and medium pores and fine fissures; moderate intimately mixed organic matter; abundant fine fibrous roots; earthworms present; sharp even boundary.
18-30 Eg	Brown (7.5 YR 5/2) and pale brown (10 YR 6/3) friable sandy loam with many distinct fine and medium yellowish red (5 YR 4/6) mottles; slightly stony; moderate medium subangular blocky breaking to fine subangular blocky and fine crumb; abundant fine and medium pores and common fine fissures; low intimately mixed organic matter; common fine fibrous roots; merging undulating boundary.
30-49 Btg	Brown (7.5 YR 5/4) friable sandy clay loam with many prominent fine and medium yellowish red (5 YR 5/8), common distinct fine light yellowish brown (10 YR 6/4) and grey (5 Y 6/1) mottles; slightly stony; moderately strong coarse subangular blocky tending towards coarse prismatic; abundant fine and medium pores and fine fissures; few fine fibrous roots; merging even boundary.
49-90 BCg	Dark brown (7.5 YR 4/4) firm to very firm clay loam with many prominent large greenish grey (5 GY 6/1) and pale olive (5 Y 6/3) mottles particularly along structure faces; slightly stony; moderately strong coarse prismatic; few fine fibrous roots; few manganiferous concretions.

*20-30m spacing  
with subsiding at  
50+cm.*

Analyses

Horizon	Ap(g)	Eg	Btg	BCg
Depth (cm)	0-18	18-30	30-49	49-90
Sand	(600 $\mu$ m-2 mm %	1	1	1
	(200-600 $\mu$ m %	28	27	22
	(60-200 $\mu$ m %	27	29	29
Silt 2-60 $\mu$ m %	25	27	23	32
Clay <2 $\mu$ m %	19	16	25	30
CaCO <sub>3</sub> equivalent %				nil
Organic carbon %	4.5	0.9	0.4	
pH in water (1:2.5)	5.9	6.1	6.3	6.9
pH in 0.01M CaCl <sub>2</sub> (1:2.5)	5.7	5.8	5.8	6.3
C.E.C. (me/100 g)	18.1	11.2	10.0	13.9

Horizon	Ap(g)	Eg	Btg	BCg
Depth (cm)	0-18	18-30	30-49	49-90
Pyrophosphate ext.				
Fe %	0.12	0.10	0.02	0.01
Al %	0.03	0.04	0.05	0.03
C %	0.43	0.27	0.13	0.06
Residual dithionite ext.				
Fe %	0.50	0.35	0.55	0.95

Physical properties (see appendix)

Available water content is high in the surface horizon due to the organic matter content, decreasing to a moderately low level at depth. The increase in fine particles with depth is expressed in the decreasing air capacity from moderately low to very low. Retained water capacity varies from high in the surface to moderately high in the Cg horizon, but with a moderately low level in the coarser intermediate Eg horizon. Available water in the profile as a whole is greater than in other series and, when compared with the average maximum potential cumulative soil moisture deficit, indicates that the Clifton series is less likely to suffer from drought.

Depart from Tattenhall Hall at approximately 1430

STCF 5 Profile No. 6 - Salop series - Woodlake Farm - Tattenhall

This is a fine loamy over clayey argillic stagnogley soil on reddish Triassic-derived till. First recognised in Shropshire in 1954, the series has since been mapped throughout north-west England, the Midlands and in Wales.

The A horizon is a dark greyish brown clay loam with a moderately developed medium subangular blocky structure. The strongly mottled brownish grey Eg horizon of clay loam passes into a reddish brown Btg of clay loam or clay, the particle size class reflecting the amount of translocated clay. This in turn passes into a coarse prismatic reddish brown plastic clay with distinct mottling along structure faces.

Although in favourable seasons excellent arable crops can be produced from soils of the Salop series, they are difficult to manage in continuous cultivation or under a rotation which includes only short-term leys. As a result Salop soils are traditionally grassland soils. Hay feeding and shippin housing are still widespread. Many farms however now conserve grass for silage, have modern livestock buildings, a high standard of grassland management and stocking rates approaching one cow per acre. Intensive stocking exerts structural problems however and many farmers feel that zero grazing could reduce the risk of structural damage. LUC class 3ws.

Profile No. 6

Grid reference: SJ 45/9174

Soil group: Stagnogley soil.

Locality: 250 m E of Woodlake Farm, Tattenhall.

Elevation: 40 m O.D.

Slope and aspect: level.

Land use: Re-seeded grassland.

Horizons:

cm

0-18  
Ap(g) Brown (10 YR 4/3) friable clay loam with many faint brown (7.5 YR 4/4) and strong brown (7.5 YR 5/6) mottles; slightly stony with small subangular and rounded igneous pebbles; moderate medium subangular blocky breaking to fine subangular blocky and medium crumb; common fine pores and fissures; moderate intimately mixed organic matter; abundant fine fibrous roots; earthworms present; narrow even boundary.

*fame says keep off dung piles*

18-29  
Eg Greyish brown to light brownish grey (2.5 Y 5/2-6/2) firm clay loam with many distinct fine and medium strong brown (7.5 YR 5/6) and very pale brown (10 YR 7/4) mottles; slightly stony; moderate medium subangular blocky; common fine pores and fissures; common fine fibrous roots; some earthworms; merging even boundary.

29-50  
Btg Yellowish brown (10 YR 5/4) and light brownish grey (10 YR 6/2) firm clay loam with common distinct medium and large brownish yellow (10 YR 6/8) and very pale brown (10 YR 7/4) mottles; slightly stony; moderate medium and coarse subangular blocky; common fine pores and fissures; common fine

*tilde @ 10m spacing with backfill*

*OR*

*tilde @ 90 cm depth*

*20m spacing with subsoil tyres @*

*3m spacing across lines.*

fibrous roots; merging even boundary.

50-90 Dark reddish grey (5 YR 4/2) plastic clay with distinct  
BCg large and medium grey (5 Y 5/1) mottles along structure  
faces and old root channels; slightly stony; strong coarse  
prismatic; few fine fibrous roots; few manganiferous  
concretions.

#### Analyses

Horizon	Ap(g)	Eg	Btg	BCg
Depth (cm)	0-18	18-29	29-50	50-90
Sand { 600 $\mu$ m-2 mm %	1	4	2	1
{ 200-600 $\mu$ m %	19	20	17	12
{ 60-200 $\mu$ m %	22	22	21	15
Silt 2-60 $\mu$ m %	33	34	26	32
Clay <2 $\mu$ m %	25	20	34	40
CaCO <sub>3</sub> equivalent %				<1
Organic carbon %	2.0	1.0	0.4	
pH in water (1:2.5)	5.8	5.4	6.4	7.1
pH in 0.01M CaCl <sub>2</sub> (1:2.5)	5.6	5.2	6.2	6.9
C.E.C. (me/100 g)	16.8	13.7	14.7	15.2
Pyrophosphate ext.				
Fe %	0.10	0.02	0.03	0.02
Al %	0.04	0.02	0.04	0.04
C %	0.46	0.23	0.27	0.09
Residual dithionite ext.				
Fe %	0.55	0.90	1.75	1.15

#### Physical properties (see appendix)

This profile has much water available at low suctions in the surface due to the high organic content, decreasing markedly in the subsoil. The increase in bulk density down the profile is reflected by air capacity, which decreases to a low level. The large amount of water retained at 15 bar suction, is typical of fine-textured soils and indicates that there are many fine pores. Profile available water exceeds the average maximum potential soil water deficit, and drought will not be a limitation in most years.

Depart from Woodlake Farm at approximately 1515.

The route first passes over a low sandstone ridge with soils of the Bromsgrove and Wick series and is then southwards along the A41, mainly over till. South of Broxton roundabout the somewhat more undulating country forming the lower western slopes of the Mid-Sheshire Ridge is of mixed sand and till.

STOP 6 Profiles No. 7, Salwick series and No. 8 Flint series. Dairy Farm Edge, near Malpas.

Although mainly of fine loamy stagnogley soils of the Clifton series, small patches of both fine loamy and fine loamy over clayey stagnogleyic soil also occur on this farm.

Profile No. 7 - Salwick series

Profile No. 7 is a fine loamy stagnogleyic argillic brown earth on reddish Triassic - derived till. The soil was first described in Lancashire and has subsequently been recognised in Cheshire and Staffordshire.

The A horizon is a moderately structured dark brown or dark greyish brown sandy clay loam. The faintly mottled dark brown to brown eluvial Eb horizon, a slightly stony sandy clay loam or sandy loam, passes into a mottled reddish brown clay loam Bt horizon with significantly more clay in the form of clay skins. The Cg horizon below is a coarse prismatic mottled reddish brown clay loam. The till contains an appreciable proportion of sand from local Triassic sandstone and glaciofluvial deposits. This sand often forms lenses or pockets within the till.

Although soils of the Salwick series are well suited to grass and are at present under the traditional Cheshire practice of permanent grass or long ley with barley a secondary enterprise, they are capable of supporting a much wider range of crops. LUC class 3ws.

Profile No. 7

Grid reference: SJ 45/8701.

Soil group: Argillic brown earth.

Parent material: Reddish till.

Locality: 500 m ESE of Dairy Farm, Edge.

Elevation: 79 m O.D.

Slope and aspect: 1°S.

Land use: Re-seeded grassland.

Horizons:

cm

0-20	Brown (7.5 YR 4/2) friable sandy loam; few faint fine strong brown
Ap	(7.5 YR 5/6) mottles; slightly stony with small and medium subangular and rounded igneous pebbles; moderate medium subangular and rounded igneous pebbles; moderate medium subangular blocky breaking to fine subangular blocky and fine and medium crumb; common fine pores and fissures; moderate intimately mixed organic matter; abundant fine fibrous roots

*3sw - top side*

*Nodanape in fame -> knowledge  
- good field.*

*too coarse to mbrace*

*if anything pipes @ 30m*

earthworms present; narrow even boundary.

20-47  
Eb(g) Light brown (7.5 YR 6/4) friable sandy loam; few faint fine strong brown (7.5 YR 5/6) mottles; slightly stony; moderate medium and coarse subangular blocky; abundant fine and medium pores and common fine fissures; low intimately mixed organic matter; common fine fibrous roots; earthworms present; merging even boundary.

47-62  
Bt(g) Yellowish red (5 YR 5/6) firm sandy clay loam with very pale brown (10 YR 7/4) loamy sand along structure faces; common faint fine and medium strong brown (7.5 YR 5/8) mottles; slightly stony; moderately strong coarse prismatic; abundant fine pores and common fine fissures; few fine fibrous roots; common manganiferous concretions (5-10 mm); merging even boundary.

62-90  
BC(g) Reddish brown (5 YR 4/4) firm to very firm sandy clay loam; common faint fine strong brown (7.5 YR 5/8) mottles; slightly stony; moderately strong very coarse prismatic; abundant fine pores and common fine fissures; rare fine fibrous roots; common manganiferous concretions (<2 mm).

#### Analyses

Horizon	Ap	Eb(g)	Bt(g)	BC(g)
Depth (cm)	0-20	20-47	47-62	62-90
Sand {	600 $\mu$ m-2 mm %	2	3	2
	200-600 $\mu$ m %	25	27	26
	60-200 $\mu$ m %	30	28	27
Silt 2-60 $\mu$ m %	28	27	21	21
Clay <2 $\mu$ m %	15	15	24	24
Loss on ignition %	5.4	2.8	2.8	2.4
CaCO <sub>3</sub> equivalent %		nil	nil	nil
Organic carbon %	2.1	0.5		
pH in water (1:2.5)	6.3	6.5	7.0	6.9
pH in 0.01M CaCl <sub>2</sub> (1:2.5)	5.8	5.9	6.2	6.2
Tryptophosphate ext.				
Fe %		0.06		
Al %		0.04		
Residual dithionite ext.				
Fe %		0.9		
Dithionite ext.				
Fe %	0.8		1.5	1.4

1600 hours approximately

Profile No. 8 - Flint series

The Flint series is a fine loamy over clayey stagnogleyic argillic brown earth on reddish Triassic-derived till.

The A horizon is a moderately structured brown sandy clay loam or clay loam overlying a slightly mottled Eb horizon of dark greyish brown moderately structured sandy clay loam. The reddish brown Bt horizon of well structured clay loam or clay contains illuviated clay in the form of clay skins or intra-ped concretions of silicate clay. On occasions the Eb may be mixed within the topsoil by cultivation and the surface horizon lies directly over the Bt. The Cg horizon is a reddish brown strongly prismatic plastic clay with distinct mottling along ped faces.

This is an ideal grassland soil and in southern Cheshire is mainly under permanent grassland or long ley. Barley is sometimes a secondary crop and with careful management yields well. Where the series is more extensive arable crops are becoming more important and are grown in rotation with short-term leys.

Profile No. 8

Grid reference: SJ 45/7493.

Soil group: argillic brown earth.

Parent material: reddish till.

Locality: 350 m S of Gates-heath Farm, Golborne Bellow.

Elevation: 23 m O.D.

Slope and aspect: 1° S.

Land use: re-seeded grassland.

Horizons:

cm	
0-23 Ap	Brown (7.5 YR 5/4) friable loam with few faint fine strong brown (7.5 YR 5/8) mottles; slightly stony with small and medium subangular blocky breaking to fine subangular blocky and fine and medium crumb; abundant fine pores and common fine fissures; moderate intimately mixed organic matter abundant fine fibrous roots; earthworms present; sharp even boundary.
23-54 Bt(g)	Reddish brown (5 YR 5/3) firm clay with common faint fine and medium light brownish grey (2.5 Y 6/2) and yellowish red (5 YR 5/8) mottles; slightly stony; moderate medium subangular blocky breaking to fine subangular blocky and medium crumb; common fine pores and fissures; low intimately mixed organic matter; common fine fibrous roots; merging even boundary.
54-90 BCg	Reddish brown (5 YR 4/3) plastic clay with many distinct large greenish grey (5 GY 6/1) mottles along structure faces; moderately strong medium prismatic; common fine pores and rare fine fissures; few fine fibrous roots concentrated along structure faces.

*Too heavy @ depth  
for flint.  
no damage nec. if  
keep off when wet.*

### Analyses

Horizon	Ap	Bt(g)	BCg	
Depth (cm)	0-23	23-54	54-90	
Sand {	600 $\mu$ m-2 mm %	1	1	2
	200-600 $\mu$ m %	19	11	8
	60-200 $\mu$ m %	23	14	13
Silt 2-60 $\mu$ m %	33	31	35	
Clay <2 $\mu$ m %	24	43	42	
CaCO <sub>3</sub> equivalent %		nil	6.0	
Organic carbon %	1.7	0.5	0.3	
pH in water (1:2.5)	6.1	6.7	7.7	
pH in 0.01M CaCl <sub>2</sub> (1:2.5)	6.0	6.5	7.3	
C.E.C. (me/100 g)	16.4	17.4	12.2	
Pyrophosphate ext.				
Fe %	0.05	0.01	0.01	
Al %	0.03	0.04	0.02	
C %	0.24	0.13	0.09	
Residual dithionite ext.				
Fe %	1.60	2.05	1.55	

Depart from Edge at approximately 1630.

The return route to Reaseheath affords good views of the Mid-Cheshire Ridge. Beyond the ridge the journey is mainly over till with areas of sand becoming more common nearer to Nantwich.

1800 Dinner.

## References

- Birks, H.J.B. (1965) Late-glacial deposits at Bagmere, Cheshire and Chat Moss, Lancashire.  
New Phytol., 64, 270-85.
- Boulton, G.S. and Worsley, P. (1965) Late Weichselian Glaciation in the Cheshire-Shropshire Basin.  
Nature, Lond, 207, 704-6.
- Evans, W.B., Wilson, A.A., Taylor, B.J. and Frice, D. (1968) Geology of the country around Macclesfield, Congleton, Crewe and Middlewich.  
Mem. geol. Surv. U.K.
- Mitchell, G.F., Penny, L.F., Shotton, F.W. and West, R.G. (1973)  
A correlation of Quaternary deposits in the British Isles.  
Geol. Soc. Lond. Special Report No. 4.
- Poole, E.G. and Whiteman, A.J. (1966) Geology of the country around Nantwich and Whitchurch.  
Mem. geol. Surv. U.K.
- Worsley, P. (1967) Problems in naming the Pleistocene deposits of the north-east Cheshire plain.  
Mercian Geol., 2, 51-5.

## APPENDIX

### Definition of terms used in discussion of physical properties of the soil

#### Water release characteristics and available water capacity

Core samples, taken in tinned metal sleeves of 22 cm<sup>3</sup> volume, were equilibrated at 0.05 and 0.15 bar suction on a sand suction table (Avery and Bascomb 1974). Subsamples from the sand cores were brought to equilibrium at 2.0 and 15 bars suction in a pressure membrane apparatus. Water contents at each suction were first calculated on the basis to oven-dry 105°C soil and then expressed as a percentage of the original soil volume.

The minimum available water capacity of a horizon ( $A_v$ ) is calculated from the difference between the volume of water retained at 0.05 bar suction, and the volume retained at 15 bar suction. This represents the water available to support crop growth after surplus, drainable, water has been removed.

#### Bulk density, air capacity and total pore space

The bulk density of the oven-dry cores and in some cases the particle density was determined. Total pore space was calculated for each horizon using a value of 2.65 g cm<sup>-3</sup>, for particle density  $\rho_p$ , where determined, the actual particle density for the horizon.

The air capacity, defined as the volume of air-filled voids at suction of 0.05 bar is expressed as a percentage of total bulk volume and indicates the relative aeration of soils during winter and spring when the soils are at or near field capacity. It also gives a general indication of the permeability of each horizon.

The results of the physical property tests are reported on the following scales

Retained water capacity ( $O_v(0.05)$ ) (vol. per cent.)	Bulk density ( $D_b$ ) (g cm <sup>-3</sup> )
0 - 9.9 VL	<0.2 VL
10 - 19.9 L	0.2-0.8 L
20 - 29.9 ML	0.8-1.3 Medium
30 - 39.9 MH	1.3-1.8 H
40 - 49.9 H	>1.8 VH
50+ VH	

Available water ( $A_v$ )  
+ air capacity ( $C_a$ )

(vol. per cent.)

0 - 4.9 VL  
5 - 9.9 L  
10 - 14.9 ML  
15 - 19.9 MH  
20 - 24.9 H  
25+ VH

VL = very low

L = low

ML = moderately low

MH = moderately high

H = high

VH = very high

PROCEEDINGS OF THE NORTH OF ENGLAND SOILS DISCUSSION GROUP

<u>No.</u>	<u>Date</u>	<u>Topic</u>	<u>Location</u>	<u>Price</u>
1	1964	Soils and Land Use Problems in the Marginal Farming Areas of the Pennine Foothills. Particular reference to drainage.	Lancaster and Bowland Uplands	87.5p
2	1965	The Use of Upland Soils and their Potential	Newcastle-upon-Tyne and the Roman Wall district of Northumberland	87.5p
3	1966	The Development, Characterisation and Potential of Estuarine Soils in the Morecambe Bay area.	Grange-over-Sands and the Lythe Valley	87.5p
4	1967	Peat and Organic Soils	Southport and the Mosslands of Lancashire	£1.25
5	1968	The Arable Sandlands of the Vale of York and the Practice of Marling	York and the Vale of York	£1.25
6	1969	The Reclamation of Colliery Spoil Tips	Leeds and the West Riding of Yorkshire	£1.25
7	1970	The Improvement of Upland Pastures	Alwrick and the Cheviots	£1.25
8	1971	Land Classification and Capability in an Upland Area	Tideswell, Derbyshire	£1.25
9	1972	Soils and Forestry	North Yorkshire Moors	<del>£1.50</del> £ 1-25