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AGRICULTURAL LAND CLASSIFICATION ASSESSMENT

Land at Briddlesford Lodge Farm
Briddlesford Road
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Isle of Wight
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Report for: Sunny Oaks Solar Park
The Ridge Group
Noah's Ark
Market Street
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BCM Ref: 2264-9963

CONTENTS

Appendices

1. INTRODUCTION

BCM (IOW) LLP have been instructed by Ridge Clean Energy Ltd to undertake an Agricultural Land Classification assessment in relation to the planning application on land south west of Wootton Bridge at Briddlesford Lodge Farm, Wootton Bridge, Newport, Isle of Wight on bare agricultural land amounting to a total planning application site area of approximately 32.5 hectares.

The report is to address the Agricultural Land Classification (ALC) using the ALC grading system to assess and compare the quality of agricultural land in the context of accepted practice in England and Wales. The report is to address the ALC across the demarcated site taking into account a combination of climate, topography and soil characteristics and their relevant interactions to determine the limitation of the soil and the ALC grade of the land.

The report is prepared by James Attrill BSc (Hons) FBIAC FAAV, a partner of BCM (IOW) LLP, Fellow of the British Institute of Agricultural Consultants and a Fellow of the Central Association of Agricultural Valuers. James Attrill has provided farm business consultancy and land agency advice on holdings across Southern England over the last 35 years. In addition to his farm consultancy and land agency work James Attrill is the managing partner of a family farming business on the Isle of Wight.

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2. DESCRIPTION OF SOIL GRADES AND SUBGRADES

The ALC grades and subgrades are described below in terms of the types of limitation which can occur, typical cropping range and the expected level and consistency of yield. In practice, the grades are defined by reference to physical characteristics and the grading guidance and cut-offs for limitation factors in Section 3 enable land to be ranked in accordance with these general descriptions. The most productive and flexible land falls into Grades 1 and 2 and Subgrade 3a and collectively comprises about one-third of the agricultural land in England and Wales. About half the land is of moderate quality in Subgrade 3b or poor quality in Grade 4. Although less significant on a national scale such land can be locally valuable to agriculture and the rural economy where poorer farmland predominates. The remainder is very poor quality land in Grade 5, which mostly occurs in the uplands.

Grade 1 - excellent quality agricultural land
Land with no or very minor limitations to agricultural use. A very wide range of agricultural and horticultural crops can be grown and commonly includes top fruit, soft fruit, salad crops and winter harvested vegetables. Yields are high and less variable than on land of lower quality.

Grade 2 - very good quality agricultural land
Land with minor limitations which affect crop yield, cultivations or harvesting. A wide range of agricultural and horticultural crops can usually be grown but on some land in the grade there may be reduced flexibility due to difficulties with the production of the more demanding crops such as winter harvested vegetables and arable root crops. The level of yield is generally high but may be lower or more variable than Grade 1.

Grade 3 - good to moderate quality agricultural land
Land with moderate limitations which affect the choice of crops, timing and type of cultivation, harvesting or the level of yield. Where more demanding crops are grown yields are generally lower or more variable than on land in Grades 1 and 2.

Subgrade 3a - good quality agricultural land
Land capable of consistently producing moderate to high yields of a narrow range of arable crops, especially cereals, or moderate yields of a wide range of crops including cereals, grass, oilseed rape, potatoes, sugar beet and the less demanding horticultural crops.

Subgrade 3b - moderate quality agricultural land
Land capable of producing moderate yields of a narrow range of crops, principally cereals and grass or lower yields of a wider range of crops or high yields of grass which can be grazed or harvested over most of the year.

Grade 4 - poor quality agricultural land
Land with severe limitations which significantly restrict the range of crops and/or level of yields. It is mainly suited to grass with occasional arable crops (e.g. cereals and forage crops) the yields of which are variable. In moist climates, yields of grass may be moderate to high but there may be difficulties in utilisation. The grade also includes very droughty arable land.

Grade 5 - very poor quality agricultural land
Land with very severe limitations which restrict use to permanent pasture or rough grazing, except for occasional pioneer forage crops.

3. GUIDELINES FOR ASSESSING LIMITATIONS

3.1 Methodology

In order to deduce the ALC of the site the relevant criteria to be considered have been collated through:

- Physical inspection
- Physical analysis of soil samples
- Limited desk based data analysis

The physical inspection of the site was made on 7th and 11th April 2022. The following methodology was followed in respect of the physical inspection and soil sampling:

- A 38.8 hectare area was mapped into one hectare sections. This incorporates but is larger than the 32.5 hectare planning application boundary. This wide survey area incorporates immediately adjacent grazing and cultivated land forming part of split field parcels. The plan under Appendix 8 shows the wider 38.8 hectare sample area.

- One soil sample was taken from each hectare section.

- The soil augur sampling (see photographic record Appendix 11) was made to a depth of 40 – 60cm.

- The separate soil samples were collated and forwarded to NRM laboratory for analysis with the instructed specification for analysis as per Appendix 7.

- In addition to the standard soil auguring sampling exercise a number of deeper inspection pits were dug and inspected.

- A photographic record of the site was also made (see Appendix 10)

In addition to the physical inspection and soil sampling/soil profile inspection a desk-based trawl of available data was made with respect to the following criteria:

3.2 Climatic Limitations

Appendix 3 sets out the climatic data sets for the site. The key criteria with respect to evaluating the ALC can be distilled as:

CLIMATIC FEATURE*	DATA
Rainfall – annual mm	941
Temperature Range monthly – degrees celcius	Average 8.22 – 14.19 | Low 3.42 | High 20.53
Air Frost Days – annual	17.37
Sunshine Hours - annual	1976
Days of rainfall – annual	123.73

*Data taken from Met office weather station Shanklin 1996-current period

Appendix 3 also contains climate information from the ALC Datasets (1941-1971 and 1961-1980) for the site proximity. This data is more historic but is broadly within 10% of the met Office 1996-current data. The ALC datasets show crop specific moisture deficits as:

Crop	Moisture Deficit
Winter Wheat	113
Potatoes	107.75

3.3 Site Limitations

- Gradient – Appendix 4 shows the gradient data for the site, the highest point being approximately 46.9 metres the lowest point being approximately 22.4 metres. Overall the gradient would be considered to be shallow and a minimal to moderate limitation. The degree of slope considered to be less than 11 degrees.

- Microrelief – the field parcels are generally level in terms of microrelief. This is not a constraint.

- Flooding – Appendix 6 sets out the flooding data for the site. The flooding risk to soils on the site from *watercourses* is minimal and not considered to be a limitation. The flooding risk to soils to the site from *surface water* is more widespread and may lead to soil waterlogging – this could be considered to be a limitation. This is not an indicator of impeded drainage.

- Land Use – the land is currently used for the purposes of agriculture being part of a mixed farming system rotating temporary ley grass with combinable arable crops and forage maize on the cultivated parcels and permanent grass occupying the non-cultivated parcels. These crop uses appear to have been in place for some 20 – 30 years as evidence by Google Earth historic mapping data sets. There is no historic evidence available to suggest that the land has been used for potato, root crop or vegetable production.

3.4 Soil Limitations

- Texture and structure – Appendix 9 sets out the soil analysis results in tabular form. These can be summarised across the site a mainly clay based soils ranging from clay to clay loam to silty clay loam.

The stone content was generally high manifested by high gravel content across the majority of samples. The structure was poor to average being anaerobic in parts with poor permeability and subsequent wetness. This is not an indicator of impeded drainage.

- Depth – from the inspections made and core samples taken the topsoil depth is considered to range between 10 centimetres and 15 centimetres.

- Stoniness – from physical inspection of soil profile and soil samples stoniness percentage is considered to be in the range of 10% to 20% of the top soil by volume across the sampled site.

- Chemical – No testing undertaken. Assumed no constraint.

3.5 Interactive Limitations

- Soil wetness – The duration of field capacity median value (FCD) is taken from the ALC 1941-1970 data set and averages 168.75 across the site. This is considered to be a limitation for root and vegetable crops and moderate limitation to combinable crops. It should be noted that this degree of wetness analysis is specific to soil cultivation suitability for arable and vegetable crops with potential seasonal limitations and not an indicator of impeded drainage.

- Droughtiness - the data in section 3.1 would suggest drought is a constraint for root and vegetable crops and a minor risk for grass and combinable arable crops.

- Erosion – Given the high clay content and relatively moderate gradient water driven erosion is not considered a limitation. The higher silt content in some samples may make some areas more prone to wind erosion or restricted localised surface erosion in intense rainfall events.

4. SUMMARY OF FACTORS RELATING TO ALC

LIMITING CRITERIA	LIMITATION FACTOR
Climate	Average summer rainfall score 347
Gradient	Less than 11 degrees on average
Microrelief	Negligible
Flooding	Surface water – localised
Texture and Structure	Clay based soil types - poor structure – drainage and compaction prone
Depth	10cm – 15cm of topsoil
Stoniness	Gravel content over majority of site
Chemical	No data available
Wetness	FCD score of 168.75
Droughtiness	MDMWHT of 113 and MDMPOT of 107.75
Erosion	Localised threat to areas of higher silt content

5. CONCLUSION – OPINION ON AGRICULTURAL LAND CLASSIFICATION

As seen from section 4 above, the criteria considered are judged to allocate the soil across the 32.5 hectare planning application site into subgrades **3b** or **lower**. This is further supported by:

- Natural England Agricultural Soil Classification data – see Appendix 2 – this map designates the land as grade **3b or lower**.

- Historical cropping records including historical aerial photographic record (see Appendix 12) the land is cropped to ley grass or combinable arable crops.

In the ALC guidance Grade 3B is described as:
"Moderate quality agricultural land – land capable of producing moderate yields of a narrow range of crops principally: cereals and grass, lower yields of a wider range of crops and higher yields of grass which can be grazed or harvested over most of the year"

For the land to fall in Grade 3A, according to the ALC guidance, its condition would need to allow for:

"…moderate yields of a wide range of crops including cereals, grass, oilseed rape, potatoes, sugar beet and the less demanding horticultural crops"

The criteria set out in this report and the constrains identified clarify that the soils are not suitable for potatoes, root crops or horticultural crops. This is further evidenced by the cropping history. Some of the land may be considered Agricultural Land Classification grade **3** – poor quality agricultural land defined by the ALC guidance notes as:

"Land with severe limitations which significantly restrict the range of crops or level of yields. It is mainly suited to grass with occasional arable crops (for example cereals and forage crops) the yields of which are variable. In moist climates, yields of grass may be moderate to high but there may be difficulties using the land. The grade also includes arable land that is very dry because of drought."

Taking into account the criteria addressed in this report it is concluded that the soil across the entirety of the 32.5 hectare site can be considered to be Agricultural Land Classification **3B or lower.**

James Attrill BSc (Hons) Agric FBIAC FAAV, Partner

August 2022

BCM Reference: 2224/9963

APPENDIX 1

Agricultural Land Assessment Proposals for Development – Guide to Assessing Development Proposals on Agricultural Land – MAFF October 1988

Ministry of Agriculture, Fisheries and Food

Agricultural Land Classification

of

England and Wales

Revised guidelines and criteria for grading the quality of agricultural land

OCTOBER 1988

CONTENTS

TABLES

TEXT FIGURES

PREFACE

This report provides revised guidelines and criteria for grading the quality of agricultural land using the Agricultural Land Classification (ALC) of England and Wales. The ALC was devised and introduced in the 1960s and Technical Report 11 (MAFF, 1966) outlined the national system, which forms the basis for advice given by the Ministry of Agriculture, Fisheries and Food (MAFF) and Welsh Office Agriculture Department (WOAD) on land use planning matters. Following a review of the system, criteria for the sub-division of Grade 3 were published in Technical Report 11/1 (MAFF, 1976). The classification is well established and understood in the planning system and provides an appropriate framework for determining the physical quality of the land at national, regional and local levels.

Experience gained has shown that some modifications to the ALC system can usefully be made to take advantage of new knowledge and data, to improve the objectivity and consistency of assessments and standardise terminology. The revised guidelines and criteria in this report have been developed and tested with the aim of updating the system without changing the original concepts. A further aim has been to calibrate the revised criteria with those used previously to maintain as far as possible the consistency of grading. The guidelines and methods used to define grades and subgrades are based on the best and most up to date information available but future revisions may be necessary to accommodate new information and technical innovation.

There is a continuing need to distinguish between the better land in Grade 3 and other land in this Grade but it is no longer considered necessary to maintain a threefold division. Two subgrades are now recognised: Subgrade 3a and Subgrade 3b, the latter being a combination of the previous Subgrades 3b and 3c.

Technical Report 11 included proposals for the development of an economic classification system linked to the physical classification. It also identified a number of significant disadvantages for a national system of economic classification, especially the problems associated with the acquisition of objective, up to date, accurate and consistent farm output data. No satisfactory means have been found of overcoming these problems and for this reason economic criteria for grading land have not been adopted. Similarly site specific crop yield data are not regarded as a reliable indication of land quality, because it is not possible to consistently make allowances for variables such as management skill, different levels of input and short-term weather factors.

The principal changes in this revision concern the criteria used to assess climatic limitations and the main limitations involving a climate-soil interaction, namely soil wetness and droughtiness. The revised methods have been developed and evaluated by the Agricultural Development and Advisory Service (ADAS) in close collaboration with the Soil Survey and Land Research Centre (SSLRC, incorporating the Soil Survey of England and Wales) and the Meteorological Office. A number of new and improved climatic datasets have been compiled on the same collaborative basis and these base data are held in LandIS, a computer information system funded by MAFF and developed by SSLRC. The datasets will also be published by the Meteorological Office (in press) and are described in Appendix 1.

The revised system incorporates some features of the 7-class Land Use Capability Classification formerly used by the Soil Survey of England and Wales (Bibby and Mackney, 1969) in which Classes 5, 6 and 7 broadly correspond to Grade 5 of the ALC system. In common with the Scottish Land Capability Classification for Agriculture (Bibby et al, 1982) some of the concepts now introduced originated from the ADAS Land Capability Working Party which met between 1974 and 1981. Although there are similarities with the Scottish system, the Agricultural Land Classification has been developed and calibrated specifically for use in England and Wales. This report describes the criteria and assessment methods which will be used by MAFF and WOAD to classify land. Wherever possible, definitions and methods common to both ADAS and SSLRC have been used.

Acknowledgements

The Ministry is indebted to the Meteorological Office and Soil Survey and Land Research Centre for their assistance, information and advice provided over a period of years. The climate-related components of the system were revised by a working group chaired by A J Hooper (ADAS) and the contributions of J H Minhinick and J F Keers (Meteorological Office), Dr R J A Jones and J M Hollis (SSLRC), D Hewgill, M R Watson and Dr I P Jones (ADAS) are gratefully acknowledged. Valuable assistance was also provided by F Broughton (ADAS). Evaluations and testing of the revised criteria were co-ordinated by M R Watson and carried out by regional staff of the Resource Planning Group, ADAS.

Ministry of Agriculture, Fisheries and Food
October 1988

SECTION 1

INTRODUCTION

The Agricultural Land Classification provides a framework for classifying land according to the extent to which its physical or chemical characteristics impose long-term limitations on agricultural use. The limitations can operate in one or more of four principal ways: they may affect the range of crops which can be grown, the level of yield, the consistency of yield and the cost of obtaining it. The classification system gives considerable weight to flexibility of cropping, whether actual or potential, but the ability of some land to produce consistently high yields of a somewhat narrower range of crops is also taken into account.

The principal physical factors influencing agricultural production are climate, site and soil. These factors together with interactions between them form the basis for classifying land into one of five grades; Grade 1 land being of excellent quality and Grade 5 land of very poor quality. Grade 3, which constitutes about half of the agricultural land in England and Wales, is now divided into two subgrades designated 3a and 3b. General descriptions of the grades and subgrades are given in Section 2.

Guidelines for the assessment of the physical factors which determine the grade of land are given in Section 3. The main climatic factors are temperature and rainfall although account is taken of exposure, aspect and frost risk. The site factors used in the classification system are gradient, microrelief and flood risk. Soil characteristics of particular importance are texture, structure, depth and stoniness. In some situations, chemical properties can also influence the long-term potential of land and are taken into account. These climatic, site and soil factors result in varying degrees of constraint on agricultural production. They can act either separately or in combination, the most important interactive limitations being soil wetness and droughtiness.

The grade or subgrade of land is determined by the most limiting factor present. When classifying land the overall climate and site limitations should be considered first as these can have an overriding influence on the grade. Land is graded and mapped without regard to present field boundaries, except where they coincide with permanent physical features.

A degree of variability in physical characteristics within a discrete area is to be expected. If the area includes a small proportion of land of different quality, the variability can be considered as a function of the mapping scale. Thus, small, discrete areas of a different ALC grade may be identified on large scale maps, whereas on smaller scale maps it may only be feasible to show the predominant grade. However, where soil and site conditions vary significantly and repeatedly over short distances and impose a practical constraint on cropping and land management a 'pattern' limitation is said to exist. This variability becomes a significant limitation if, for example, soils of the same grade but of contrasting texture occur as an extensive patchwork thus complicating soil management and cropping decisions or resulting in uneven crop growth, maturation or quality. Similarly, a form of pattern limitation may arise where soil depth is highly variable or microrelief restricts the use of machinery. Because many different combinations of characteristics can occur no specific guidelines are given for pattern limitations. The effect on grading is judged according to the severity of the limitations imposed by the pattern on cropping and management, and is mapped where permitted by the scale of the survey.

The guidelines provide a consistent basis for land classification but, given the complex and variable nature of the factors assessed and the wide range of circumstances in which they can occur, it is not possible to prescribe for every possible situation. It may sometimes be necessary to take account of special or local circumstances when classifying land. For this reason, the physical criteria of eligibility in this report are regarded as guidelines rather than rules although departures from the guidance should be exceptional and based on expert knowledge. Physical conditions on restored land may take several years to stabilise; therefore, the land is not normally graded until the end of the statutory aftercare period, or otherwise not until 5 years after soil replacement.

To ensure a consistent approach when classifying land the following assumptions are made:

1. Land is graded according to the degree to which physical or chemical properties impose long-term limitations on agricultural use. It is assessed on its capability at a good[1] but not outstanding standard of management.

2. Where limitations can be reduced or removed by normal management operations or improvements, for example cultivations or the installation of an appropriate underdrainage system, the land is graded according to the severity of the remaining limitations. Where an adequate supply of irrigation water is available this may be taken into account when grading the land (Section 3.4). Chemical problems which cannot be rectified, such as high levels of toxic elements or extreme subsoil acidity, are also taken into account.

3. Where long-term limitations outside the control of the farmer or grower will be removed or reduced in the near future through the implementation of a major improvement scheme, such as new arterial drainage or sea defence improvements, the land is classified as if the improvements have already been carried out. Where no such scheme is proposed, or there is uncertainty about implementation, the limitations will be taken into account. Where limitations of uncertain but potentially long-term duration occur, such as subsoil compaction or gas-induced anaerobism, the grading will take account of the severity at the time of survey.

4. The grading does not necessarily reflect the current economic value of land, land use, range of crops, suitability for specific crops or level of yield. For reasons given in the preface, the grade cut-offs are not specified on the basis of crop yields as these can be misleading, although in some cases crop growth may give an indication of the relative severity of a limitation.

5. The size, structure and location of farms, the standard of fixed equipment and the accessibility of land do not affect grading, although they may influence land use decisions.

[1] Previously described as 'satisfactory'; no change in the assumed standard of management is intended.

SECTION 2

DESCRIPTION OF THE GRADES AND SUBGRADES

The ALC grades and subgrades are described below in terms of the types of limitation which can occur, typical cropping range and the expected level and consistency of yield. In practice, the grades are defined by reference to physical characteristics and the grading guidance and cut-offs for limitation factors in Section 3 enable land to be ranked in accordance with these general descriptions. The most productive and flexible land falls into Grades 1 and 2 and Subgrade 3a and collectively comprises about one-third of the agricultural land in England and Wales. About half the land is of moderate quality in Subgrade 3b or poor quality in Grade 4. Although less significant on a national scale such land can be locally valuable to agriculture and the rural economy where poorer farmland predominates. The remainder is very poor quality land in Grade 5, which mostly occurs in the uplands.

Descriptions are also given of other land categories which may be used on ALC maps.

Grade 1 - excellent quality agricultural land
Land with no or very minor limitations to agricultural use. A very wide range of agricultural and horticultural crops can be grown and commonly includes top fruit, soft fruit, salad crops and winter harvested vegetables. Yields are high and less variable than on land of lower quality.

Grade 2 - very good quality agricultural land
Land with minor limitations which affect crop yield, cultivations or harvesting. A wide range of agricultural and horticultural crops can usually be grown but on some land in the grade there may be reduced flexibility due to difficulties with the production of the more demanding crops such as winter harvested vegetables and arable root crops. The level of yield is generally high but may be lower or more variable than Grade 1.

Grade 3 - good to moderate quality agricultural land
Land with moderate limitations which affect the choice of crops, timing and type of cultivation, harvesting or the level of yield. Where more demanding crops are grown yields are generally lower or more variable than on land in Grades 1 and 2.

Subgrade 3a - good quality agricultural land
Land capable of consistently producing moderate to high yields of a narrow range of arable crops, especially cereals, or moderate yields of a wide range of crops including cereals, grass, oilseed rape, potatoes, sugar beet and the less demanding horticultural crops.

Subgrade 3b - moderate quality agricultural land
Land capable of producing moderate yields of a narrow range of crops, principally cereals and grass or lower yields of a wider range of crops or high yields of grass which can be grazed or harvested over most of the year.

Grade 4 - poor quality agricultural land
Land with severe limitations which significantly restrict the range of crops and/or level of yields. It is mainly suited to grass with occasional arable crops (e.g. cereals and forage crops) the yields of which are variable. In moist climates, yields of grass may be moderate to high but there may be difficulties in utilisation. The grade also includes very droughty arable land.

Grade 5 - very poor quality agricultural land
Land with very severe limitations which restrict use to permanent pasture or rough grazing, except for occasional pioneer forage crops.

Descriptions of other land categories used on ALC maps

Urban
Built-up or 'hard' uses with relatively little potential for a return to agriculture including: housing, industry, commerce, education, transport, religious buildings, cemeteries. Also, hard-surfaced sports facilities, permanent caravan sites and vacant land; all types of derelict land, including mineral workings which are only likely to be reclaimed using derelict land grants.

Non-agricultural
'Soft' uses where most of the land could be returned relatively easily to agriculture, including: golf courses, private parkland, public open spaces, sports fields, allotments and soft-surfaced areas on airports/ airfields. Also active mineral workings and refuse tips where restoration conditions to 'soft' after-uses may apply.

Woodland
Includes commercial and non-commercial woodland. A distinction may be made as necessary between farm and non-farm woodland.

Agricultural buildings
Includes the normal range of agricultural buildings as well as other relatively permanent structures such as glasshouses. Temporary structures (e.g. polythene tunnels erected for lambing) may be ignored.

Open water
Includes lakes, ponds and rivers as map scale permits.

Land not surveyed
Agricultural land which has not been surveyed,

Where the land use includes more than one of the above land cover types, e.g. buildings in large grounds, and where map scale permits, the cover types may be shown separately. Otherwise, the most extensive cover type will usually be shown.

SECTION 3

GUIDELINES FOR ASSESSING LIMITATIONS

This section explains why and how the main limiting factors used in the ALC system influence the grade of land.

3.1 Climatic Limitations

Climate has a major, and in places overriding, influence on land quality by affecting both the range of potential agricultural uses and the cost and level of production. Its most fundamental influence is on the potential for plant growth, by determining the energy available for photosynthesis and water supply to plant roots. The effect on plant growth occurs partly through interactions with soil and site properties which determine soil wetness and droughtiness. There are also more direct effects on crops or stock such as exposure to damaging wind, persistent wetness or high humidity and frost which can cause physical damage, disease or stress. It is therefore necessary to include in the ALC an assessment of the overall climatic limitation in addition to the interactive limitations which are assessed separately (Section 3.4).

The climatic criteria are considered first when classifying land. Climate can be overriding in the sense that severe limitations will restrict land to low grades irrespective of favourable soil or site conditions. The general principle followed is to assign increasing degrees of limitation to agricultural use as rainfall increases and average temperature decreases. Thus, in climatic terms, the poorest areas are both the wettest and coldest and conversely the climate is regarded as more favourable as temperature increases and rainfall moderates.

The main parameters used in the assessment of the climatic limitation are average annual rainfall (AAR), as a measure of overall wetness; and accumulated temperature, as a measure of the relative warmth of a locality. Accumulated temperature is the excess of daily air temperatures above a selected threshold temperature, summed over a specified period. When calculated over an appropriate part of the growing season it can be used as an indication of heat energy input and soil drying potential and has been shown to correlate with crop growth and yield. Work on grass (Peacock, 1975) and cereals (Biscoe and Gallagher, 1978) showed that leaf extension occurs, albeit slowly, down to temperatures as low as 0° Celsius, which is adopted as the threshold temperature for the ALC system. For the climatic assessment, accumulated temperature is calculated, using an established algorithm (Meteorological Office, 1969), for the period January to June (AT0); this being the critical growth period for most crops.

The above parameters provide the basis for the evaluation of overall climate. Local climatic factors including aspect, exposure and frost risk are also considered when grading land but are not easily quantified and require careful judgement for individual sites.

Assessment of the overall climate limitation
The permitted combinations of AAR and AT0 for each ALC grade and subgrade are defined graphically in Figure 1. The AAR and AT0 datasets used for this assessment are described in Appendix 1.

Local climatic factors
At the local scale differences in the aspect, gradient and elevation of the land can significantly modify the overall climate, particularly in relation to temperature, exposure and frost risk.

Aspect can have a marked influence on the amount of solar radiation that a site receives. In general, mean daily temperatures and hence accumulated temperatures in spring and early summer are higher on slopes with sheltered southerly aspects than on those facing in northerly directions. Radiation intensity also varies with slope angle such that differences due to aspect are more marked on steeper slopes. In valleys, the relationships are often more complex due to the effect of shading, which can moderate the benefits of a southerly aspect and increase the penalties on north facing slopes.

The influence of a favourable aspect on mean temperatures may be reduced or removed by exposure. In certain situations exposure may constitute a significant climatic factor in its own right. Persistent strong or cold winds can be damaging to crops or cause stress to livestock, especially in wet weather. Upland areas, and land which stands above the surrounding countryside, are often exposed. Many coastal districts are exposed to strong, salt-laden winds and their effects can extend for several miles inland. Windspeed is strongly influenced by topography. In general, wind velocities increase with altitude and decrease with distance from the west coast, while the funnelling of winds along valleys, particularly in the uplands, may result in consistently higher windspeeds.

The incidence of damaging frost is also closely related to topography and can be localised. Spring frosts can cause serious damage to fruit crops and may check the growth of arable crops. A slope of 2° is sufficient to initiate the movement of cold air downslope, and valley bottoms and basin sites are particularly susceptible to frost. The assessment of frost risk is most significant in relation to the better quality land where the more sensitive horticultural crops are likely to be grown. Soil type also influences frost risk, with sandy and dry peat soils being more prone to late spring frosts than other soils.

The interactions between topography and climate are often complex and it is not possible to give detailed guidance for their assessment. Where the overall climate is liable to be modified significantly by local factors, the effect on grading should be assessed on the basis of expert agrometeorological advice.

3.2 Site Limitations

The assessment of site factors is primarily concerned with the way in which topography influences the use of agricultural machinery and hence the cropping potential of the land. Flood risk is also regarded as a site limitation as it is usually associated with well-defined topographic features.

Gradient
Gradient has a significant effect on mechanised farm operations since most conventional agricultural machinery performs best on level ground. The safe and

efficient use of machinery on sloping land depends very much on the type and design of the machine and on the nature of the slope being farmed. For example, slopes with adequate turning space at the top and bottom may be negotiated safely whereas similar slopes without turning space may not. The bearing strength of the topsoil is also critical in the safe operation of machinery on slopes. Where surfaces have a low bearing strength the safe angle for working is reduced.

Table 1 gives the gradient limits for each grade and subgrade of land. They are based primarily on the type of machinery which can be safely and efficiently operated. The grade cut-offs are modelled principally on the use of two-wheel drive machines. The ability to work on steeply sloping land has increased to some extent with the wider use of four-wheel drive machines. However, where cultivation is involved there is often an attendant risk of soil erosion particularly if the soil is weakly structured. For this reason, and on safety grounds, the previous limits of 11° and 18° are retained. Grade 1, 2 and 3a land is suitable for most kinds of agricultural machinery including precision seeding and harvesting equipment.

Table 1 Grade according to gradient

Grade/ Subgrade	Gradient limits (degrees)
1, 2, 3a	7
3b	11
4	18
5	>18

Microrelief

Complex changes of slope angle and direction over short distances, or the presence of boulders or rock outcrops, even on level ground or gentle slopes, can severely limit the use of agricultural machinery. The degree of limitation depends upon the distribution and severity of such features. For example, relatively few abrupt changes of slope angle on a site with a gentle overall slope may preclude the use of precision sowing or planting equipment. On steep slopes, rock outcrops, or frequent changes of slope direction, may prevent the safe use of a tractor with mounted equipment. Level sites may be impossible to cultivate satisfactorily because of frequent rock outcrops. Differential settlement can create a microrelief limitation on restored land, which may only become apparent some years after soil replacement, and may also give rise to a pattern limitation if it causes patchy wetness over a significant area.

The effect of microrelief is considered in conjunction with overall gradient, though detailed guidance is not feasible. The degree of limitation should be assessed in relation to the hindrance to mechanical operations.

Flooding
The incidence of flooding is strongly influenced by topography but the extent, duration, frequency and timing can be difficult to establish precisely. The risk of flooding may be significant in affecting the choice of crops to be grown, because at certain times of the year it can have a detrimental effect on yield, and may give rise to soil management problems. The overall effect of flooding depends on a range of circumstances. The after-effects of inundation depend in part on soil type and will generally be more serious on impermeable soils, which remain saturated for longer periods than permeable soils. Flood-plain morphology influences water velocities and therefore affects the amount of soil erosion, siltation and physical damage to crops. The time of year at which flooding occurs is particularly significant. Floods which occur in summer are generally more damaging than winter floods because the crop root systems are active and more likely to be affected by waterlogging. Crops vary in their tolerance to flooding and this is reflected in the stricter limits on high quality land where flexibility of cropping is required.

The guidelines in Tables 2 and 3 take account of frequency, duration and timing of flooding and apply to soils of good or moderate permeability. Further downgrading may be justified where flooding affects soils of low permeability. The year is divided into two parts, with a long 'summer' period which includes the spring sowing and late autumn harvesting seasons. When grading land, the flood limitation is assessed separately for the summer and winter seasons and, applying the 'most limiting factor' principle, either assessment can determine the grade. Information on flooding at a local scale is often fragmentary and the assessment may have to be based on local knowledge, together with any information or advice which can be obtained from Water Authorities. Most weight should be given to the predicted long-term risk, or the return periods used in the design of flood protection schemes, rather than to the average incidence of flooding in recent years, which may have been influenced by atypical climatic conditions.

Table 2 Grade according to flood risk in summer

Grade/ Subgrade		Flood limits *frequency*	*duration*
1		very rare	short
2		rare	short
3a		very rare	medium or long
	or	rare	medium
	or	occasional	short
3b		rare	long
	or	occasional	medium
4		occasional	long
	or	frequent	short or medium
5		frequent	long

Table 3 Grade according to flood risk in winter

Grade/ Subgrade		Flood limits *frequency*	*duration*
1		rare	short
2		rare	medium
	or	occasional	short
3a		rare	long
	or	occasional	medium
	or	frequent	short
3b		occasional	long
	or	frequent	medium
4		frequent	long

The terms used in Tables 2 and 3 are defined as follows:

Season summer - mid March to mid November
winter - mid November to mid March

Duration short - not more than 2 days (48 hours)
medium - more than 2 but not more than 4 days
long - more than 4 days

Frequency	very rare - not more than once in 15 years
	rare - once in 10 to once in 14 years
	occasional - once in 3 to once in 9 years
	frequent - more than once in 3 years

3.3 Soil Limitations

The main soil properties which affect the cropping potential and management requirements of land are texture, structure, depth, stoniness and chemical fertility. These may act as limitations separately, in combination or through interactions with climate or site factors. The interactive limitations of soil wetness, droughtiness and erosion risk are discussed separately in Section 3.4. The relationships are often complex and the criteria used in this land classification are designed to provide a practical method for grading land on the basis of field assessments.

In this document the term 'topsoil' refers to true topsoil material which developed originally at the top of a soil profile and is characteristically darker in colour and has a higher organic matter content than subsoil material. The term 'top 25 cm' is used to refer to the uppermost 25 cm of the soil profile which defines, for ALC purposes, the depth zone within which the soil is most frequently cultivated.

It is generally assumed in the soil related assessments that natural topsoil is in *situ.* If the land has been disturbed and there is little or no topsoil, this may be an additional limitation which needs to be taken into account when grading the land.

Soil texture and structure
Soil texture and structure have a major influence on water retention, water movement and aeration in soils and therefore on workability, trafficability, poaching risk and suitability as a medium for plant growth. Texture class is determined by the relative proportions of sand, silt and clay particles and the amount of organic matter in a soil horizon and may be assessed in the field by hand texturing or measured in a laboratory by particle-size analysis. The soil texture system used for ALC purposes is described in Appendix 2.

In most soils the primary particles are aggregated into structural units called peds. Soil structure is influenced considerably by soil texture and is described by reference to the size, shape and degree of development of the peds and the pores and fissures within and between them (Hodgson, 1976). A well structured soil is characterised by clearly identifiable, stable peds with a high proportion of pores and fissures which allow easy movement of air, water and roots through the soil. Such soils are often found under permanent pasture where the soil has not been disturbed by cultivation and prolonged root action has assisted structural development.

Clay soils tend to be coarse structured and the peds swell on wetting, thus closing fissures and reducing permeability. The risk of damage to soil structure by cultivation generally increases with increasing clay content. Clay soils tend to form large, hard surface clods when dry and are plastic when wet. They can therefore only be cultivated satisfactorily under a relatively narrow range of soil moisture conditions. Calcareous clay soils are generally better structured than non-calcareous clays and are consequently better drained and easier to cultivate.

Soils with a high proportion of silt or fine sand are inherently weakly structured and are prone to surface capping and slaking, especially if the topsoils have a low organic matter content. Sandy soils are more easily worked but are weakly structured and readily form compacted layers if cultivated or traversed when wet. They may also be susceptible to erosion and drought.

Soil texture and structure are therefore significant parameters in the assessments of droughtiness and wetness. Texture is a key variable for estimating the available water capacity of a soil profile, as explained in Section 3.4 and Appendix 4. The coarser sandy soils are very susceptible to drought stress in dry periods. Irrespective of the moisture balances which result from the droughtiness assessment, soils with sand topsoils are not eligible for Grades 1, 2 or 3a and those with loamy sand topsoils are not eligible for Grade 1.

Soil wetness is assessed in the field by identifying the depth to any slowly permeable soil horizon, which is defined in terms of soil texture, structure and gleying and relating this to the texture of the top 25 cm (Section 3.4 and Appendix 3). For certain combinations of wetness class, texture and field capacity days (FCD, see page 31), a distinction is made between some naturally calcareous (i.e. those in which the calcium carbonate is derived from the soil parent material and not artificial liming) and other soils, as the former are usually better structured and therefore more workable. The distinction applies where a soil:

- i) has at least 1% calcium carbonate in the top 25 cm and a similar or greater calcium carbonate content below 25 cm, *and*
- ii) has between 18 and 50% clay content in the top 25 cm, *and*
- iii) occurs in an area with not more than 150 FCD.

Similarly, under favourable climatic and soil water regimes, some medium and heavy textured soils are more workable if there is a high organic matter content within the top 25 cm and this is reflected in the higher grades for such soils given in Table 7.

Soil structure can be damaged by agricultural use. Most structural problems which occur in the upper soil profile are caused by mechanical operations or grazing carried out when the soil is too wet. Where such damage can be corrected by normal soil management methods it is regarded as a short-term limitation and does not affect grading. However, more persistent problems can occur, particularly on disturbed soils. On land which has been restored, soil structure is often weakened and can be significantly damaged by soil movement and storage. The return of a restored soil to a stable and more natural structural condition is normally a gradual process which needs to be encouraged over a period of years by maintaining an appropriate cropping and soil management regime. Some soils can be rendered very unstable by such disturbance and therefore respond very slowly to remedial measures, even in the topsoil. In such circumstances, it cannot be assumed (as applies to undisturbed soils, see page 37) that any slowly permeable layer within 35 cm can be removed satisfactorily. Thus where very unstable structure gives rise to wetness problems which are likely to persist, it should be taken into account when grading the land (see page 22). Similarly, unstable structure is a factor to be considered when grading saline soils which have slaked as a consequence of deflocculation (see page 19). Where significant compaction occurs below 35 cm, for example on disturbed or restored land, it may be difficult or impossible to ameliorate practically or economically. Such compaction is therefore a long-term limitation which is taken into account through reduced permeability and available water capacity in the wetness and droughtiness assessments (see pages 37 and 26 respectively).

A soil limitation can sometimes occur on sites restored to agriculture where different soils, or topsoil and subsoil, have been mixed. If the physical characteristics of the materials are very different, such as large clay inclusions within a sandy matrix, and are likely to cause significant management problems for many years, the limitation will be assessed and the land graded accordingly.

Soil depth

Soil depth is an important factor in determining the available water capacity of a soil and is considered in that context in Section 3.4. Shallowness affects cropping in other ways, notably by influencing the range and type of cultivations which can be carried out but also by restricting nutrient uptake, root growth and, in the case of fruit trees, root anchorage. It is therefore necessary to specify minimum soil depth requirements for the grades and subgrades.

Limiting depths are given in Table 4 for soil overlying consolidated or fragmented rock which cannot be penetrated satisfactorily by cultivation implements.

Table 4 Grade according to soil depth

Grade/ Subgrade	Depth limits (cm)
1	60
2	45
3a	30
3b	20
4	15
5	<15

Stoniness

The main effects of stones are to act as an impediment to cultivation, harvesting and crop growth and to cause a reduction in the available water capacity of a soil. This section is concerned with the 'mechanical' limitations and refers to stoniness in the top 25 cm of the soil. The effect on available water capacity is considered in Section 3.4 and Appendix 4.

A high stone content can increase production costs by causing extra wear and tear to implements and tyres. Crop quality may also be reduced in stony soil by causing, for example, the distortion of root crops or bruising of potatoes during harvesting. Stones can impair crop establishment by causing reduced plant populations in precision-drilled crops, and they reduce the nutrient capacity of the soil.

The degree of limitation imposed by stones depends on their quantity, size, shape and hardness. Stoniness can vary markedly over short distances and is time-consuming to measure. The size limits specified in Table 5 are for volumes of stones which will not pass through sieves with 2 cm or 6 cm square mesh. Grade limits have been specified for stones retained on a 6 cm sieve because they usually have a more detrimental effect than smaller stones. The limits apply to hard stones; where the stones are of soft lithology, such as soft chalk, weakly cemented sandstones or siltstones, the limits are relaxed by one grade or subgrade. Both stone percentage columns in Table 5 are expressed in terms of the percentage of total volume of the top 25 cm of the soil; either can be most limiting and determine the grade. Thus, if 30% of the top 25 cm comprises hard stones larger than 2 cm, the land cannot be graded higher than 3b. However, if that same soil layer contains 25% stones larger than 6 cm the land cannot be graded higher than Grade 4. Small numbers of large boulders or stones which can be removed easily should be ignored. Stones smaller than 2 cm, which have no or only minor effects on cultivation, should also be ignored.

Table 5 Grade according to stoniness

Grade/ Subgrade	Limiting percentages (volume) of hard stones in the top 25cm of soil	
	stones larger than 2 cm[1]	*Stones larger than 6 cm*[1]
1	5	5
2	10	5
3a	15	10
3b	35	20
4	50	35
5	>50	>35

[1] Stones retained on a 2 cm or 6 cm square mesh sieve, as appropriate.

Chemical Limitations
The chemical status of a soil does not affect ALC grading where nutrient levels can be maintained or corrected by normal applications of fertiliser or lime. Chemical factors will only affect grading where they have, or are likely to have, a detrimental long- term effect on the physical condition of the soil, the crop yield, the range of crops that may be safely grown, stocking rates or grazing management.

Physical limitations induced by soil chemical properties are most likely to be encountered with saline or certain organic mineral or peat soils. Sodium-rich clay and silty clay soils developed in marine alluvium are potentially unstable if the land is drained. Progressive leaching of salt from the soil profile causes deflocculation of the clay particles and may lead to structural collapse (slaking) and drain failure through siltation. Measures to avoid or ameliorate these conditions may be unsuccessful.

Where such land is currently undrained and expert advice indicates that it is not prudent to drain it, the land should be graded in the undrained condition.

When peat or marine alluvium rich in iron sulphide is drained, iron compounds may be released and deposited in the form of iron ochre, which can block pipe drainage systems. The problem can sometimes be ameliorated, but in severe cases may justify downgrading. Where expert advice indicates that new drainage work is likely to be uneconomic, the land should be graded in the undrained condition. The chemical reactions which produce ochre can cause extreme subsoil acidity which is difficult to rectify. This limitation should be taken into account and assessed according to the effect on the flexibility and productivity of the land.

Where landfill containing organic material has been used in the restoration of land to agriculture, gases such as methane can be generated when the waste decomposes. Where methods for sealing the landfill surface and venting gas emissions are not used or are not fully effective, such gas can create anaerobic conditions in the overlying soil affecting plant roots and therefore reducing crop yield. The effect on plant growth varies according to the degree of oxygen depletion and concentration of phytotoxic gases which may also be present in the soil atmosphere. In severe situations crop growth may be absent or stunted. The production and release of landfill gases can vary according to site conditions and may be very localised. Severe gas-induced anaerobism is often indicated by a foul-smelling greenish or bluish mottled subsoil. Gases may also be present at lower concentration in the soil above such visually anaerobic soil horizons. The duration of gas emission and the long-term effect on productivity of the land are unpredictable and grading will take account of the degree of limitation at the time of survey. The data available on the effect of such anaerobism on crops are very limited and the following guidance is therefore provisional. Where such anaerobism is visible within one metre of the soil surface the land will not be graded higher than Subgrade 3b. Where the anaerobism is within 50 cm of the surface the land will be Grade 4 or, if within 30 cm, Grade 5.

Toxic elements can occur at levels which adversely affect plant growth (phytotoxicity) or are potentially harmful to animals or man (zootoxicity). The most commonly occurring toxic elements are zinc, copper, lead and cadmium although others including mercury, arsenic, nickel, chromium and fluorine are also found. High concentrations of these elements are most likely to be associated with spoil heaps from metalliferous mining, industrial waste and sewage disposal. The level of toxicity depends on the type, form and concentration of elements present and on complex chemical interactions which may be influenced by soil pH, texture and organic matter content. It is therefore not practicable to indicate precise concentrations as limits for grades or subgrades.

The effect of soil toxicity on grading is assessed in relation to the effects on plant growth and any limitations placed on the management or use of the land, such as restrictions on cultivation (which may bring contaminated material to the surface), stocking levels or grazing periods, or on the use made of produce obtained from it. Land will not be graded higher than Subgrade 3b if it is considered to be unsuitable for growing crops for direct human consumption. Land which is limited to grass production and on which there are significant restrictions on grassland management will be no better than Grade 4. Where only extensive grazing is possible the land will be Grade 5 and, where it is unfit for all forms of agricultural production, can be regarded as non-agricultural.

3.4 Interactive Limitations

The physical limitations which result from interactions between climate, site and soil are soil wetness, droughtiness and erosion. Soil wetness expresses the extent to which excess water imposes restrictions on crop growth and cultivations while droughtiness indicates the degree to which a shortage of soil water influences the range of crops which may be grown and level of yield which may be achieved. The limitations are not mutually exclusive in that some soils can be wet in winter but droughty in summer. For ALC purposes wetness and droughtiness are assessed separately by relating soil profile characteristics to appropriate climatic parameters.

Soil Wetness

A soil wetness limitation exists where the soil water regime adversely affects plant growth or imposes restrictions on cultivations or grazing by livestock. The importance of this limitation is reflected by the widespread use of and dependence on field drainage in both arable and grassland areas in England and Wales. Excessive soil wetness adversely affects seed germination and survival, partly by a reduction in soil temperature and partly because of anaerobism. It also inhibits the development of a good root system and can, in extreme cases, lead to plant death. Soil wetness also influences the sensitivity of the soil to structural damage and is therefore a major factor in determining the number of days when the soil is in a suitable condition for cultivation, trafficking by machinery or grazing by livestock.

The severity of the limitation is influenced by the amount and frequency of rain in relation to evapotranspiration, the duration of waterlogging and the texture of the uppermost layers of the soil. A wetness limitation can exist in both permeable and impermeable soils. Permeable soils are most significantly affected by wetness where there is a ground water table that cannot be removed by normal field drainage improvements. In less permeable soils the degree of waterlogging depends in part on the depth at which the soil becomes slowly permeable. Topsoil texture influences the wetness limitation because of its effect on soil water retention and the mechanical properties of the soil. Soils with a high clay content tend to retain more water than sandy soils and are therefore slower to return to a workable condition after wetting. Such soils also have a higher mechanical strength when dry, which further reduces the period during which they can be effectively cultivated.

For ALC purposes the soil wetness assessment takes account of:

- i) the climatic regime
- ii) the soil water regime
- iii) the texture of the top 25 cm of the soil

Climatic regime

The influence of climate on soil wetness is assessed by reference to median field capacity days (FCD). FCD ranges are specified within which similar soils are expected to have similar degrees of wetness limitation. The spatial distribution of

FCD has been mapped at a scale of 1:1 million by the SSLRC (Jones and Thomasson, 1985) and there is also a gridpoint dataset (Appendix 1).

Soil water regime
This assessment is based on soil wetness classes (Hodgson, in preparation) which are defined in terms of the average duration of waterlogging at specified depths in the soil profile. The procedure for inferring soil wetness class from observed soil profile characteristics is described in Appendix 3.

Soil texture
Mineral soil texture classes are divided into four groups according to ease of cultivation and susceptibility to damage by grazing animals. Where appropriate, a distinction is also made between mineral textures, their organic variants (organic mineral textures) and peaty textures. The system of soil texture classification used is given in Appendix 2.

Wetness assessment
For most soils, the overall wetness limitation is assessed in two stages, namely:

i) determine the soil wetness class, according to Appendix 3

ii) relate soil wetness class to soil texture and median field capacity days, using Table 6 where the top 25 cm is a mineral texture or Table 7 where the top 25 cm is an organic mineral or peaty texture.

On restored soils structural instability in the top 35 cm (see page 17) may have a significant effect on permeability and therefore soil wetness. Where this condition is unlikely to be ameliorated in the short-term by normal improvement techniques, assess the wetness limitation using the procedure described above and then downgrade by one grade or subgrade. This limitation may be ignored where the dominant texture is sand, loamy sand or sandy loam.

Table 6 Grade according to soil wetness - mineral soils

Wetness Class	Texture[1] of the top 25 cm	Field Capacity Days				
		<126	126-150	151-175	176-225	>225
	S[2] LS[3] SL SZL	1	1	1	1	2
	ZL MZCL MCL SCL	1	1	1	2	3a
I	HZCL HCL	2	2	2	3a	3b
	SC ZC C	3a(2)	3a(2)	3a	3b	3b
	S[2] LS[3] SL SZL	1	1	1	2	3a
	ZL MZCL MCL SCL	2	2	2	3a	3b
II	HZCL HCL	3a(2)	3a(2)	3a	3a	3b
	SC ZC C	3a(2)	3b(3a)	3b	3b	3b
	S[2] LS SL SZL	2	2	2	3a	3b
	ZL MZCL MCL SCL	3a(2)	3a(2)	3a	3a	3b
III	HZCL HCL	3b(3a)	3b(3a)	3b	3b	4
	SC ZC C	3b(3a)	3b(3a)	3b	4	4
	S[2] LS SL SZL	3a	3a	3a	3b	3b
	ZL MZCL MCL SCL	3b	3b	3b	3b	3b
IV	HZCL HCL	3b	3b	3b	4	4
	SC ZC C	3b	3b	3b	4	5
	S LS SL SZL	4	4	4	4	4
	ZL MZCL MCL SCL	4	4	4	4	4
V	HZCL HCL	4	4	4	4	4
	SC ZC C	4	4	4	5	5
Soils in Wetness Class VI - Grade 5						

[1]For naturally calcareous soils with more than 1% $CaCO_3$ and between 18% and 50% clay in the top 25 cm, the grade, where different from that of other soils, is shown *in brackets* (see page 16).

[2] Sand is not eligible for Grades 1, 2 or 3a (see page 16).

[3] Loamy sand is not eligible for Grade 1 (see page 16).

Table 7 Grade according to soil wetness - organic mineral and peaty[1] soils

Wetness Class	Texture of the top 25 cm	Field Capacity Days <126	126 -175	175 - 225	>225
	PTY	1	1	1	*
	S LS SL SZL	1	1	1	*
I	ZL MZCL MCL SCL	1	1	2	*
	HZCL HCL	1	2	3a	*
	SC ZC C	1	2	3b	*
	PTY	1	1	1	*
	S LS SL SZL	1	1	2	*
II	ZL MZCL MCL SCL	1	1	3a	*
	HZCL HCL	2	2	3a	*
	SC ZC C	2	3a	3b	*
	PTY	2	2	2	*
	S LS SL SZL	2	2	3a	*
III	ZL MZCL MCL SCL	2	2	3a	*
	HZCL HCL	3a	3a	3b	*
	SC ZC C	3a	3a	4	*
	PTY	3a	3a	3a	*
	S LS SL SZL	3a	3a	3b	*
IV	ZL MZCL MCL SCL	3b	3b	3b	*
	HZCL HCL	3b	3b	4	*
	SC ZC C	4	4	4	*
	PTY	4	4	4	5
	S LS SL SZL	4	4	4	4
V	ZL MZCL MCL SCL	4	4	4	4
	HZCL HCL	4	4	4	5
	SC ZC C	5	5	5	5
Soils in Wetness Class VI - Grade 5					

[1] For the definitions of 'organic mineral' and 'peaty' see Appendix 2.

* Combinations which do not occur or occur very rarely.

Droughtiness

To achieve full yield potential a crop requires an adequate supply of soil moisture throughout the growing season. Soil moisture requirements vary considerably between crops and according to growth stage. The potential demand for moisture generally rises as leaf cover, and hence transpiration, increases. In addition, deep rooting crops are able to exploit the moisture reserves of a larger volume of soil than shallow rooting crops. Thus the extent to which yield is depressed when moisture is in short supply is influenced by the crop type, amount and duration of the shortfall, and the growth stage at which it occurs.

Droughtiness is most likely to be a significant limitation to crop growth in areas with relatively low rainfall or high evapotranspiration, or where the soil holds only small reserves of moisture available to plant roots. The severity of the limitation in an area depends on the relationship between the soil properties and climatic factors and the moisture requirements of the crops grown. These relationships are complex and the degree of moisture stress varies from year to year according to the weather.

In the ALC system the method used to assess droughtiness is based on work by Thomasson (1979). It provides an indication of the average drought risk based on two reference crops, winter wheat and maincrop potatoes. These crops have been selected because they are widely grown and, in terms of their susceptibility to drought, are representative of a broad range of crops. The method used to assess droughtiness takes account of crop rooting and foliar characteristics to obtain an estimate of the average soil moisture balance (MB) for the reference crops at a given location. MB is calculated on the basis of two parameters namely:

i) crop-adjusted available water capacity of the soil profile (AP)
ii) moisture deficit (MD).

Crop-adjusted available water capacity (AP)

AP is a measure of the quantity of water held in the soil profile which can be taken up by a specified crop. The water storage capacity of soil is strongly influenced by texture, structure, organic matter content and stone content. The method used to calculate crop-adjusted AP values for wheat and potatoes is described in detail in Appendix 4. Table 14 gives available water values for different combinations of texture and structure. A distinction is made according to textures in the topsoil and subsoil, to take account of the higher organic matter content of topsoils. These values are used to calculate the amount of available water, adjusted for stone content, in each soil horizon within the rooting depth of the crop concerned. The horizon values are added together to give a total crop-adjusted AP (in mm). Typically, wheat will root to about 120 cm and horizon values are summed to this depth. However, allowance is made for the fact that the root system of winter wheat is less well developed, and therefore less efficient at water extraction, in the subsoil below 50 cm. Thus below that depth only easily available (as opposed to total available) water is taken into account. For potatoes the values for total available water are used for all horizons down to the full rooting depth of 70 cm.

Although crop-adjusted AP provides a measure of the amount of available water retained in a soil, it does not allow for the fact that the rate at which moisture is conducted to roots from the surrounding soil not occupied by roots varies between soil types, especially in relation to texture and structure. Hydraulic conductivity is generally adequate, in terms of moisture supply, in medium and fine textured soils over a wide range of soil moisture content. However, in the case of the coarser sands and loamy sands conductivity is adequate when the soil is at or near to field capacity but decreases very rapidly as the soil dries because there are few medium or fine pores through which moisture can be transmitted (Salter and Williams 1965; Craull 1985). This factor, in combination with low AP, makes such soils extremely susceptible to drought stress because wilting point is reached more rapidly and frequently in dry periods. Allowance is made for this limitation in the droughtiness assessment by reducing by 20% the AP of subsoil horizons with coarse sand, medium sand, loamy coarse sand or loamy medium sand textures.

Where significant subsoil compaction occurs, root penetration is generally restricted and moisture reserves in the soil below a severely compacted, very poorly structured horizon will make a negligible contribution to plant growth. In such cases the calculation of AP should be limited to the soil horizons above the compacted layer.

Moisture deficit (MD)

The moisture deficit term used in the ALC droughtiness assessment is a crop-related meteorological variable which represents the balance between rainfall and potential evapotranspiration calculated over a critical portion of the growing season. The concept of potential evapotranspiration (PE) was introduced by Penman (1948) who defined it as the water transpired by a short green crop, such as grass, which completely covers the ground surface and has an ample supply of water around its roots. PE is used in combination with rainfall (R) to calculate the potential soil moisture deficit, PSMD (Smith, 1967) as follows:

$$\text{PSMD} = \sum (\text{R-PE})$$

where (R-PE) is calculated daily and summed for a defined period.

In lowland situations a deficit will typically develop in April or May and will reach a maximum in July, August or September; thereafter it will decrease as temperatures, and hence evapotranspiration, decline in the autumn. PSMD can be calculated for daily or monthly periods and the maximum value in any year used to indicate the shortfall in moisture supply for that year. For land classification purposes the PSMD needs to be averaged over a period of years and selecting the median value of PSMD avoids the bias of extreme years. Potential deficits under grass are greater than for arable crops which do not attain full ground cover early in the growing season. For example, winter wheat does not usually develop full leaf cover until the end of April. Maincrop potatoes have negligible leaf cover until mid-May and full cover is not usually achieved until the end of June. Jones and Thomasson (1985) describe a method for deriving MD values (in mm) for wheat and potatoes from end-of-month and mid-month accumulated values of PSMD (under grass) as follows:

MD (Winter Wheat) = mid-July PSMD -1/3 April PSMD
MD (Potatoes) = August PSMD -1/3 June PSMD -1/3 mid-May PSMD

Crop-adjusted values of MD based on these formulae are used for droughtiness assessment in the ALC system and are obtained by means of regression techniques from accumulated summer temperature (ATS) and summer rainfall (ASR) data (Appendix 1).

Moisture balance (MB)

Droughtiness limits for grades and subgrades are defined in terms of moisture balances (MB, in mm) for wheat and potatoes which are calculated using the following formulae:

MB (Wheat) = **AP** (Wheat) **- MD** (Wheat)
MB (Potatoes) = **AP** (Potatoes) **- MD** (Potatoes)

The MB limits for each grade and sub grade are shown in Table 8. To be eligible for Grades 1 to 3b the MBs must be equal to, or exceed, the stated minimum values for *both* wheat and potatoes. If the MB for *either* crop is less (i.e. more negative) than that shown for Subgrade 3b, the soil is Grade 4 on droughtiness. It should be noted that, as explained on page 16, soils with sand topsoils are not eligible for Grades 1,2 or 3a and those with loamy sand topsoils are not eligible for Grade 1.

Table 8 Grade according to droughtiness

Grade/	Moisture Balance limits (mm)		
Subgrade	*wheat*		*potatoes*
1	+30	*and*	+10
2	+5	*and*	-10
3a	-20	*and*	-30
3b	-50	*and*	-55
4	<-50	*or*	<-55

Irrigation
Irrigation can significantly enhance the potential of agricultural land, especially in drier areas, and should therefore be taken into account in ALC grading where it is current or recent practice. In determining the effect of irrigation on ALC grade, the following factors should be taken into account:

i) adequacy of irrigation water supply
ii) the range of crops to which water is usually applied
iii) climate and soil factors.

When considering the effects of irrigation on ALC grading, it should normally be assumed that potatoes, responsive field vegetable and fruit crops and, in drier areas, sugarbeet would receive irrigation water but that cereals, oilseed rape and grass would not. Furthermore, irrigation will generally be of less benefit, and therefore have less influence on ALC grade in wetter areas and on heavier land which may not be well suited to growing irrigation-responsive crops. Even on more flexible land in drier areas, because irrigation is likely to benefit only part of the full range of crops which could be grown, it will usually upgrade land by no more than one grade or subgrade.

Soil erosion
Soil erosion is mainly caused by wind or water action, although the wastage of peat can also be regarded as a form of erosion. The incidence of erosion is determined by interactions between weather, soil type and condition, topography and the amount

and type of vegetative cover. It is also strongly influenced by land management practices. In agricultural terms, the problem is most significant in the arable lowlands.

Water-induced erosion is more widespread than wind erosion. It occurs most frequently on sloping land with bare soil or sparse crop cover where the soil is weakly structured and has a fine sandy or coarse silty texture. The risk is greatest during periods of heavy rainfall when the soil has become saturated and surface soil structure broken down by the impact of raindrops. The resulting run-off can quickly form rills and gullies which destroy crops in localised areas or bury them under deposited sediment downslope. The use of farm machinery may be hindered subsequently where gullies are wide and deep.

Significant wind erosion (or 'blowing') is restricted to a relatively narrow range of susceptible soil types. The risk is greatest in spring or early summer on flat or gently sloping land where light textured, bare or sparsely vegetated soil is exposed to strong wind and the surface is dry. The soils most at risk are sands and loamy sands with a high fine sand content, organic sand, sandy and loamy peats and peats. The presence of stones reduces erosion risk to some extent. Blowing can result in the loss of topsoil, seeds, seedlings and fertiliser and cause damage by abrasion to remaining plants. Yields of re-sown crops are often reduced through late establishment and development.

Soil wastage is a form of erosion confined to peaty soils and is the result of shrinkage and biochemical degradation. Loss of soil by this process can result in a gradual change in cropping potential as the depth of peat over the substratum is reduced.

The effects of soil erosion on land quality may be expressed in two ways. Firstly, erosion may have directly affected physical characteristics by, for example, reducing soil depth or creating steep sided gullies which inhibit the use of machinery. Such problems are taken into account by using the standard assessments of soil depth, droughtiness, gradient and microrelief. The second, rare circumstance is when soils especially prone to erosion may be downgraded because the risk of erosion constrains management to a degree which significantly reduces the range of crops which can be grown or markedly raises production costs. In nearly all cases where such a significant management problem occurs, erosion will tend to be a secondary factor accompanying other, more critical limitations such as slope or droughtiness.

APPENDIX 1

AGROCLIMATIC DATASETS

Introduction

Climatic data are used in the assessment of the climate, droughtiness and wetness limitations. To provide consistency in those assessments a standard data source is required for the calibration and operation of the system. Traditionally, maps or meteorological station data have been used to estimate climatic parameters at a site. However, the manual interpretation of maps or extrapolation of values from recording stations to sites under investigation involves subjective judgements, and even where data are available from a nearby meteorological station it cannot be assumed that the station value is representative of the surrounding area. A number of gridpoint datasets with a spacing of 5 km have therefore been developed covering the whole of England and Wales and standard methods have been devised for estimating the value of each parameter at any location. The grid is coincident with the 5 km intervals of the Ordnance Survey National Grid, having its origin south-west of the Scilly Isles.

The use of gridpoint data has significant advantages for computerised storage and manipulation of information. The datasets are held in LandIS, a computer-based land information system developed by the SSLRC and funded by MAFF. The system can be used to obtain both gridpoint and interpolated values for specified grid references. The complete dataset will also be published by the Meteorological Office (in press) and the procedure for obtaining interpolated values will be explained in that publication.

Climate Datasets

The five agroclimatic parameters used in the ALC system and the associated limitation factors are listed in Table 9. The FCD dataset was compiled by the SSLRC on the basis of Meteorological Office data. The other datasets were compiled by the Meteorological Office and processed by the SSLRC prior to their incorporation in LandIS. Datasets of altitude and of average annual rainfall change with altitude (ie lapse rate of AAR) are also held on LandIS for use in the interpolation from gridpoint values to site values.

Table 9 Limitation factors and associated agroclimatic parameters

Limitation Factor	Parameter	Observation period
Climate	Average Annual Rainfall (AAR)	1941 - 1970
	Median Accumulated Temperature above 0°C, January to June (AT0)	1961 - 1980
Soil Wetness	Median Duration of Field Capacity Days (FCD)	1941 - 1970
Soil Droughtiness	Average Summer Rainfall, April to September (ASR)	1941 - 1970
	Median Accumulated Temperature above 0°C, April to September (ATS)	1961 - 1980

The data sources were as follows:

Average annual rainfall (AAR)

Gridpoint AAR values (mm) were interpolated from unpublished rainfall maps at a scale of 1:250,000, on which the published 1:625,000 map for 1941-70 was originally based (Meteorological Office, 1977).

Average summer rainfall (ASR)

Gridpoint ASR values (mm) were manually interpolated from an unpublished 1:625,000 scale map of average summer rainfall for 1941-70.

Median accumulated temperature above 0°C, January to June (AT0)

The AT0 dataset is based on temperature data from the 94 stations in the Complete Agromet Database (Field, 1983), which have complete records over the period 1961-1980. Accumulated temperatures for the period January to June each year were computed for each station from daily measurements of maximum and minimum temperature and the median value of AT0 in the period 1961-80 was determined. The median values were then extrapolated to gridpoints by means of a regression equation which relates accumulated temperature, altitude, latitude (National Grid northing) and longitude (National Grid easting). The following equation was used:

AT0 (day degrees Celsius) = 1708 -1.14A -0.023E -0.044N
where
A is altitude above mean sea level (metres)
E is National Grid easting to 100 m (four significant figures)
N is National Grid northing to 100 m (four significant figures)

This equation explains approximately 90% of the variation in AT0 for the 94 agrometeorological recording stations.

Median accumulated temperature above 0°C, April to *September (ATS)*

The ATS dataset (1961-80) was created directly from the AT0 dataset using the following linear regression:
ATS (day degrees Celsius) = 611 + 1.11AT0 + 0.042E
where
AT0 is the grid point AT0 value
E is the National Grid easting to 100 m (four significant figures)

This regression explains more than 90% of the variation in ATS for the 94 stations.

Median duration of field capacity (FCD)

FCD is a meteorological parameter which estimates the duration of the period when the soil moisture deficit is zero. Soils usually return to field capacity (zero deficit) during the autumn or early winter and the field capacity period, measured in days, ends in the spring when evapotranspiration exceeds rainfall and a moisture deficit begins to accumulate. Smith and Trafford (1976) described a method for estimating the average period of meteorological field capacity from rainfall and evapotranspiration for the period 1941-70 and listed median dates for the return to and end of field capacity for 52 MAFF agroclimatological areas. These dates were regressed on AAR by the SSLRC to generate a 10 km grid dataset which has subsequently been resolved to 5 km using the gridpoint values of AAR described above (Jones and Thomasson, 1985; Ragg et al, 1988).

MOISTURE DEFICIT (MD) DATA

The gridpoint values (in mm) of crop-adjusted moisture deficit required for droughtiness assessments (Section 3.4, page 26) are obtained by regression from ATS and ASR using the following equations:

MD (Winter Wheat) = 325.4 -162.3 $\log_{10}$ ASR + 0.08022 ATS
MD (Potatoes) = 326.4 -196.5 $\log_{10}$ ASR + 0.1127 ATS

The above equations are based on an analysis of station data in the Complete Agromet Database and explain approximately 90% of the variation in crop-adjusted MD at those stations. When these equations result in negative values (ie a moisture surplus) they are assumed to be zero for the purpose of droughtiness calculations.

INTERPOLATION FROM GRIDPOINTS TO INTERMEDIATE SITES

For sites not located precisely at a 5 km gridpoint standard routines are available in LandIS to calculate the value of any climatic parameter by interpolation from adjacent gridpoint values. The routines make adjustments for height differences between the site and up to four adjacent gridpoints, using the appropriate lapse rate or altitude correction factor, and then interpolate by calculating a distance weighted mean. Where a site falls exactly on an easting or northing which passes through two gridpoints the interpolation uses only those two gridpoint values. Interpolated values do not take account of microclimatic factors.

APPENDIX 2

SOIL TEXTURE

TEXTURE CLASSIFICATION – MINERALS SOILS

The mineral texture classes used for ALC purposes are defined in Figure 2 according to the relative proportions of sand, silt and clay fractions.

Figure 2 Limiting percentages of sand, silt and clay fractions for mineral texture classes

The particle size fractions used are given in Table 10.

Table 10 Particle size fractions

		(mm)
Clay		<0.002
Silt		0.002 – 0.06
Sand	(fine	0.06 – 0.2
	(medium	0.2 – 0.6
	(coarse	0.6 – 2.0

For the ALC wetness assessment (Tables 6 and 7) the clay loam and silty clay loam texture classes are divided into 'medium' and 'heavy' subclasses, the 'medium' subclasses having less than 27% clay content.

TEXTURE CLASSIFICATION -ORGANIC MINERAL AND PEAT SOILS

Class limits for organic mineral and peaty textures are defined in Figure 3.

For references to peat soils and textures, the following terminology is used in this document:

Peat is a soil texture class (Figure 3);

Peaty refers to a soil texture group comprising peat, loamy peat, sandy peat, peaty loam and peaty sand textures;

Peat soil is a soil which meets both of the following criteria:

i) more than 40 cm of peaty textured material within the upper 80 cm of the soil profile, *and*

ii) organic mineral or peaty textures present within 30 cm depth.

Figure 3 Limiting percentages of organic matter, clay and sand for peaty and organic mineral texture classes

NOTATION

The texture classes are denoted by the following abbreviations:

Sand	S
Loamy sand	LS
Sandy loam	SL
Sandy silt loam	SZL
Silt loam	ZL
Sandy clay loam	SCL
Clay loam	CL
Silty clay loam	ZCL
Clay	C
Silty Clay	ZC
Sandy Clay	SC
Peat	P
Sandy peat	SP
Loamy peat	LP
Peaty loam	PL
Peaty sand	PS
Marine light silts	MZ

For the *sand, loamy sand, sandy loam and sandy silt loam* classes the predominant size of sand fraction (see Table 10) may be indicated by the use of prefixes, thus:

F	fine	(more than ⅔ of sand less than 0.2 mm)
C	coarse	(more than ⅓ of sand greater than 0.6 mm)
M	medium	(less than ⅔ fine sand and less than ⅓ coarse sand).

The subdivisions of *clay loam and silty clay loam* classes according to clay content are indicated as follows:

M	medium	(less than 27% clay)
H	heavy	(27 - 35% clay)

The prefix 'Calc' is used to identify naturally calcareous soils containing more than 1% calcium carbonate.

For organic mineral soils, the texture of the mineral fraction is prefixed by the term 'organic' or the abbreviation 'Org' e.g. organic (or org) clay loam.

Peaty textures, as a group, are denoted by the abbreviation 'PTY'.

APPENDIX 3

FIELD ASSESSMENT OF SOIL WETNESS CLASS

SOIL WETNESS CLASSIFICATION

Soil wetness is classified according to the depth and duration of waterlogging in the soil profile. Six revised soil wetness classes (Hodgson, in preparation) are identified and are defined in Table 11.

Table 11 Definition of Soil Wetness Classes

Wetness Class	Duration of Waterlogging[1]
I	The soil profile is not wet within 70 cm depth for more than 30 days in most years[2].
II	The soil profile is wet within 70 cm depth for 31-90 days in most years *or,* if there is no slowly permeable layer within 80 cm depth, it is wet within 70 cm for more than 90 days, but not wet within 40 cm depth for more than 30 days in most years.
III	The soil profile is wet within 70 cm depth for 91-180 days in most years *or,* if there is no slowly permeable layer within 80 cm depth, it is wet within 70 cm for more than 180 days, but only wet within 40 cm depth for between 31 and 90 days in most years.
IV	The soil profile is wet within 70 cm depth for more than 180 days but not within 40 cm depth for more than 210 days in most years *or,* if there is no slowly permeable layer within 80 cm depth, it is wet within 40 cm depth for 91-210 days in most years.
V	The soil profile is wet within 40 cm depth for 211- 335 days in most years.
VI	The soil profile is wet within 40 cm depth for more than 335 days in most years.

[1] The number of days specified is not necessarily a continuous period.
[2] 'In most years' is defined as more than 10 out of 20 years.

Soils can be allocated to a wetness class on the basis of quantitative data recorded over a period of many years or by the interpretation of soil profile characteristics, site and climatic factors. Adequate quantitative data will rarely be available for ALC surveys and therefore the interpretative method of field assessment is used to identify soil wetness class in the field. The method adopted here is common to ADAS and the SSLRC.

CLIMATE AND SOIL CHARACTERISTICS USED TO ASSESS SOIL WETNESS CLASS

Soil wetness class is normally assessed in the field by reference to:

i) the duration of field capacity

ii) the presence of a gleyed horizon

iii) the depth to a slowly permeable layer.

In disturbed soils, the assessment is made without reference to gley morphology because any gleying present may not be a true reflection of the prevailing soil water regime. The procedure also provides for situations where reddish soils with slowly permeable layers do not exhibit gleying.

Duration of field capacity

This provides a measure of the effect of climate on the soil water regime and is expressed in terms of field capacity days (FCD). Details of data sources for FCD are given in Appendix 1.

Identification of *a gleyed horizon*

A gleyed horizon has one of the following features:

either greyish or pale colours dominant in the matrix or on ped faces and at least 2% ochreous (rusty) mottles;

or if it underlies an organic mineral or peaty topsoil and there are less than 2% ochreous mottles, grey colours are dominant in the matrix;

or if reddish colours are dominant in the matrix, it has at least 2% greyish, brownish or ochreous mottles or ferri-manganiferous concentrations, and dominantly pale coloured ped faces;

the above colours being defined as follows:

greyish is a Munsell soil colour of any hue with chroma 2 or less and value more than 3;

pale is a Munsell soil colour of any hue with *either* chroma 3 and value more than 4 *or* chroma 4 and value more than 5;

brownish is Munsell soil colour of hues 7.5YR to 10YR with *either* chroma 3 and value 4 *or* chroma 4 and value 4 or 5;

ochreous is Munsell soil colour of hue 10YR or redder with chroma more than 4 and value less than 7;

reddish is Munsell soil colour of hue 5YR or redder.

The above gley colours (greyish, pale, brownish and ochreous) are shown diagrammatically in Munsell Soil Colour Chart notation in Figure 4.

Identification of *a slowly permeable layer*

This is defined as being a layer at least 15 cm in thickness with the upper boundary within 80 cm of the surface and having the following characteristics:

either C, SC, ZC, MCL, HCL, MZCL, HZCL or SCL texture *and* massive, platy, medium or coarse or very coarse prismatic, weakly developed fine prismatic, coarse or very coarse angular blocky, weakly developed fine or medium angular blocky, or weakly developed coarse or very coarse subangular blocky structure[1];

or ZL, SZL, or any type of SL with massive structure[1] *and* at least firm consistence[1];

and less than 0.5% biopores greater then 0.5 mm diameter;

and evidence of wetness in, or immediately above the layer, such as ochreous mottles, ferri-manganiferous concentrations or gleying.

The combinations of texture, structure and consistence[1] defined in the 'either' and 'or' options above are shown diagrammatically in Figure 5.

[1]See Hodgson, 1976, pages 30 to 50, for detailed descriptions and definitions related to soil structure and consistence.

Figure 4 **Diagrammatic representation of gley colours defined according to the Munsell soil colour system**

Figure 5 **Diagrammatic representation of the combinations of structure, texture and consistence which are characteristic of slowly permeable layers**

It should be noted that:

- i) soils developed in marine alluvium can have very porous subsoils due to the presence of vertical channels and such soils often do not have slowly permeable horizons
- ii) if the soil comprises artificially replaced or disturbed material or has a Munsell hue of 5YR or redder, only the textural, structural and porosity characteristics given above need be present (see (v) and (vi), page 37)
- iii) severely compacted horizons, as sometimes found in restored soils, may be virtually impermeable (see (v), page 37).

PROCEDURE FOR ASSESSING WETNESS CLASS

Introduction

This method assumes that soils have an appropriate underdrainage system and that there are satisfactory outfalls (see assumption (2), page 8). It is not suitable for soils which are affected by high groundwater tables which cannot be drained effectively. Such soils can only be assigned objectively to a wetness class on the basis of long-term dipwell measurements. In the absence of such data the assessment of wetness class requires specialist knowledge and needs to take account of profile morphology, climate, site characteristics, prevailing water levels and time of year.

On sites with less than 225 FCD it is assumed that, with the exception of certain soils with very unstable structure (see pages 17 and 22), any slowly permeable layer near the surface can be removed by cultivation. The assumed potential depth of loosening decreases from 35 cm, for sites with not more than 150 FCD, to 0 cm at 225 FCD (see Figures 7 and 8).

Method

The method and sequence for assessing the wetness class of soils which can be drained is described below and shown diagrammatically in Figure 6.

i) Examine the soil profile to a depth of 1 metre to identify the presence of any peaty or organic mineral topsoil, the depth to gleying and depth to a slowly permeable layer. Establish whether or not the soil has been significantly disturbed or restored. Note whether the soil is reddish and has a slowly permeable layer starting within 80 cm but is not gleyed within 70 cm depth.

ii) If the soil is undisturbed, has no slowly permeable layer starting within 80 cm depth and no gleyed subsoil is present within 70 cm depth, the soil is **Wetness Class I.**

iii) If the site has at least 225 FCD *and* there is a peat soil, or the topsoil is peaty or organic mineral texture with a gleyed subsoil or rock immediately below, the soil is **Wetness Class V or VI**. Soils in Wetness Class VI are more or less perpetually waterlogged and will have standing surface water for long periods. Such soils are most likely to occur in areas with more than 300 FCD or in basin sites.

iv) If the site has less than 225 FCD and there is an undisturbed peat soil, the assessment is made as follows:
-if there is a slowly permeable layer which starts within 80 cm depth, refer to Figure 7;
-if there is no slowly permeable layer starting within 80 cm depth, refer to Table 12.

v) If the soil has been significantly disturbed or restored, the assessment of wetness class is made without reference to gleying as follows:
-if there is a slowly permeable layer starting within 60 cm depth, refer to Figure 7;
-if there is a slowly permeable layer starting between 60 and 80 cm depth, refer to Figure 8;

-if there is no slowly permeable layer starting within 80 cm depth, assess the likelihood and degree of waterlogging from any available evidence and, if there is uncertainty make clear the tentative nature of the assessment when assigning a grade.

It should be noted that severely compacted layers may be virtually impermeable (rather than slowly permeable) and that consequently, in such cases, Figures 7 and 8 may give an underestimate of the duration of waterlogging.

vi) If the soil is reddish (5YR or redder) and not gleyed within 70 cm depth, the assessment is made as follows:
-if there is no slowly permeable layer within 80 cm depth, the soil is **Wetness Class I**;
-if there is a slowly permeable layer that starts within 60 cm depth and extends to at least 100 cm, refer to Figure 7;
-in all other cases, refer to Figure 8.

vii) If there is a mineral or organic mineral soil which has no slowly permeable layer starting within 80 cm and has a subsoil which is gleyed within 70 cm depth, refer to Table 13.

viii) If there is a mineral or organic mineral soil which has a slowly permeable layer starting within 80 cm, the assessment is made as follows:
-if gleying is present within 40 cm depth, refer to Figure 7;
-if gleying is present within 70 cm depth but not within 40 cm, refer to Figure 8.

Table 12 Estimation of Wetness Class of peat soils with no slowly permeable layer starting within 80 cm depth

FCD range	Peat soils with coarse textured subsoil[1]	Other peat soils
≤ 100	I	I
101 - 150	I	II
151 - 200	I	II - IV
201 - 225	II	II - IV

[1]Peat soils in which the mineral subsoil horizons are predominantly coarse textured (ie contain less than 18% clay) within, and are coarse textured at and immediately below, 80 cm.

Table 13 Estimation of Wetness Class of mineral or organic mineral soils with no slowly permeable layer starting within 80 cm depth but with gleying present within 70 cm

FCD range	Gleyed within 70 cm but not within 40 cm		Gleyed within 40 cm	
	Coarse textured subsoil[1]	*Other soils*	*Coarse textured subsoil*[1] *or in marine alluvium with a peaty or organic mineral topsoil*	*Other soils*
≤ 100	I	I	I	I
101 - 200	I	I	I	II
201 - 250	I	II	II	III
> 250	II	II	III	III

[1] Mineral soils in which the subsoil is predominantly coarse textured (i.e. contains less than 18% clay) within 80 cm depth and is coarse textured at and immediately below 80 cm depth.

APPENDIX 4

THE CALCULATION OF CROP-ADJUSTED SOIL AVAILABLE WATER CAPACITY (AP) FOR WHEAT AND POTATOES

THE CONCEPT AND ESTIMATION OF 'AVAILABLE WATER'

The total amount of soil water available to plants (TA_v) is considered to be the volumetric soil water content between 0.05 and 15 bar suction or, in the case of sands and loamy sands, 0.10 and 15 bar suction. These suctions approximate to the conditions of *field capacity,* when all excess water has drained away under the influence of gravity, and *wilting point,* when the plants can extract no more moisture from the soil. The TA_v of any soil layer can be measured in the laboratory from representative undisturbed cores (Avery and Bascomb, 1982), but as this method is both expensive and time-consuming, values of TA_v for combinations of texture and structure, which can be assessed in the field, are given in Table 14. The values are based on a dataset[1] of about 3,600 TA_v measurements from different layers in over 1,000 soil profiles throughout England and Wales.

A previous analysis of these data (Hall et al, 1977) showed that the main factors affecting TA_v are texture, structure and organic matter content and the TA_v values for each texture are therefore stratified according to whether they are for topsoils or subsoils and according to whether the subsoil layers have good, moderate or poor structural development. To help in this assessment definitions of good, moderate and poor subsoil structural conditions are given in Figures 9, 10 & 11. In topsoils, structural conditions depend very much on previous management and, under arable cultivation, can have an annual cycle encompassing all three states. Because of this, and bearing in mind that ALC assessments assume a good management standard only one TA_v value, that for moderate structural conditions, is given for topsoils. The values for poor structural conditions in Table 14 are based on measurements from undisturbed soils. These values may overestimate the available water in artificially compacted horizons which occur in some restored soils.

THE CALCULATION OF CROP-ADJUSTED AVAILABLE WATER CAPACITY (AP)

The amount of soil water that is available to a growing crop depends on both soil properties and crop rooting patterns. The rooting models used to assess AP for ALC purposes are based on those of Thomasson (1979). These suggest that, under favourable conditions, cereals will root to about 120 cm, whereas potato roots rarely extend below 70 cm. However, the root systems of cereals are less well developed below 50 cm and their ability to extract water below this depth is thus diminished. Below 50 cm therefore, the model for calculating cereal available water capacity uses only the volume of 'easily available water' (EA_v) held in the soil between 0.05 and 2.0 bar suction. EA_v values for texture and structure combinations are given in brackets in Table 14.

[1]This dataset was collected by staff of the Soil Survey and Land Research Centre and is stored in LandIS, a computerised Land Information System based at their Headquarters at Silsoe Campus, Silsoe, Beds MK45 4DT.

For wheat, the soil available water capacity in millimetres is calculated by multiplying either the TA_v or the EA_v (whichever is applicable) of each soil layer by its thickness, adding the products for all layers to a depth of 120 cm and dividing the result by 10. This can be expressed as follows:

$$\text{AP wheat (mm)} = \frac{TA_{vt} \times LT_t + \Sigma (TA_{vs} \times LT_{50}) + \Sigma (EA_{vs} \times LT_{50\text{-}120})}{10}$$

where

TA_{vt} is Total available water (TA_v) for the topsoil texture

TA_{vs} is Total available water (TA_v) for each subsoil layer

EA_{vs} is Easily available water (EA_v) for each subsoil layer

LT_t is thickness (cm) of topsoil layer

LT_{50} is thickness (cm) of each subsoil layer to 50 cm depth

$LT_{50\text{-}120}$ is thickness (cm) of each subsoil layer between 50 and 120 cm depth

Σ means 'sum of'.

For potatoes no adjustments using EA_v are necessary. The soil available water capacity is calculated simply by multiplying the TA_v of each layer by its thickness, adding the products to a depth of 70 cm and dividing by 10. Thus:

$$\text{AP potatoes (mm)} = \frac{TA_{vt} \times LT_t + \Sigma (TA_{vs} \times LT_{70})}{10}$$

where

LT_{70} is thickness (cm) of each subsoil layer to 70 cm depth

ADJUSTMENTS TO SOIL AVAILABLE WATER CAPACITY TO TAKE INTO ACCOUNT THE PRESENCE OF STONES, ROCK OR A VERY POORLY STRUCTURED HORIZON

The values for TA_v and EA_v given in Table 14 are for the fine earth fraction of soils (material less than 2 mm in diameter) and adjustments are therefore necessary to take into account the presence of stones in soil layers. Such adjustments are only made for layers with less than 70% stones by volume and further modification of AP is necessary where gravelly layers (defined as containing at least 70% rounded stones by volume) or massive, fissured or shattered rock material (defined as having at least 70% angular stones by volume) occur within the model rooting depths.

Where massive, non-rootable rock of any kind restricts rooting, then soil available water is calculated only for those layers above the rock. Usually, however, massive rock is overlain by a transitional layer of fissured or shattered rock material that can be exploited by roots to a limited extent. The amount of available water in such layers depends on their lithology and values for different types are given in Table 15[1]. Where layers of gravel, fissured or shattered rock occur within 120 cm depth, the appropriate TA_v or EA_v values from Table 15 are used in the calculation of soil available water capacity.

The values for rocks given in Table 15 are also used when adjusting TA_v or EA_v values for stony soil layers with less than 70% stones by volume. Adjustments are made as follows:

$$\text{Stone-adjusted } TA_v \text{ or } EA_v = \frac{A_{vf} \times \%f + (A_{vr} \times \% \text{ Stones})}{100}$$

where

f is fine earth component, i.e. (100-% volume of stone)

A_{vf} is TA_v or EA_v (as appropriate) of fine earth component

A_{vr} is TA_v or EA_v (as appropriate) of stone component

Where the soil has a severely compacted layer with very poor structure which generally restricts root penetration, soil available water is calculated only for layers above the compacted layer.

[1] There is little information on the amount of available water in different rocks and the values used in Table 15 are mostly estimates based on a few, as yet unpublished measurements. They should be regarded as tentative values and should only be used where actual site measurements are unavailable.

EXAMPLES

The following examples illustrate how crop-adjusted APs are calculated.

Example 1. A stoneless clayey soil with slowly permeable subsoil

Soil data

Layer	Depth (cm)	Texture	Structural Condition	Stones
Topsoil	30	clay loam	-	0
Subsoil 1	30 - 60	clay	moderate	0
Subsoil 2	60 - 120	clay	poor	0

Variables

		%
From Table 14	Topsoil TA_v	18
	Subsoil 1 TA_v	16
	Subsoil 1 EA_v	8
	Subsoil 2 TA_v	13
	Subsoil 2 EA_v	7

Calculation: AP Wheat

	cm	
Topsoil	0 - 30	30 x 18 = 540
Subsoil 1	30 - 50	20 x 16 = 320
Subsoil 1	50 - 60	10 x 8 = 80
Subsoil 2	60 - 120	60 x 7 = 420

$$\textbf{AP wheat} = \frac{540 + 320 + 80 + 420}{10} = \textbf{136 mm}$$

Calculation: AP potatoes

	cm	
Topsoil	0 - 30	30 x 18 = 540
Subsoil 1	30 - 60	30 x 16 = 480
Subsoil 2	60 - 70	10 x 13 = 130

$$\textbf{AP potatoes} = \frac{540 + 480 + 130}{10} = \textbf{115 mm}$$

Example 2. A deep loamy soil in till with few to common hard quartzite stones (Bunter pebbles) and a slowly permeable subsoil at depth

Soil data

Layer	Depth (cm)	Texture	Structural Condition	Stones
Topsoil	0 - 35	medium sandy loam	-	6%
Subsoil 1	35 - 60	medium sandy loam	moderate	8%
Subsoil 2	60 - 120	clay loam	poor	3%

Variables

		%
From Table 14	Topsoil TA_v	17
	Subsoil 1 TA_v	15
	Subsoil 1 EA_v	11
	Subsoil 2 TA_v	12
	Subsoil 2 EA_v	7
From Table 15	TA_v stones	1
	EA_v stones	0.5

Calculation: AP Wheat

	cm	
Topsoil	0 - 35	$\frac{(17 \times 94) + (1 \times 6)}{100} \times 35 = 561.4$
Subsoil 1	30 - 50	$\frac{(15 \times 92) + (1 \times 8)}{100} \times 15 = 208.2$
Subsoil 1	50 - 60	$\frac{(11 \times 92) + (0.5 \times 8)}{100} \times 10 = 101.6$
Subsoil 2	60 - 120	$\frac{(7 \times 97) + (0.5 \times 3)}{100} \times 60 = 408.3$

AP wheat = $\frac{561.4 + 208.2 + 101.6 + 408.3}{10}$ **= 128 mm**

Calculation: AP potatoes

	cm		
Topsoil	0 - 35	$\frac{(17 \times 94) + (1 \times 6)}{100}$	x 35 = 561.4
Subsoil 1	35 - 60	$\frac{(15 \times 92) + (1 \times 8)}{100}$	x 25 = 347
Subsoil 2	60 - 70	$\frac{(12 \times 97) + (1 \times 3)}{100}$	x 10 = 116.7

AP potatoes = $\frac{561.4 + 347 + 116.7}{10}$ **= 102 mm**

Table 14 Estimation of available water (%) from texture class, horizon and structural conditions

Texture Class	Topsoil TA_v	Subsoil TA_v (EA_v in brackets)		
		good[1]	*moderate*[1]	*poor*[1]
Clay	17	21 (15)	16 (8)	13 (7)
Silty clay	17	21 (15)	15 (8)	12 (7)
Sandy clay	17	19 (14)	15 (10)	13 (8)
Sandy clay loam	17	19 (14)	15 (10)	13 (8)
Clay loam	18	21 (14)	16 (10)	12 (7)
Silty clay loam	19	21 (12)	17 (10)	12 (6)
Silt loam	23	23 (17)	22 (14)	15 (9)
Fine sandy silt loam	22	22 (16)	21 (15)	15 (9)
Medium sandy silt loam	19	19 (13)	17 (11)	15 (9)
Coarse sandy silt loam	19	23 (17)	19 (11)	15 (7)
Fine sandy loam	18	22 (17)	18 (13)	17 (11)
Medium sandy loam	17	17 (13)	15 (11)	11 (8)
Coarse sandy loam	17	22 (15)	16 (11)	11 (8)
Loamy fine sand	18	15 (13)	15 (13)	*
Loamy medium sand	13	12 (9)	9 (6)	*
Loamy coarse sand	11	11 (7)	8 (6)	*
Fine sand	*	14 (12)	14 (12)	*
Medium sand	12	7 (5)	7 (5)	*
Coarse sand	*	5 (4)	5 (4)	*
Marine light silts[2]		33 (30)	28 (22)	*
	All Horizons			
Organic sands	23 (16)			
Organic loams	28 (20)			
Organic clays	23 (16)			
Peaty sands	39 (36)			
Peaty loams	27 (18)			
Sandy peats	45 (30)			
Loamy peats	35 (26)			
Humified peats	33 (24)			
Fibrous and semi-fibrous peats	44 (35)			

[1] Criteria for good, moderate and poor structural conditions are given in Figures 9, 10 & 11.

[2] Use these figures only for subsoils in marine alluvium where textures are fine sandy silt loam, fine sandy loam or loamy fine sand *and* most of the sand is finer than 0.1 mm.

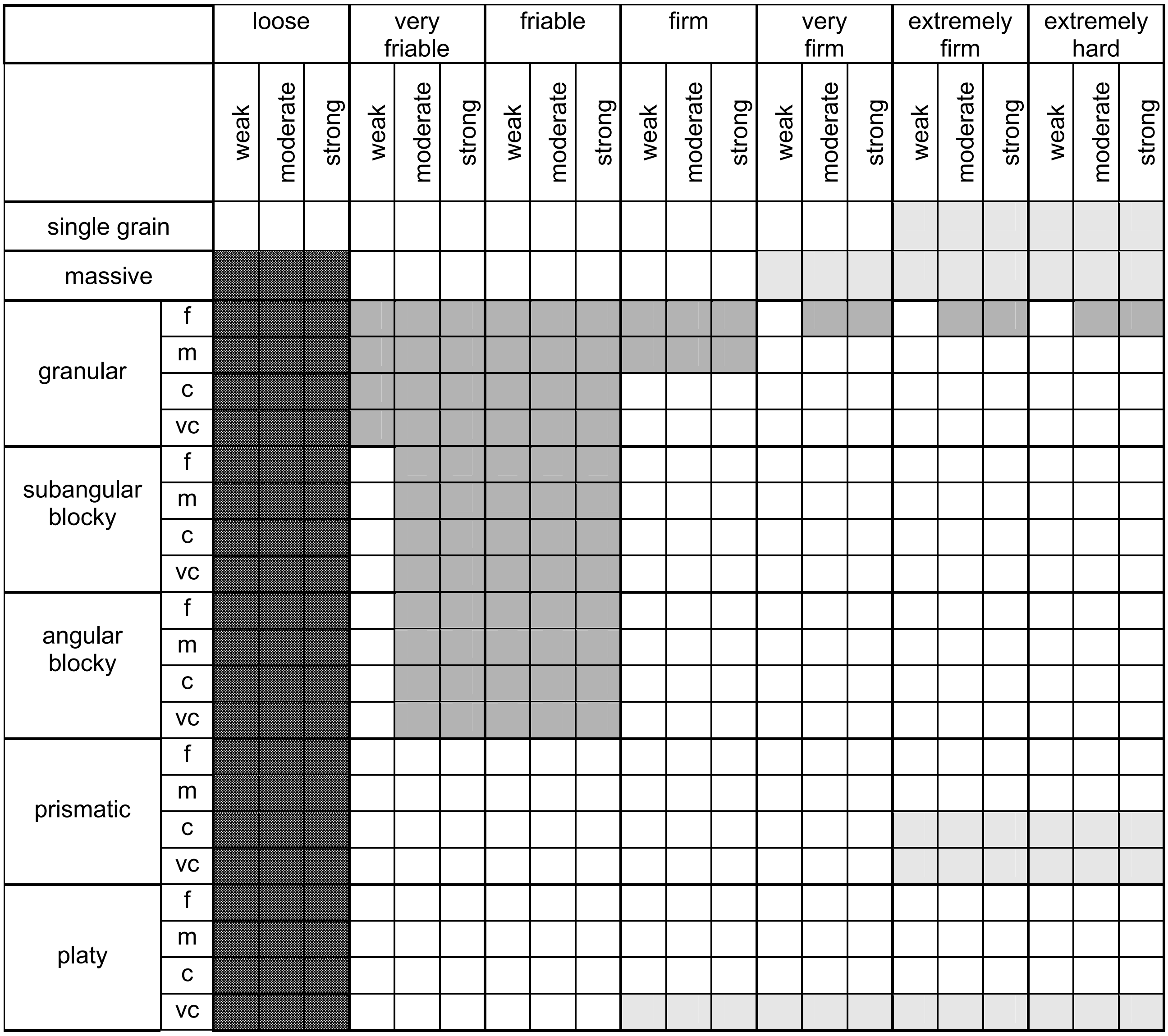
* Rare occurrences for which there are no data.

Table 15 Available water in stones and rocks (%)

Rock, gravel or stone type	TA_v	EA_v
All hard rocks or stones (i.e. those which cannot be scratched with a finger nail)	1	0.5
Soft, medium or coarse grained sandstones	3	2
Soft 'weathered' igneous or metamorphic rocks or stones	4	2
Soft oolitic or dolomitic limestones	4	3
Soft fine grained sandstones	5	3
Soft, argillaceous or silty rocks or stones	8	5
Chalk or chalk stones	10	7
Gravel[1] with non-porous (hard) stones	2	1
Gravel[1] with porous stones (mainly soft stone types listed above)	5	3

[1]Gravel with at least 70% rounded stones by volume

Figure 9. Assessment of structural conditions[1] in subsoil horizons with S or LS texture

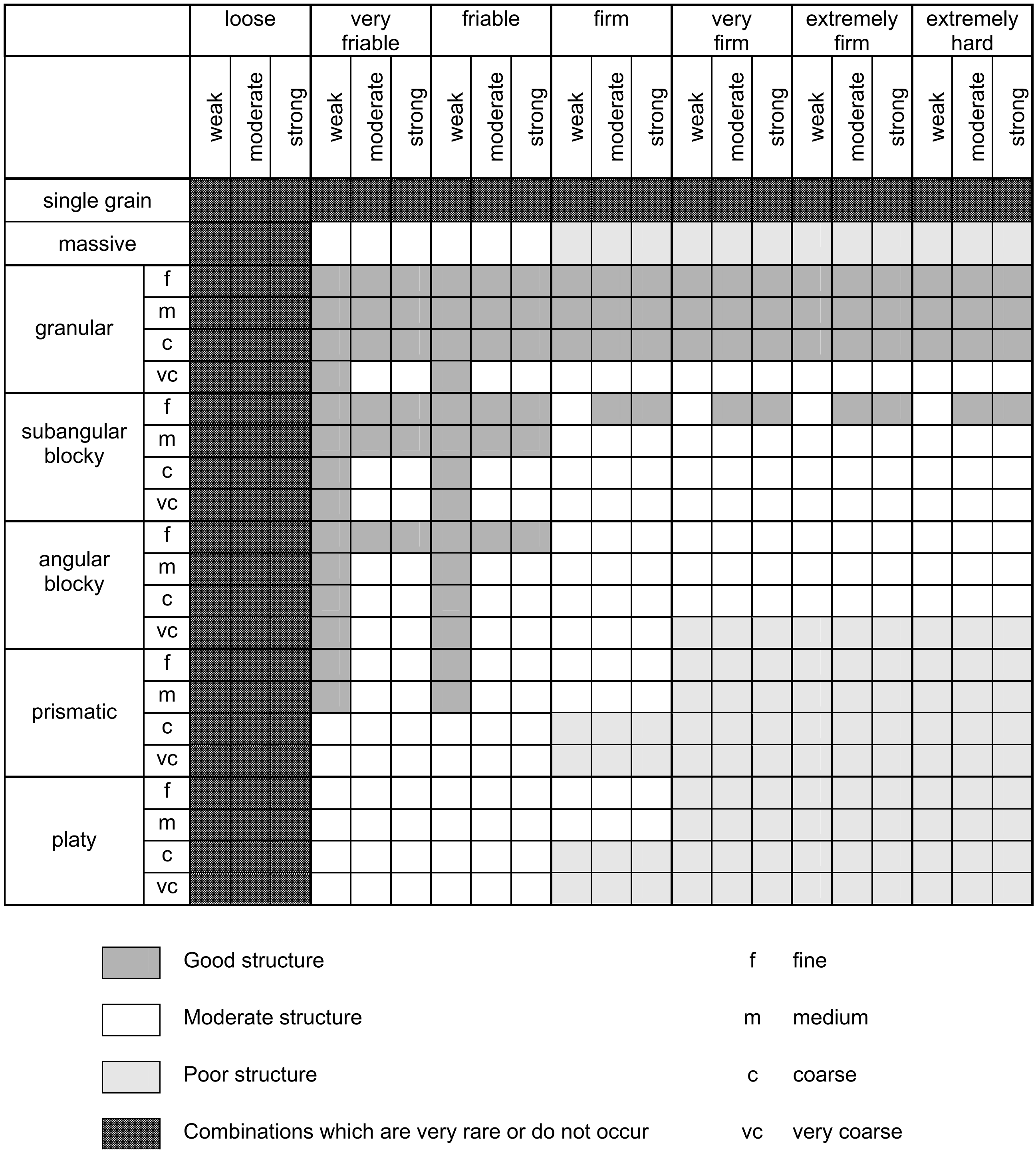


- Good structure
- Moderate structure
- Poor structure
- Combinations which are very rare or do not occur

f fine
m medium
c coarse
vc very coarse

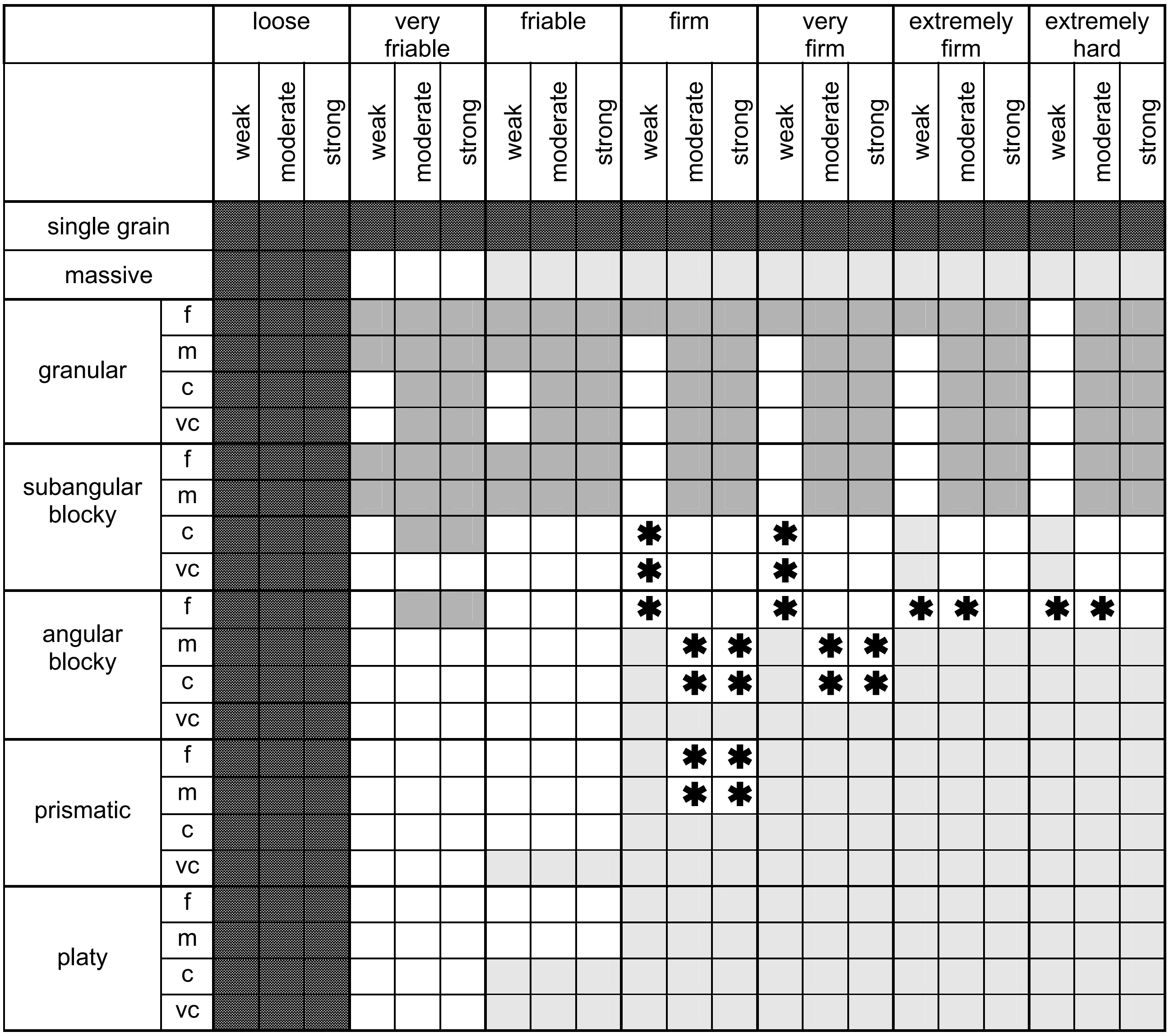
[1]See Hodgson, 1976, pages 30 to 50, and Hodgson (in preparation) for detailed descriptions and definitions related to soil structure and consistence.

Figure 10. Assessment of structural conditions[1] in subsoil horizons with SL, SZL or ZL texture



[1]See Hodgson, 1976, pages 30 to 50, and Hodgson (in preparation) for detailed descriptions and definitions related to soil structure and consistence.

Figure 11. Assessment of structural conditions[1] in subsoil horizons with SCL, CL, ZCL, SC, C or ZC texture



Good structure

Moderate structure

Poor structure

Combinations which are very rare or do not occur

✱ Poor structure if ped faces are gleyed

f fine

m medium

c coarse

vc very coarse

[1]See Hodgson, 1976, pages 30 to 50, and Hodgson (in preparation) for detailed descriptions and definitions related to soil structure and consistence.

REFERENCES

- Avery, B W and Bascomb, C L (Ed) (1982) *Soil Survey Laboratory Methods.* Soil Survey Technical Monograph No.6.
- Bibby, J S, Douglas, H A, Thomasson, A J and Robertson, J S(1982) *Land Capability Classification for Agriculture.* Macaulay Institute for Soil Research, Aberdeen.
- Bibby, J S and Mackney, D (1969) *Land Use Capability Classification.* Soil Survey Technical Monograph No.1.
- Biscoe, P V and Gallagher, J N (1978) A physiological analysis of cereal yield. I. Production of dry matter. *Agric. Prog.* 53, 34-50.
- Craull, P J (1985) A description of urban soils and their desired characteristics. *J Aboriculture 11(11)*, 330-39.
- Field, M (1983) Creating the Complete Agromet Database. Agricultural Memorandum 983 (unpublished paper), Meteorological Office.
- Hall, D G M, Reeve, M J, Thomasson, A J and Wright, V F (1977) *Water retention, porosity and density of field soils.* Soil Survey Technical Monograph No.9.
- Hodgson, J M (Ed) (1976) *Soil Survey Field Handbook.* Soil Survey Technical Monograph No.5.
- Hodgson, J M (in preparation) *Soil Survey Field Handbook* (revised edition).
- Jones, R J A and Thomasson, A J (1985) *An Agroclimatic Databank for England and Wales.* Soil Survey Technical Monograph No. 16.
- Meteorological Office (1969) Tables of the evaluation of daily values of accumulated temperature above and below 42°F from daily values of maximum and minimum temperature. *Leaflet 10* (formerly 3300) Meteorological Office Library.
- Meteorological Office (1977) Map of Average Annual Rainfall 1941-70.
- * Meteorological Office (in press) C*limatological datastes for Agricultural Land Classification.* Meteorological Office, Bracknell.
- Ministry of Agriculture, Fisheries and Food (1966) *Agricultural Land Classification,* Technical Report No. 11. Agricultural Land Service.
- Ministry of Agriculture, Fisheries and Food (1976) *Agricultural Land Classification* of *England and Wales: the Definition and Identification* of *Sub-grades within Grade* 3, Technical Report No. 11/1.
- Peacock, J M (1975) Temperature and leaf growth in *Lolium perenne.* I. The thermal microclimate: its measurement and relation to crop growth. *J. appl. Ecol.* 12,99-114.
- Penman, H L (1948) Natural evaporation from open water, bare soil and grass. *Proc. Roy. Soc. Series A* 193, 120-45.
- Ragg, J M, Jones, R J A and Proctor ME (1988) The refinement and representation of spatial data in an information system using statistical and DBMS procedures, and trend surface analysis. In: *Proc. IUGS Colloquium on the Construction and Display of Geoscientific Maps derived from Databases* (ed. R Vinken).
- Salter, P J and Williams, J B (1965) The influence of texture on the moisture characteristics of soils. II. Available-water capacity and moisture release characteristics. *J. Soil Science* 16 (2), 310-17.

- Smith, L P (1967) *Potential transpiration.* Technical Bulletin No. 16, Ministry of Agriculture, Fisheries and Food.
- Smith, L P and Trafford, B D (1976) *Climate and Drainage.* Ministry of Agriculture, Fisheries and Food, Reference Book 434 (formerly Technical Bulletin No. 34), HMSO.
- Thomasson, A J (1979) Assessment of soil droughtiness. In : *Soil Survey Applications* (ed. M G Jarvis and D Mackney). Soil Survey Technical Monograph No. 13, 43-50.

* Expected publication date, January 1989.
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Figure 1

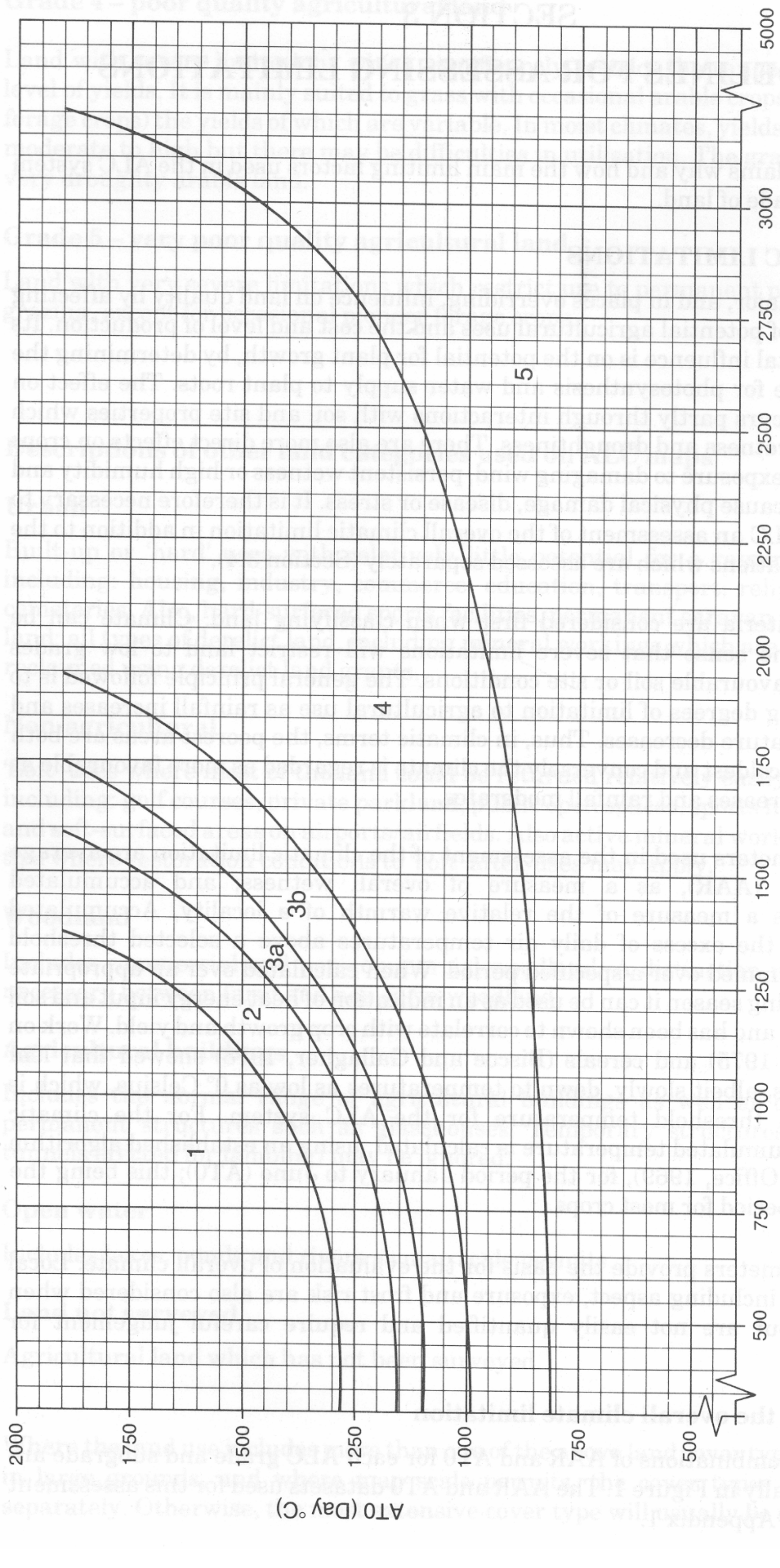

Figure 1. Grade according to climate

Figure 2

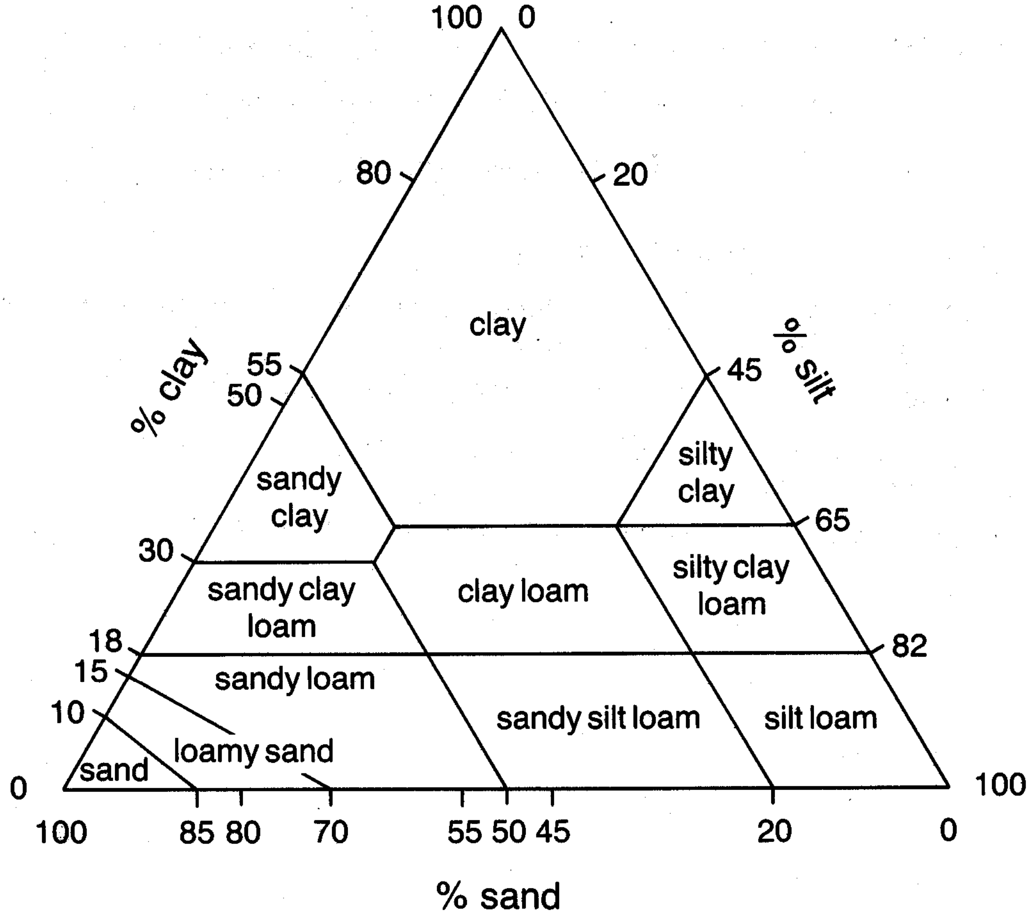

Figure 2. Limiting percentages of sand, silt and clay fractions for mineral texture classes

The particle size fractions used are given in Table 10.

Figure 3

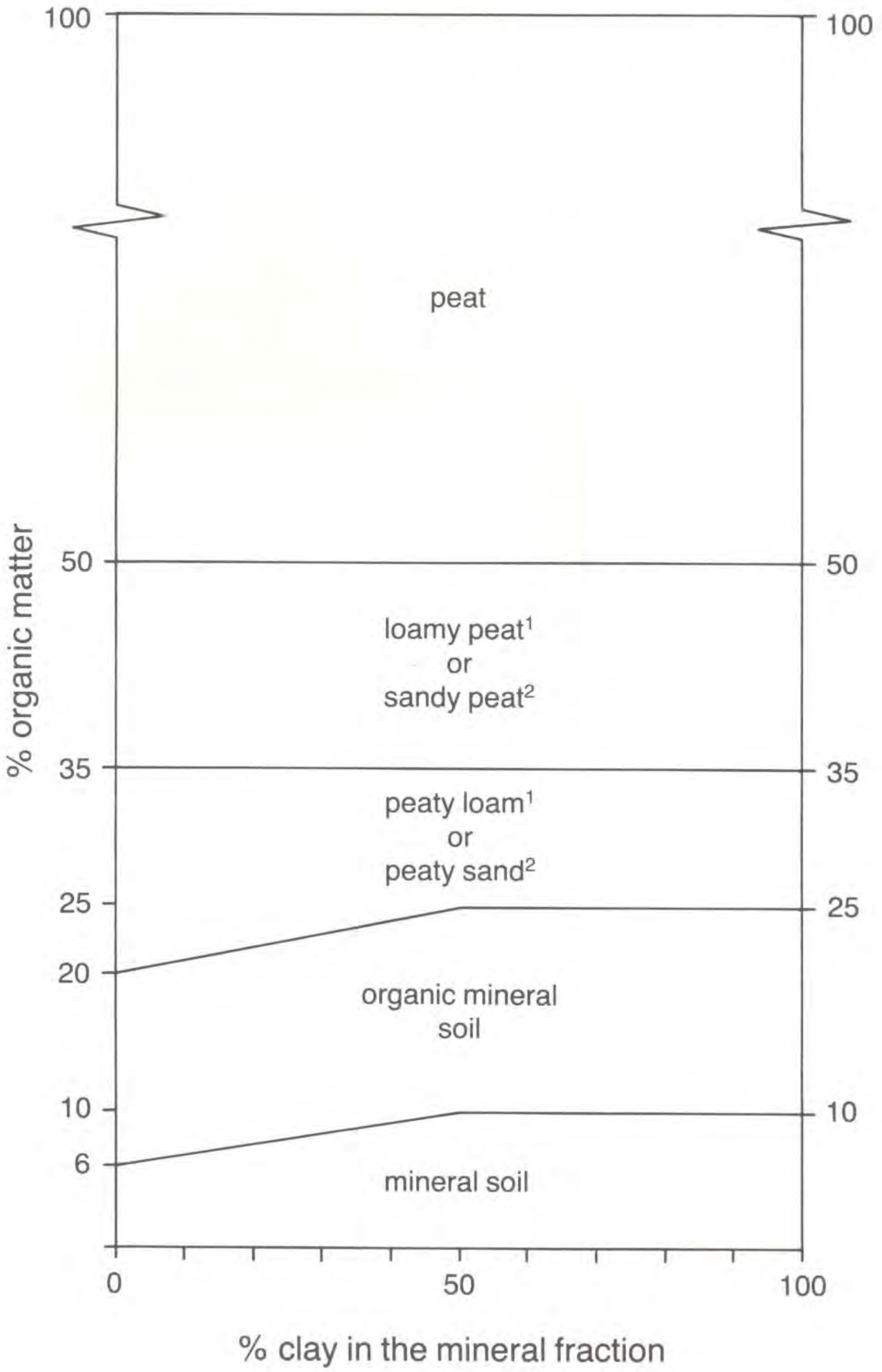

Figure 3. Limiting percentages of organic matter, clay and sand for peaty and organic mineral texture classes

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[1] Less than 50% sand in the mineral fraction
[2] 50% sand or more in the mineral fraction

Figure 4

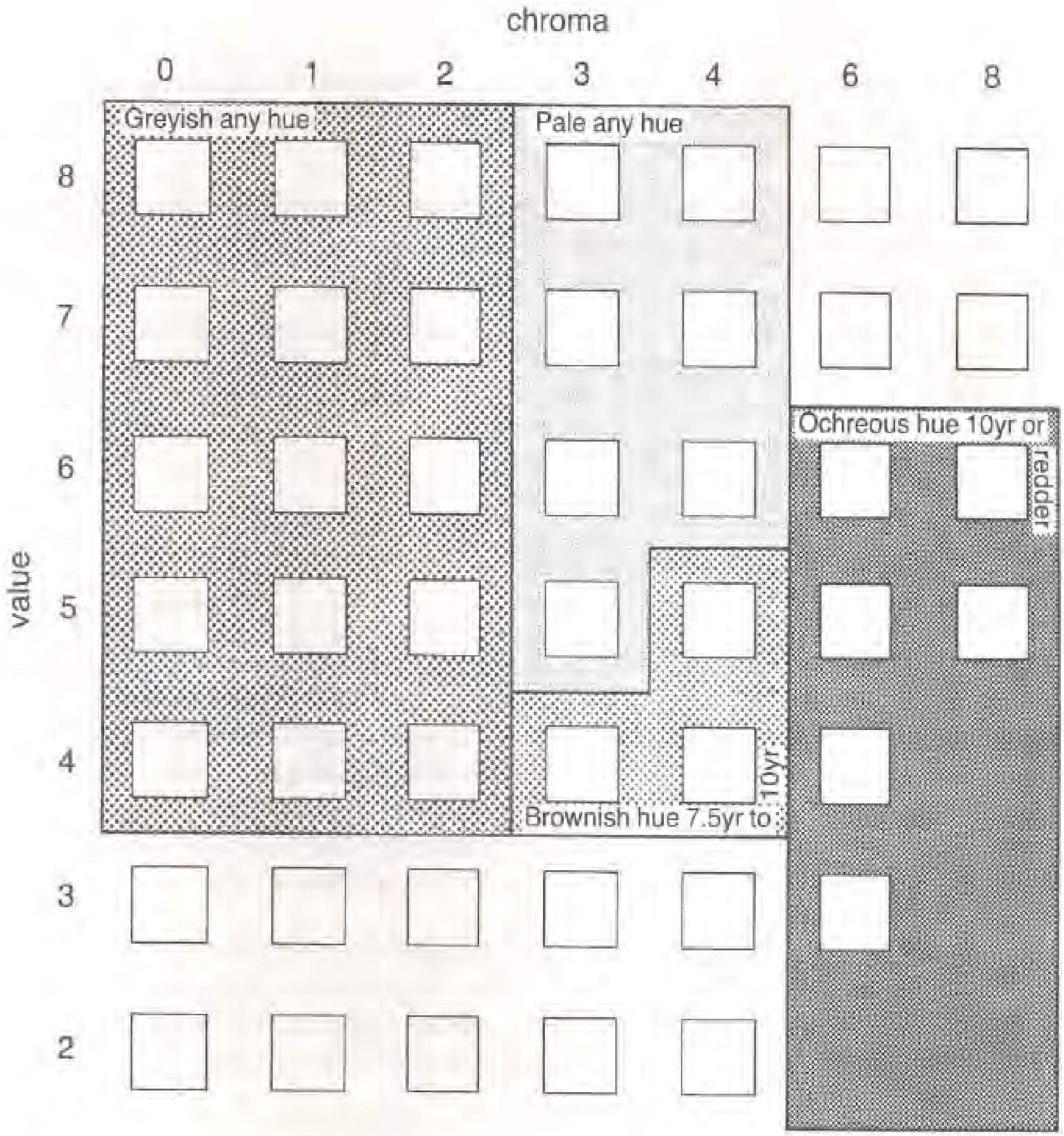


Figure 4. Diagrammatic representation of gley colours defined according to the Munsell[1] soil colour system

Figure 5

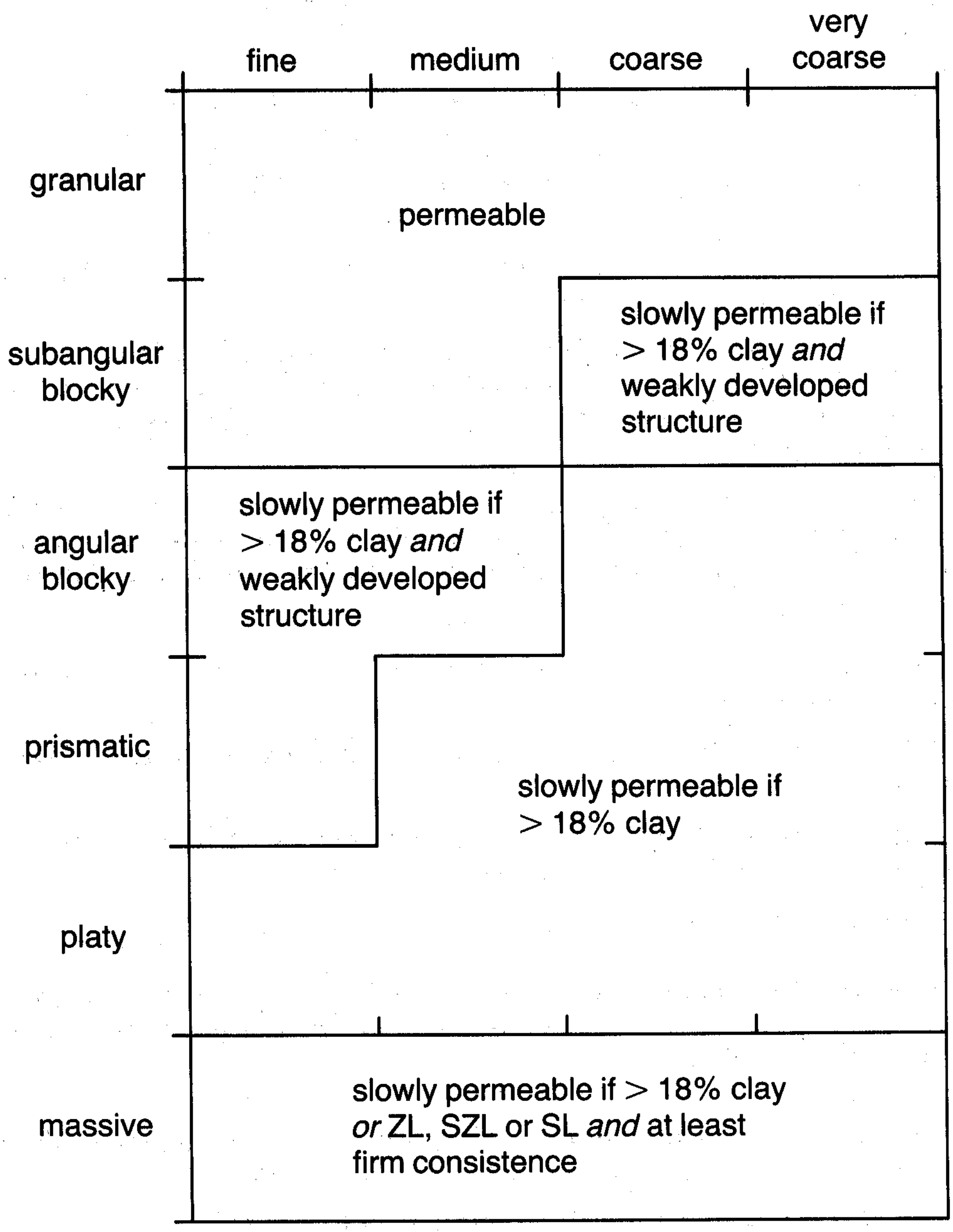


Figure 5. Diagrammatic representation of the combinations of structure, texture and consistence which are characteristic of slowly permeable layers

Figure 6

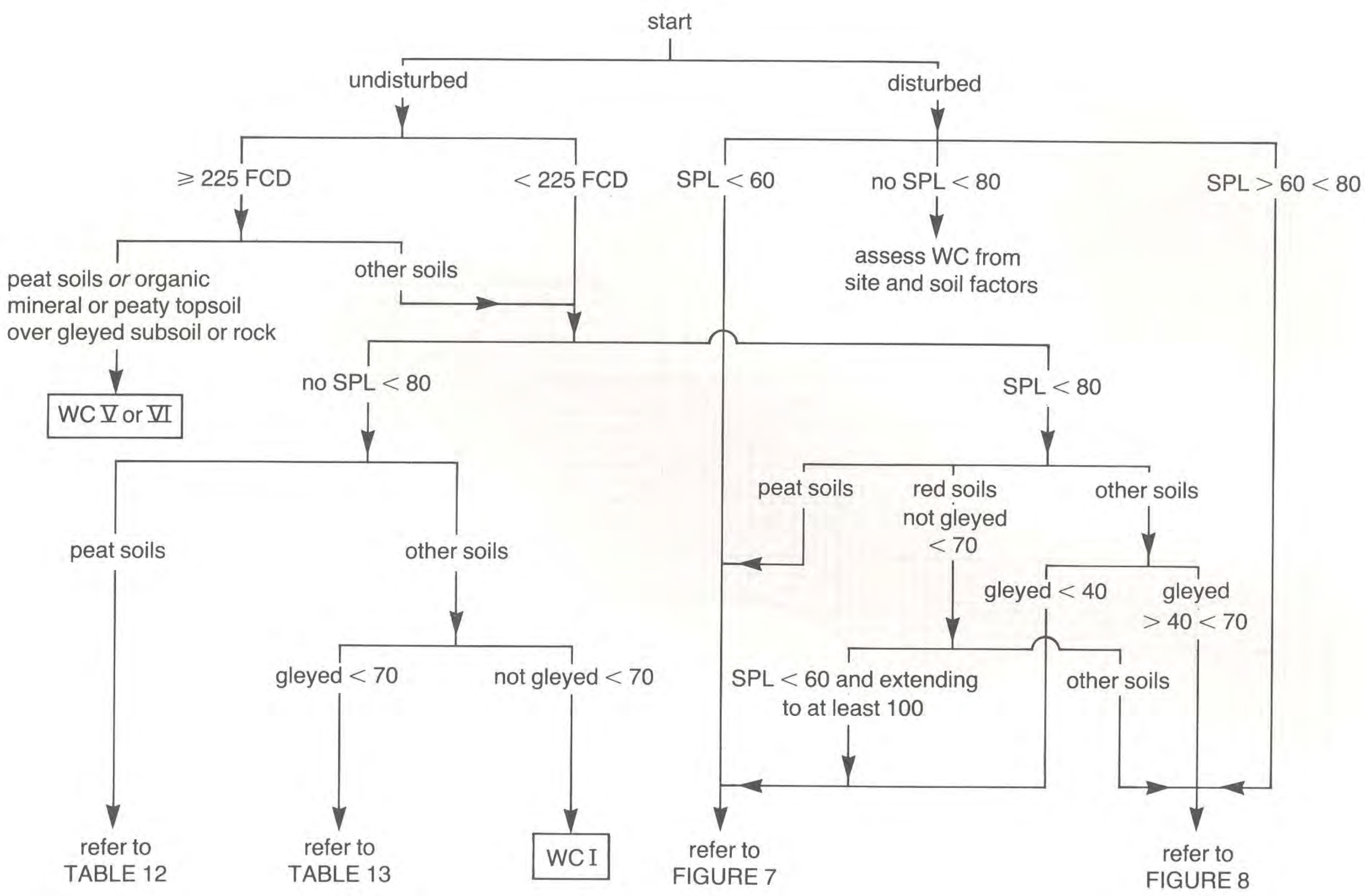


Figure 6. Flow diagram for assessing soil wetness class (WC) from field capacity days (FCD), depth to gleying (in cm) and depth to a slowly permeable layer (SPL, in cm)

Figure 7

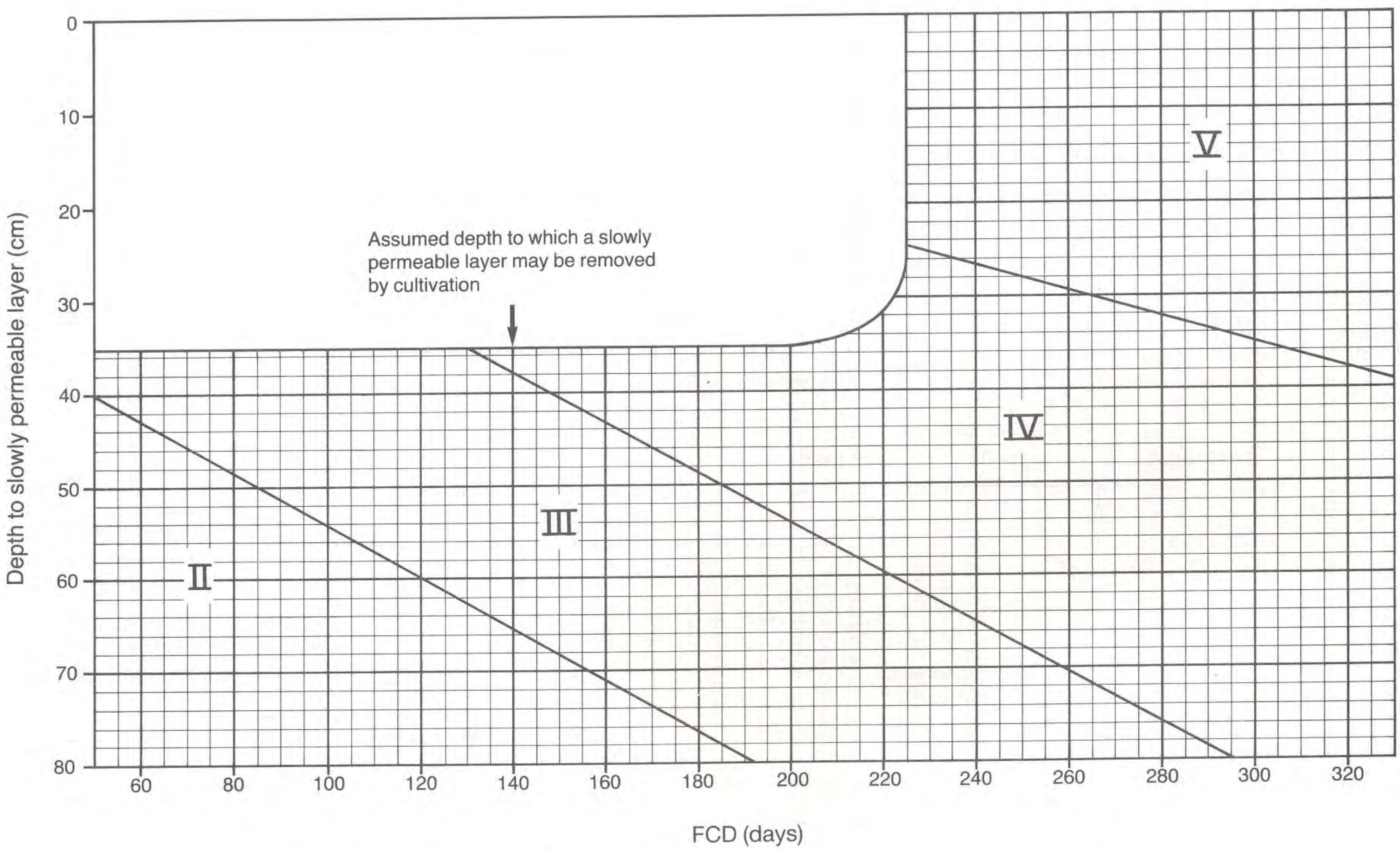


Figure 7. Estimation of Wetness Class from depth to slowly permeable layer and duration of field capacity (FCD) for soils with gleying present within 40 cm depth and a slowly permeable layer starting within 80 cm depth; and for peat soils with a slowly permeable layer

Figure 8

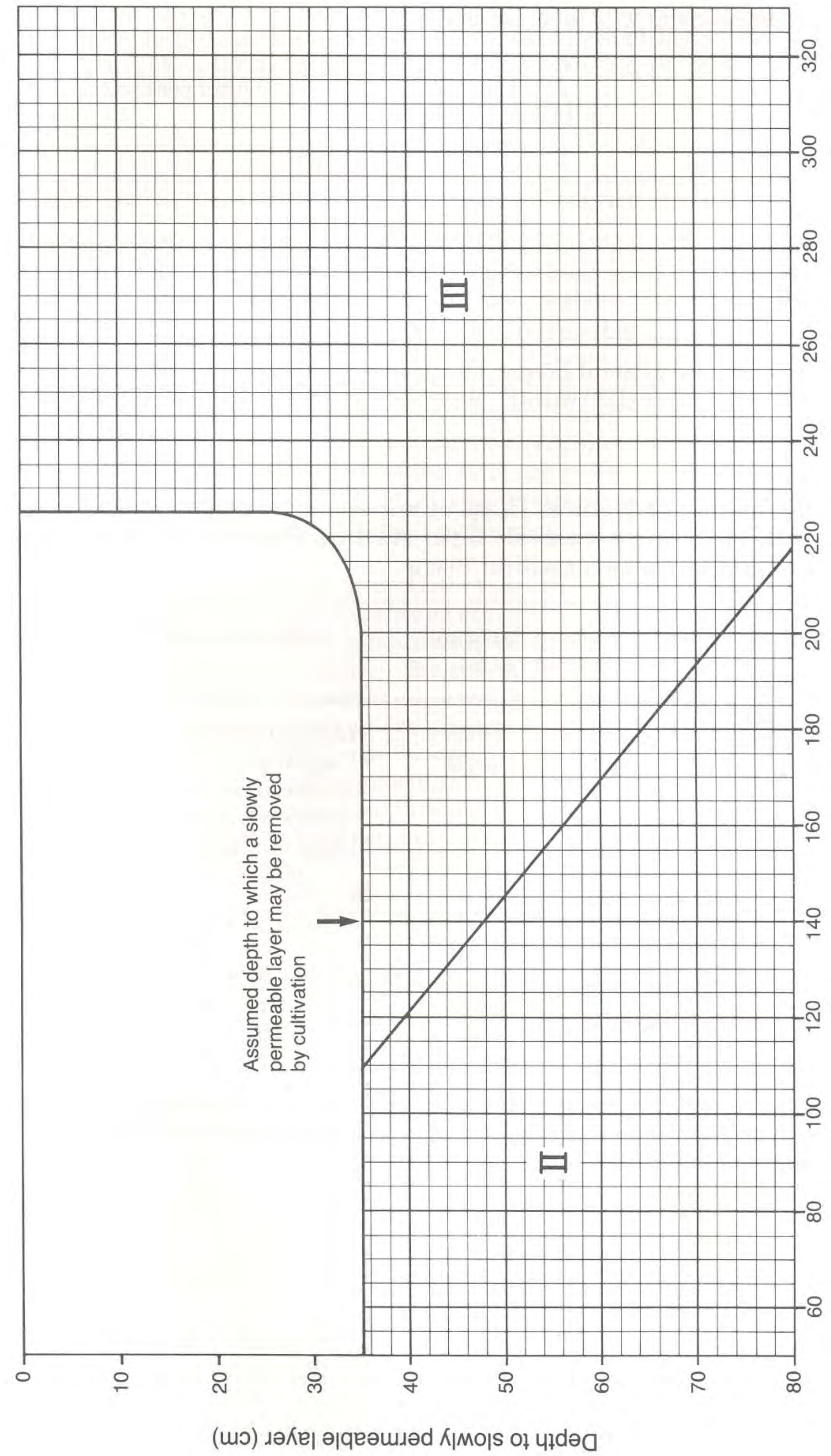


Figure 8. Estimation of Wetness Class from depth to slowly permeable layer and duration of field capacity (FCD) for soils with gleying present within 70 cm depth but not within 40 cm and a slowly permeable layer starting within 80 cm depth

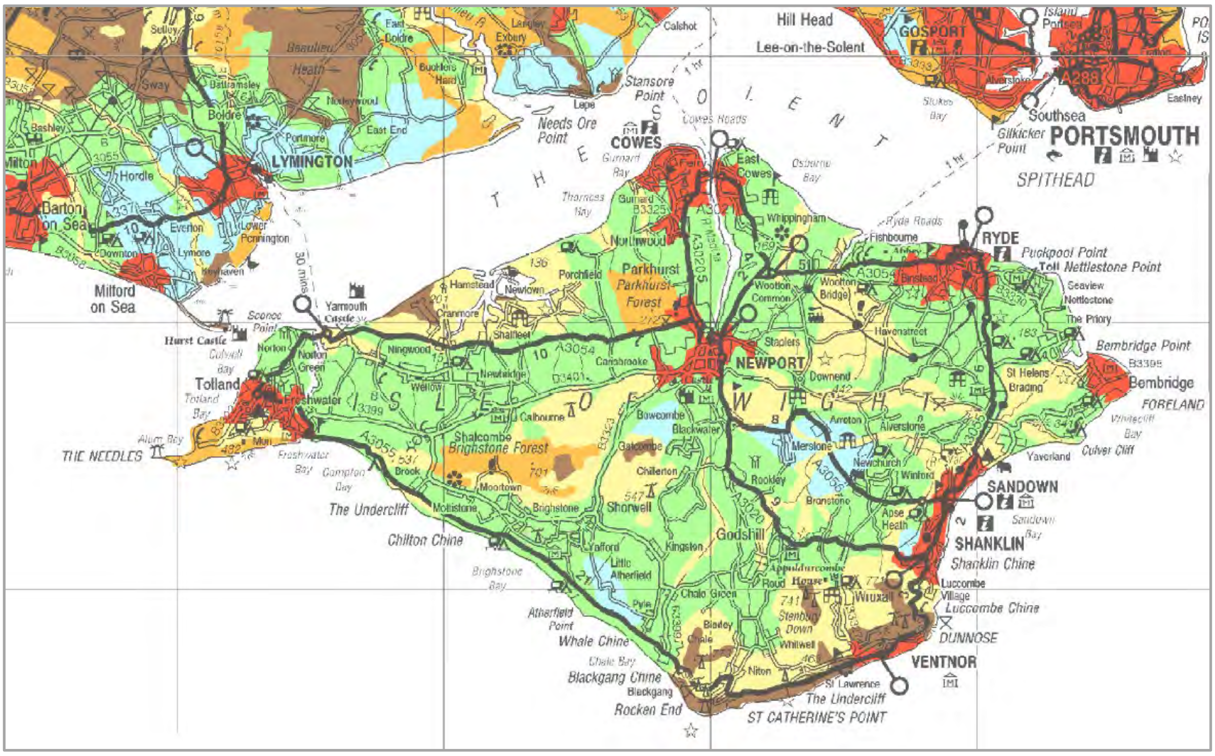
A P P E N D I X 2

2 Existing ALC Data – Natural England ALC Map

Grade	Description
1	Excellent
2	Very Good
3	Good to Moderate
4	Poor
5	Very Poor

Non-Agricultural Land

- Other land primarily in non-agricultural use
- Land predominantly in urban use



APPENDIX 3

Climate Data – ALC Data sets 1941 – 1980 &
Met Office 1996 - Current

SQ	E	N	MAP REF	ALT	AAR	LR	ASR	ATO	ATS	MDW	MDP	FCD
SZ	450	800	44500800	30	765	0.3	320	1536	2503	120	116	164
SZ	450	850	44500850	103	881	0.6	370	1451	2409	102	93	183
SZ	450	900	44500900	17	808	0.6	370	1546	2514	110	105	168
SZ	450	950	44500950	0	774	0.8	330	1564	2534	120	117	160
Average				**37.5**	**807**	**0.575**	**347.5**	**1524.25**	**2490**	**113**	**107.75**	**168.75**

APPENDIX

ALC DATASETS

List of abbreviations to identify the datasets

Abbreviation	Identification for Dataset	Units
SQ	Lettering for 100 km grid square	—
E	National Grid easting (four significant figures)	$m \times 10^2$
N	National Grid northing (four significant figures)	$m \times 10^2$
ALT	Height above mean sea level	m
AAR	Average annual rainfall (1941–70)	mm
LR_AAR	Lapse rate of average annual rainfall	mm/m
ASR	Average summer rainfall (April to September 1941–70)	mm
AT0	Accumulated temperature above 0°C — median value (January to June 1961–80)	day degree C
ATS	Accumulated temperature above 0°C — median value (April to September 1961–80)	day degree C
MDMWHT	Moisture deficit, winter wheat	mm
MDMPOT	Moisture deficit, potatoes	mm
FCD	Duration of field capacity median value (1941–70)	day

The Met. Office

SSLRC

Soil Survey and
Land Research Centre
Incorporating the Soil
Survey of England and Wales

MAFF

CLIMATOLOGICAL DATA FOR AGRICULTURAL LAND CLASSIFICATION

Gridpoint datasets of climatic variables, at 5 km intervals, for England and Wales

JANUARY 1989

CONTENTS

TEXT FIGURES

PREFACE

Climate has an important influence on the agricultural potential of land and is therefore one of the key physical factors taken into account in the Agricultural Land Classification of England and Wales (ALC). The ALC system is used by the Ministry of Agriculture, Fisheries and Food (MAFF) to advise planning authorities about the quality of agricultural land. A revision of the ALC system was published in October 1988 (MAFF, 1988) which includes modified methods for assessing the overall climatic limitation and the degree of soil wetness or droughtiness of a particular location. Climatic data are required for these assessments and a number of datasets have been compiled to provide a standard data source for the initial calibration and subsequent operation of the system.

The climatic data listed in this document as grid datasets with 5 km spacings are to be used in preference to any other published sources for ALC purposes. The origin and derivation of the data are described and interpolation procedures are given for obtaining the estimated value of each parameter at any location in England and Wales. The use of grid data in combination with a standard interpolation procedure avoids the discrepancies which can arise from the subjective interpretation of climate maps or of meteorological station data, which may not be fully representative of the surrounding area. The use of grid data also has significant advantages for computerized storage and manipulation of information.

The data listed are consistent with the agrometeorological reference books published by MAFF (Smith 1976, Smith and Trafford 1976), and in the case of rainfall and duration of field capacity (FCD) supersede those in existing published sources if detailed local estimates are required. In addition to use in the ALC system the data will also be of value for a wide range of other purposes being the best fine resolution datasets for the parameters listed, and because there is a standard interpolation method.

Acknowledgements

The gridpoint datasets were created over a period of years with the co-operation of the Meteorological Office, Soil Survey and Land Research Centre (SSLRC — formerly Soil Survey of England and Wales) and the Agricultural Development and Advisory Service (ADAS) of the MAFF. The contributions of J H Minhinick, J F Keers, Dr M Shawyer and M Field (Meteorological Office), Dr R J A Jones (SSLRC), A J Hooper and M R Watson (ADAS) are gratefully acknowledged. Evaluation and testing of these datasets involved staff of the Meteorological Office Advisory Services Branch and the regional staff of the Resource Planning Group of ADAS.

Meteorological Office
January 1989

SECTION 1

INTRODUCTION

This document describes and lists the location, altitude and climatic data which are to be used when grading land with the MAFF Agricultural Land Classification of England and Wales (MAFF, 1988). Data are provided for 5 km intersections of the National Grid. Hereafter these intersections are termed 'gridpoints'. The methods used to interpolate the data from gridpoints to intermediate locations are also described.

The Agricultural Land Classification (ALC) provides a framework for classifying land according to the extent to which its physical or chemical characteristics impose long-term limitations on agricultural use. The principal physical factors influencing agricultural production are climate, site and soil. These factors, together with interactions between them, form the basis for classifying land into one of five grades, the grade or subgrade of land being determined by the most limiting factor present.

The datasets are derived from data supplied by the Meteorological Office, Bracknell. They were compiled and validated in collaboration with the Soil Survey and Land Research Centre (SSLRC) and the MAFF Agricultural Development and Advisory Service (ADAS) and are held in LandIS, a computer-based land information system funded by MAFF and developed by SSLRC. The system can be used to obtain both gridpoint and interpolated values for specified grid references. Computer-interpolated values from LandIS are available from the Agrometeorological Unit or Resource Planning Group at MAFF Regional Offices[1] and from the SSLRC[2].

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[1] Located at Bristol, Reading, Cambridge, Wolverhampton, Leeds and Trawscoed (Aberystwyth).

[2] Soil Survey and Land Research Centre, Silsoe Campus, Silsoe, Bedfordshire, MK45 4DT.

SECTION 2

LOCATION, ALTITUDE AND CLIMATIC DATASETS

The following sections describe the location, altitude, rainfall, temperature, moisture deficit and duration of field capacity datasets. In the preparation of these datasets, a 'Complete' Agromet Dataset (Field, 1983a) was created which comprises meteorological records for 94 observing stations in England and Wales. The algorithms used to compute temperatures and moisture deficits for gridpoints were derived from analyses of station data in this dataset. A dataset based on several thousand rain gauges was used to create the rainfall and duration of field capacity datasets.

2.1 LOCATION AND ALTITUDE DATA

2.11 National Grid

The data are referenced according to the National Grid of the Ordnance Survey which has a false origin at zero easting and zero northing to the south-west of the Isles of Scilly. Grid references are used to locate gridpoints and in Equation 9 to calculate the distance between gridpoints and intermediate points. For ease of location they are given in the familiar alphanumeric form. The two letters which precede the six digits of the grid reference identify a 100 km grid square. To calculate distances on a national basis these letters are converted to number codes by referring to Figure 1. The number code equivalent to the first letter is placed before the 3-figure eastings number and that equivalent to the second letter goes before the northings number. For example, NT 950 050 identifies a location to 100 m in the north-east of England. The number code for NT is 36. In full numeric form this reference is 3950 6050, in which EAST = 3950 and NORTH = 6050; see Equations 1, 2 and 9.

2.12 Altitude (ALT)

The altitude data (ALT) were obtained from a 0.5 km resolution dataset of representative altitudes held by the Meteorological Office, Bracknell. The values are given in metres (m) above Ordnance Datum (OD), the reference mean sea level. They are used, in Equation 1, to calculate a gridpoint value and in Equations 6, 7, 8, 14, 15, 17 and 19, to make adjustments to rainfall, temperature, duration of field capacity and moisture deficit which allow for any differences in altitude between the site and the surrounding gridpoints.

2.2 RAINFALL

The rainfall data are averages in millimetres (mm) based on records from several thousand rain gauges for the years 1941–70, which is the current international standard period.

2.21 Average annual rainfall (AAR)

Average annual rainfall values were plotted on to a 1:250,000 scale topographic base map and isohyets drawn manually. Gridpoint values were obtained by interpolation using this base map. The published 1:625,000 map of AAR (Met.O.886, 1977) was also derived from the 1:250,000 base map. AAR is used in the assessment of the overall climatic limitation, and was used to derive the altitude adjustments for moisture deficit.

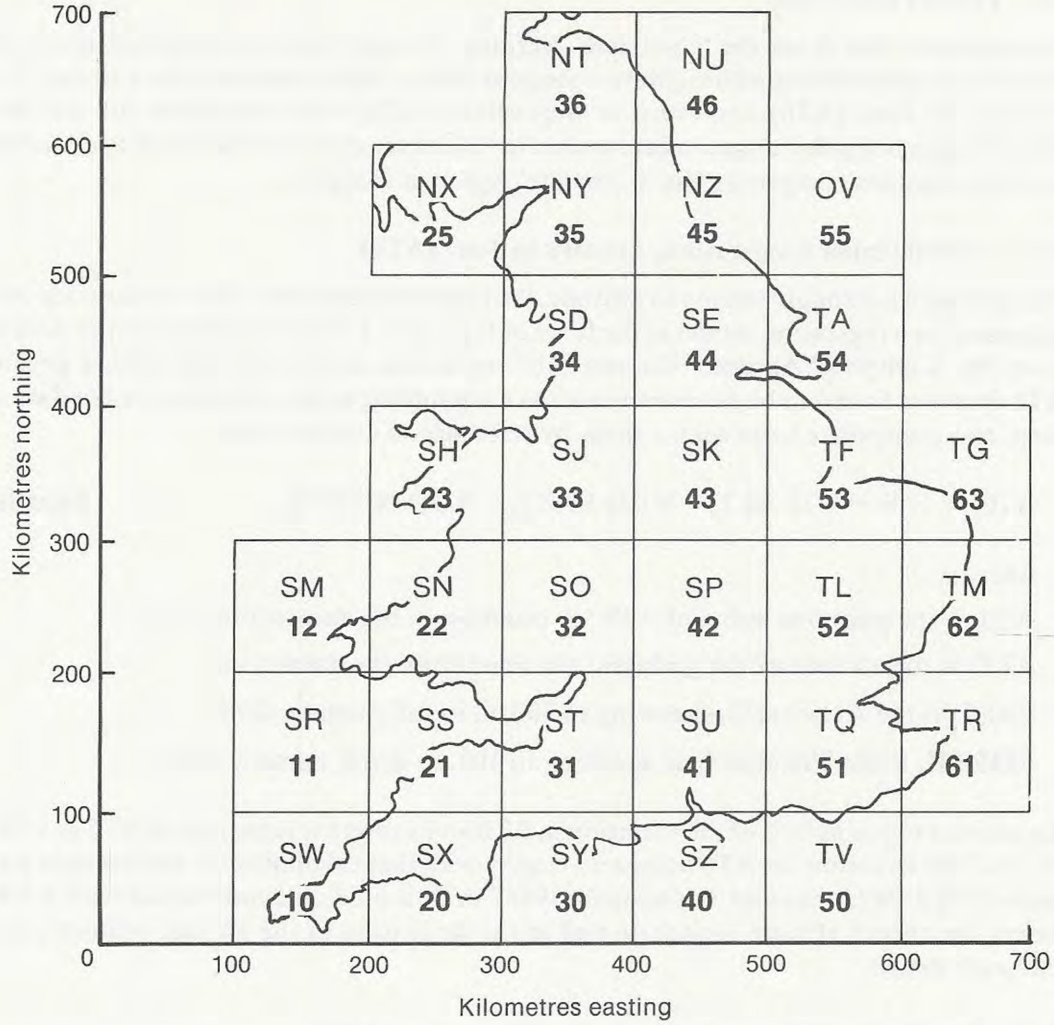


Figure 1. The lettering and numbering of the 100 km squares of the National Grid

2.22 Lapse rate for average annual rainfall (LR_AAR)

The rate at which rainfall changes with altitude (lapse rate) is used to enable gridpoint values of AAR to be interpolated for intermediate locations between gridpoints taking account of altitude changes. The lapse rate (LR_AAR) dataset was derived from the AAR and ALT datasets to give a lapse rate for each 5 km gridpoint. The AAR and ALT data for every 5 km gridpoint and for the surrounding 8 gridpoints were analysed to establish the relationship between annual rainfall and altitude. A simple linear regression produced a lapse rate for the 10 km square area centred on the 5 km gridpoint. The values are given in mm/m. LR_AAR is used to make altitude adjustments in Equations 6, 8, 14, 15, 17 and 19.

2.23 Average summer rainfall (ASR)

Average summer rainfall was calculated for the period April to September. Rain gauge values were plotted on to a 1:625,000 scale topographic map, isohyets drawn, and gridpoint values interpolated, following the procedure used for AAR. ASR is used in Equations 4 and 5 to calculate moisture deficits.

2.3 TEMPERATURE

Temperature data from the 'Complete' Agromet Dataset were accumulated above 0 °C using the established algorithm (Meteorological Office, 1969). Median values, in day °C, for January to June (AT0) and April to September (ATS) were calculated for the period 1961–80, this being the longest recent period for which temperature data have been recorded at all the stations comprising the 'Complete' Agromet Dataset.

2.31 Accumulated temperature, January to June (AT0)

Temperature is strongly related to altitude, latitude and longitude. This relationship can be expressed as a regression model in the form of Equation 1 which was fitted to the AT0 data from the 'Complete' Agromet Dataset. The regression method for calculating gridpoint AT0 data was found to be more accurate than attempting to plot and analyse the data on a map, and interpolate from such a map, by reference to contour lines.

$$AT0_g = 1708 - 1.14\ ALT_g - 0.023\ EAST_g - 0.044\ NORTH_g$$ **Equation 1**

where

$AT0_g$ is the gridpoint value of AT0 for insertion in the dataset (day °C)

ALT_g is the altitude of the gridpoint obtained from the dataset (m)

$EAST_g$ is the National Grid easting to 100 m, in full numeric form

$NORTH_g$ is the National Grid northing to 100 m, in full numeric form

Equation 1 explains 88% of the variation in AT0 and shows the lapse rate of AT0 as 1.14 day °C/m. This equation for AT0 compares closely with that calculated for similar data for the period 1959–78 (Jones and Thomasson, 1985). AT0 is used, in combination with AAR, to assess the overall climate limitation and in the derivation of the altitude adjustments for moisture deficit.

2.32 Accumulated temperature, April to September (ATS)

Gridpoint ATS values were obtained directly from AT0 and National Grid easting using Equation 2. This equation was derived from an analysis of station data from the 'Complete' Agromet Dataset and explains 95% of the variation in ATS.

$$ATS_g = 611 + 1.11\ AT0_g + 0.042\ EAST_g$$ **Equation 2**

where

ATS_g is the gridpoint value of ATS for insertion in the dataset (day °C)

$AT0_g$ is the gridpoint value of AT0 obtained from the dataset (day °C)

$EAST_g$ is the National Grid easting to 100 m in full numeric form

ATS is used, in combination with ASR, to calculate moisture deficits in Equations 4 and 5.

2.4 MOISTURE DEFICIT (MD)

Moisture deficit is a crop-related meteorological variable which represents the balance between rainfall and potential evapotranspiration calculated over a critical portion of the growing season. The concept of potential evapotranspiration (PE) was introduced by Penman (1948) who defined it as the water transpired by a short green crop, such as grass, which completely covers the ground surface and has an ample supply of water around its roots. PE is used in combination with rainfall (R) to calculate the potential soil moisture deficit, PSMD (Smith, 1967) as follows:

$$\mathrm{PSMD} = \sum(\mathrm{PE}-\mathrm{R})$$

where (PE–R) is calculated daily and summed for a defined period and is identical to the negative sum of (R–PE) as in MAFF (1988). During the period, which may be a week, month or season, when running total of PSMD becomes positive it is set to zero.

In many situations where land is in agricultural use a deficit will typically develop in April or May and will reach a maximum in July, August or September; thereafter it will decrease as temperatures, and hence evapotranspiration, decline in the autumn. PSMD can be calculated for daily or monthly periods and the maximum value in any year used to indicate the shortfall in moisture supply for that year. For land classification purposes, the PSMD needs to be averaged over a period of years and selecting the median value of PSMD avoids the bias of extreme years. Potential deficits under grass are greater than under arable crops which do not attain full ground cover early in the growing season. For example, winter wheat does not usually develop full leaf cover until the end of April. Maincrop potatoes have negligible leaf cover until mid-May and full cover is not usually achieved until the end of June. Jones and Thomasson (1985) describe a method for deriving MD values (in mm) for wheat and potatoes from end-of-month and mid-month accumulated values of PSMD (under grass) as follows:

$$\text{MD (Winter Wheat)} = \text{mid-July PSMD} - \tfrac{1}{3}\,\text{April PSMD}$$

$$\text{MD (Potatoes)} = \text{August PSMD} - \tfrac{1}{3}\,\text{June PSMD} - \tfrac{1}{3}\,\text{mid-May PSMD}$$

Field (1983b, 1983c) described a number of problems encountered with the mapping of PSMD calculated using PE data from the Meteorological Office Rainfall and Evaporation Calculation System (MORECS, see Thompson *et al*, 1981). Suitable long-period meteorological data for some of the variables required by the model to compute PE, notably humidity and windspeed, are scarce. This is because the measurements of these parameters obtained at some observing stations, which may be sited on airfields, at the coast or in urban areas, are so influenced by local environmental factors that the general trends in spatial variation are masked. Furthermore, in some places the readings, being restricted to once a day, give no indication of diurnal variation.

To gain the benefit of using a MORECS-based estimate and also obtain a satisfactory measure of the spatial variation of moisture deficit, regression models were developed for estimating gridpoint values of crop-adjusted MD directly from summer temperature and summer rainfall data. These are the dominant weather factors affecting MD and have spatial distributions which are well recorded and understood and which can therefore be mapped with sufficient accuracy. Crop-adjusted MDs were obtained from MORECS-based

PSMD, for the stations in the 'Complete' Agromet Dataset, and the data were analysed to establish best-fit multiple linear regression equations for wheat and potatoes, using ATS and ASR as the variables. These equations are of the general form:

$$MD_g = A_0 + A_1 \log_{10}ASR_g + A_2\ ATS_g \qquad \textbf{Equation 3}$$

where

MD_g is the gridpoint value of MD for wheat or potatoes for insertion in the dataset (mm)

ASR_g is the gridpoint value of ASR obtained from the dataset (mm)

ATS_g is the gridpoint value of ATS obtained from the dataset (day °C)

A_0, A_1, A_2 are constants

The forms of Equation 3 specifically for winter wheat and potatoes are given in Equations 4 and 5, these equations explain 88% of the variation in crop-adjusted MD. Moisture deficit is used, in combination with crop-adjusted soil available water capacity (AP), to assess the droughtiness limitation.

2.41 Moisture deficit for winter wheat (MDMWHT)

Gridpoint values (in mm) were obtained from ASR and ATS using the following equation:

$$MDMWHT_g = 325.4 - 162.3 \log_{10}ASR_g + 0.08022\ ATS_g \qquad \textbf{Equation 4}$$

When this equation gave a negative value (i.e. a moisture surplus) it was adjusted to zero.

2.42 Moisture deficit for potatoes (MDMPOT)

Gridpoint values (in mm) were obtained from ASR and ATS using the following equation:

$$MDMPOT_g = 326.4 - 196.5 \log_{10}ASR_g + 0.1127\ ATS_g \qquad \textbf{Equation 5}$$

When this equation gave a negative value (i.e. a moisture surplus) it was adjusted to zero.

2.5 DURATION OF FIELD CAPACITY (FCD)

Duration of field capacity (FCD) is a meteorological parameter which estimates the period when the soil moisture deficit is zero. Soils usually return to field capacity (zero deficit) during the autumn or early winter and the field capacity period, measured in days, ends in the spring when evapotranspiration exceeds rainfall and a moisture deficit begins to accumulate. Smith and Trafford (1976) described a method for estimating the average period of meteorological field capacity from rainfall and evapotranspiration for the period 1941–70 and listed median dates for the return to and end of field capacity for 52 agroclimatological areas. Based on the strong correlation between FCD and AAR, these dates were regressed on AAR by the SSLRC to generate a 10 km grid dataset which has subsequently been resolved to 5 km using the gridpoint values of AAR described above (Jones and Thomasson, 1985; Ragg *et al*, 1988). Duration of field capacity is used, in combination with soil characteristics, to assess the wetness limitation.

SECTION 3

INTERPOLATION BETWEEN GRIDPOINTS

This section describes the procedures which are used to obtain AAR, AT0, FCD and MD values for sites located between gridpoints. These procedures take account of altitude differences and the distance between a site and the adjacent gridpoints. They can be applied manually or by computer and are the interpolation methods used in LandIS.

The term 'site' is used here to refer to a specified grid reference (in the form described in Section 2.11) for which climatic data are required. If the area to be assessed is small and uniform, a single (usually central) grid reference may suffice. If there is likely to be significant variation within an area, a number of grid references will need to be selected at representative locations.

The same interpolation procedure is used for AAR, AT0 and FCD. This includes the use of an altitude adjustment factor (or lapse rate) to allow for altitude differences between a site and the surrounding reference gridpoints. Lapse rates for AAR (LR_AAR) are obtained from the dataset (see Section 2.22). Because there is a high correlation between AAR and FCD, LR_AAR is also used for altitude adjustments of FCD. For AT0, the lapse rate used is 1.14 day °C/m (see Section 2.31). Altitude adjustments to MD are less straightforward and are calculated using an equation in which AAR and AT0 are the climatic variables (see Section 3.3).

3.1 GENERAL PRINCIPLES

Interpolated values are calculated in 3 stages, namely:

(i) select the reference gridpoints which surround the site;

(ii) apply an altitude adjustment factor (lapse rate) which adjusts each reference gridpoint value to correspond with the altitude of the site;

(iii) obtain the site estimate by calculating the distance-weighted mean of altitude-adjusted values for the reference gridpoints.

3.2 INTERPOLATION PROCEDURE FOR AAR, AT0 AND FCD

The interpolation procedure for AAR, AT0 and FCD is described in Sections 3.21 to 3.23.

3.21 Selection of reference gridpoints

Select the reference gridpoints according to Figure 2 as follows:

(i) If the site falls exactly on a gridpoint, use the values for that gridpoint.

(ii) If the site falls within a square formed by four adjacent gridpoints (Site A), use those four gridpoints.

(iii) If the site falls exactly on a grid reference northing between two gridpoints (Site B), use those two gridpoints.

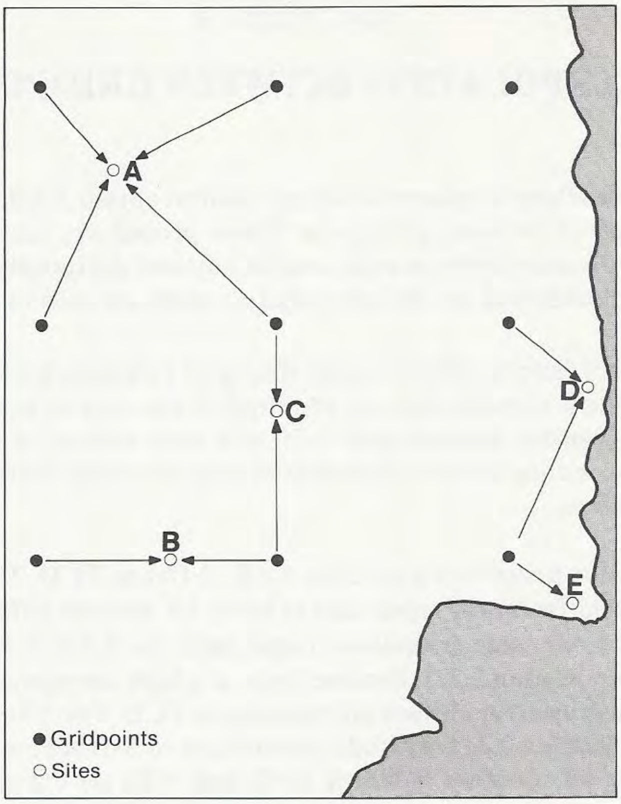


Figure 2. Diagrammatic representation of the procedure for selecting reference gridpoints

(iv) If the site falls exactly on an easting between two gridpoints (Site C), use those two gridpoints.

(v) If one or more of the gridpoints is missing (Sites D and E), use the gridpoint(s) available.

3.22 Altitude adjustment

Adjust each reference gridpoint value for the altitude difference between the site and the gridpoint.

The adjustment to **AAR** is made using Equation 6:

$$AAR_a = AAR_g + LR\_AAR_g\,(ALT_s - ALT_g) \qquad \textbf{Equation 6}$$

where

AAR_a is the altitude-adjusted gridpoint value of AAR (mm)

AAR_g is the gridpoint value of AAR obtained from the dataset (mm)

LR_AAR_g is the gridpoint value for the lapse rate of AAR obtained from the dataset (mm/m)

ALT_s is the altitude of the site (m)

ALT_g is the altitude of the gridpoint obtained from the dataset (m)

The adjustment to **AT0** is made using Equation 7:

$$AT0_a = AT0_g + 1.14\,(ALT_g - ALT_s) \qquad \textbf{Equation 7}$$

where

$AT0_a$ is the altitude-adjusted gridpoint value of AT0 (day °C)

$AT0_g$ is the gridpoint value of AT0 obtained from the dataset (day °C)

1.14 is the lapse rate of AT0 (day °C/m)

ALT_g is the altitude of the gridpoint obtained from the dataset (m)

ALT_s is the altitude of the site (m)

The adjustment to **FCD** is made using Equation 8:

$$FCD_a = FCD_g + 0.1446\,[LR\_AAR_g\,(ALT_s - ALT_g)] \qquad \textbf{Equation 8}$$

where

FCD_a is the altitude-adjusted gridpoint value of FCD (day)

FCD_g is a gridpoint value of FCD obtained from dataset (day)

LR_AAR_g is the gridpoint value of the lapse rate of AAR obtained from the dataset (mm/m)

ALT_s is the altitude of the site (m)

ALT_g is the altitude of the gridpoint obtained from the dataset (m)

When Equation 8 gives $FCD_a > 365$, take FCD_a to be 365.

3.23 Calculation of site value of AAR, AT0 or FCD

Having calculated an altitude-adjusted value for each reference gridpoint, the interpolated site value can be obtained in four steps.

Calculate the distance between the site and each reference gridpoint, using Equation 9

$$D_{sg} = \sqrt{(EAST_g - EAST_s)^2 + (NORTH_g - NORTH_s)^2} \qquad \textbf{Equation 9}$$

where

D_{sg} is the computed distance between site and gridpoint

$EAST_g$ is the National Grid easting for the gridpoint

$EAST_s$ is the National Grid easting for the site

$NORTH_g$ is the National Grid northing for the gridpoint

$NORTH_s$ is the National Grid northing for the site

and where the above National Grid references, to 100 m, are entered in full numeric form (see Section 2.11)

Calculate an inverse distance squared factor for each reference gridpoint, using Equation 10

$$W_g = \left[\frac{1}{D_{sg}}\right]^2$$ **Equation 10**

where

W_g is the inverse distance squared factor for the gridpoint

D_{sg} is the computed distance (from Equation 9) between the site and gridpoint

Obtain a distance weighting factor for each reference gridpoint, using Equation 11

$$W_p = \frac{W_g}{W_t}$$ **Equation 11**

where

W_p is the distance weighting factor for the gridpoint

W_g is the inverse distance squared factor (from Equation 10) for the gridpoint

W_t is the sum of W_g values for all reference gridpoints for the site (up to 4)

Obtain the site estimate for AAR, AT0 or FCD by calculating a distance-weighted mean of reference gridpoint values, using Equation 12

$$V_s = V_{g1}\,W_{p1} + V_{g2}\,W_{p2} + V_{g3}\,W_{p3} + V_{g4}\,W_{p4}$$ **Equation 12**

where

V_s is the interpolated site value of AAR, AT0 or FCD

V_{g1}, V_{g2} etc are the altitude-adjusted gridpoint values of AAR, AT0 or FCD for reference gridpoints 1, 2, etc. calculated from Equations 6, 7 or 8

W_{p1}, W_{p2}, etc. are the distance weighting factors for gridpoints 1, 2, etc. calculated from Equation 11.

3.3 INTERPOLATION PROCEDURE FOR MD

The procedure differs from that used to interpolate AAR, AT0 and FCD because there is no simple lapse rate for MD. In order to make altitude adjustments to MD_g (i.e. gridpoint values of MD in the dataset) directly, a function is required which includes lapse rates for ATS and ASR. The lapse rate for ATS is the same as that for AT0, namely 1.14 day °C/m, but there is no established lapse rate for ASR, which is somewhat less height-dependent than AAR. This is because a higher proportion of summer rainfall occurs as a result of convection due to differential heating. The best and most convenient method available for calculating altitude adjustments to the MD values in the datasets uses AAR and AT0, in place of ASR and ATS respectively. The derivation of the method used to calculate these adjustments is explained, as background information, in Section 3.31. The actual steps in the interpolation procedure for MD are described in Sections 3.32 to 3.34.

3.31 Derivation of equation for obtaining altitude adjustment factors for MD

The amount (in mm) by which a gridpoint MD from the dataset has to be adjusted can be obtained by:

(i) calculating the gridpoint MD value for the *gridpoint altitude*, using AAR and AT0 in place of ASR and ATS (see Equation 13);

(ii) calculating, using the lapse rates of AAR and AT0, an AAR/AT0 derived MD value for that gridpoint, but at *site altitude* (see Equation 14);

(iii) subtracting (ii) from (i) to give the amount (in mm) by which the reference gridpoint value from the dataset should be adjusted (see Equation 15).

The equation used to obtain, for wheat or potatoes, the AAR/AT0 derived MD values for a reference gridpoint (step (i) above) has the same general form as Equation 3:

$$MD_x = B_0 + B_1\,AAR_g + B_2\,AT0_g \qquad \textbf{Equation 13}$$

where

MD_x is the AAR/AT0 derived MD at the gridpoint (mm)

AAR_g is the gridpoint value of AAR obtained from the dataset (mm)

$AT0_g$ is the gridpoint value of AT0 obtained from the dataset (day °C)

B_0, B_1 and B_2 are constants

A similarly derived MD value for the same gridpoint, but at site altitude, is provided by Equation 14:

$$MD_{xa} = B_0 + B_1\,[AAR_g + LR\_AAR_g\,(ALT_s - ALT_g)] + B_2\,[AT0_g + 1.14\,(ALT_g - ALT_s)] \qquad \textbf{Equation 14}$$

where

MD_{xa} is the altitude-adjusted AAR/AT0 derived MD (mm)

AAR_g is the gridpoint value of AAR obtained from the dataset (mm)

LR_AAR_g is the gridpoint value of the lapse rate of AAR obtained from the dataset (mm/m)

ALT_s is the altitude of the site (m)

ALT_g is the altitude of the gridpoint obtained from the dataset (m)

$AT0_g$ is the gridpoint value of AT0 obtained from the dataset (day °C)

1.14 is the lapse rate of AT0 (day °C/m)

B_0, B_1 and B_2 are constants

The difference between Equations 13 and 14 ((iii) above) is the altitude adjustment (C) to be applied to a gridpoint value from the dataset. Thus:

$C = MD_x - MD_{xa}$

after substituting from Equations 13 and 14 the above relationship simplifies to:

$$C = B_1 [LR\_AAR_g (ALT_s - ALT_g)] + B_2 [1.14 (ALT_g - ALT_s)]$$ **Equation 15**

where, for winter wheat

$B_1 = -0.07$

$B_2 = +0.09$

and, for potatoes

$B_1 = -0.09$

$B_2 = +0.12$

Equations 17 and 19 below are the specific forms of Equation 15 for wheat and potatoes respectively. The altitude adjustment factors obtained using these equations are applied to the MD values for reference gridpoints. The stops for obtaining interpolated MD values are described in the following sections.

3.32 Selection of reference gridpoints

Select the reference gridpoints as described in Section 3.21 and obtain the MD values for those points from the dataset.

3.33 Altitude adjustment

For MD Winter Wheat (MDMWHT) adjust each gridpoint value for the altitude difference between the site and the gridpoint, using Equations 16 and 17.

$$MDMWHT_a = MDMWHT_g + C_w$$ **Equation 16**

where

$MDMWHT_a$ is the altitude-adjusted gridpoint value of MD Wheat (mm)

$MDMWHT_g$ is the gridpoint value of MD Wheat obtained from dataset (mm)

C_w is the adjustment factor for the altitude difference between the gridpoint and site (mm)

and where

$$C_w = -0.07 [LR\_AAR_g (ALT_s - ALT_g)] + 0.09 [1.14 (ALT_g - ALT_s)]$$ **Equation 17**

in which

LR_AAR_g is the gridpoint value of the lapse rate of AAR obtained from the dataset (mm/m)

ALT_s is the altitude of the site (mm)

ALT_g is the altitude of the gridpoint obtained from the dataset (m)

1.14 is the lapse rate of AT0 (day °C/m)

When Equation 16 gives $MDMWHT_a < 0$, take $MDMWHT_a$ to be 0.

For MD Potatoes (MDMPOT) adjust each gridpoint value for the altitude difference between the site and the gridpoint, using Equations 18 and 19

$$MDMPOT_a = MDMPOT_g + C_p \qquad \textbf{Equation 18}$$

where

$MDMPOT_a$ is the altitude-adjusted gridpoint value of MD Potatoes (mm)

$MDMPOT_g$ is the gridpoint value of MD Potatoes obtained from dataset (mm)

C_p is the adjustment factor for the altitude difference between gridpoint and site (mm)

and where

$$C_p = -0.09\,[LR\_AAR_g\,(ALT_s - ALT_g)] + 0.12\,[1.14\,(ALT_g - ALT_s)] \qquad \textbf{Equation 19}$$

in which the notation is the same as used in Equation 17.

When Equation 18 gives $MDMPOT_a < 0$, take $MDMPOT_a$ to be 0.

3.34 Calculation of site value of MD

Obtain a site value using the procedure described for AAR, AT0 and FCD (Section 3.23, Equations 9 to 12).

The distance weighting factors are the same for AAR, AT0, and FCD but in Equation 12 $MDMWHT_1$, $MDMWHT_2$, etc., or $MDMPOT_1$, $MDMPOT_2$, etc. are substituted for V_{g1}, V_{g2}, etc.

REFERENCES

FIELD, M (1983a) Creating the 'Complete' Agromet Dataset. *Agricultural Memorandum No. 983*. (Unpublished, copy available in the National Meteorological Library, Bracknell.)

FIELD, M (1983b) The spatial variability of potential evapotranspiration at mean sea level in England and Wales and the implications for mapping median values of potential soil moisture deficit. *Agricultural Memorandum No. 997*. (Unpublished, copy available in the National Meteorological Library, Bracknell.)

FIELD, M (1983c) A technique that has been used in an attempt to map median maximum potential soil moisture deficit. *Agricultural Memorandum No. 999*. (Unpublished, copy available in the National Meteorological Library, Bracknell.)

JONES, R J A and THOMASSON, A J (1985) *An Agroclimatic Databank for England and Wales*. Soil Survey Tech. Monogr. 16, Harpenden.

MAFF (1988) *Agricultural Land Classification of England and Wales*. — Revised guidelines and criteria for grading the quality of agricultural land. MAFF (Publications), Alnwick, Northumberland.

MET.O.886 (1977) Average Annual Rainfall Maps of Southern Britain and Northern Britain. *Met.O.886 (SB) and Met.O.886 (NB)*. HMSO, London.

METEOROLOGICAL OFFICE (1969) Tables of the evaluation of daily values of accumulated temperature above and below 42 °F from daily values of maximum and minimum temperature. *Meteorological Office Leaflet No. 10 (formerly 3300)*. (Unpublished, copy available in the National Meteorological Library, Bracknell.)

PENMAN, H L (1948) Natural evaporation from open water, bare soil and grass. *Proc. Roy. Soc. Series A 193*, 120–45.

RAGG, J M, JONES, R J A and PROCTOR, M E (1988) The refinement and presentation of spatial data in an information system using statistical and DBMS procedures, and trend surface analysis. In: *Proc. of the IUGS colloquium on the Construction and Display of Geoscientific Maps derived from Databases*. (ed. R Vinken). *Geologische Jahrbuch, A 104*, 295–308. Hannover.

SMITH, L P (1976) The Agricultural Climate of England and Wales. *MAFF Reference Book 435*. (formerly Technical Bulletin No. 35). HMSO, London.

SMITH, L P (1967) Potential transpiration. *Technical Bulletin No. 16*, HMSO, London.

SMITH L P and TRAFFORD, B D (1976) Climate and Drainage. *MAFF Reference Book 434*. (formerly Technical Bulletin No. 34). HMSO, London.

THOMPSON, N, BARRIE, I A and AYLES, M (1981) The Meteorological Office Rainfall and Evaporation Calculation System: MORECS (July 1981). *Hydrol Memo, Meteorol Off.* No. 45.

APPENDIX

ALC DATASETS

List of abbreviations to identify the datasets

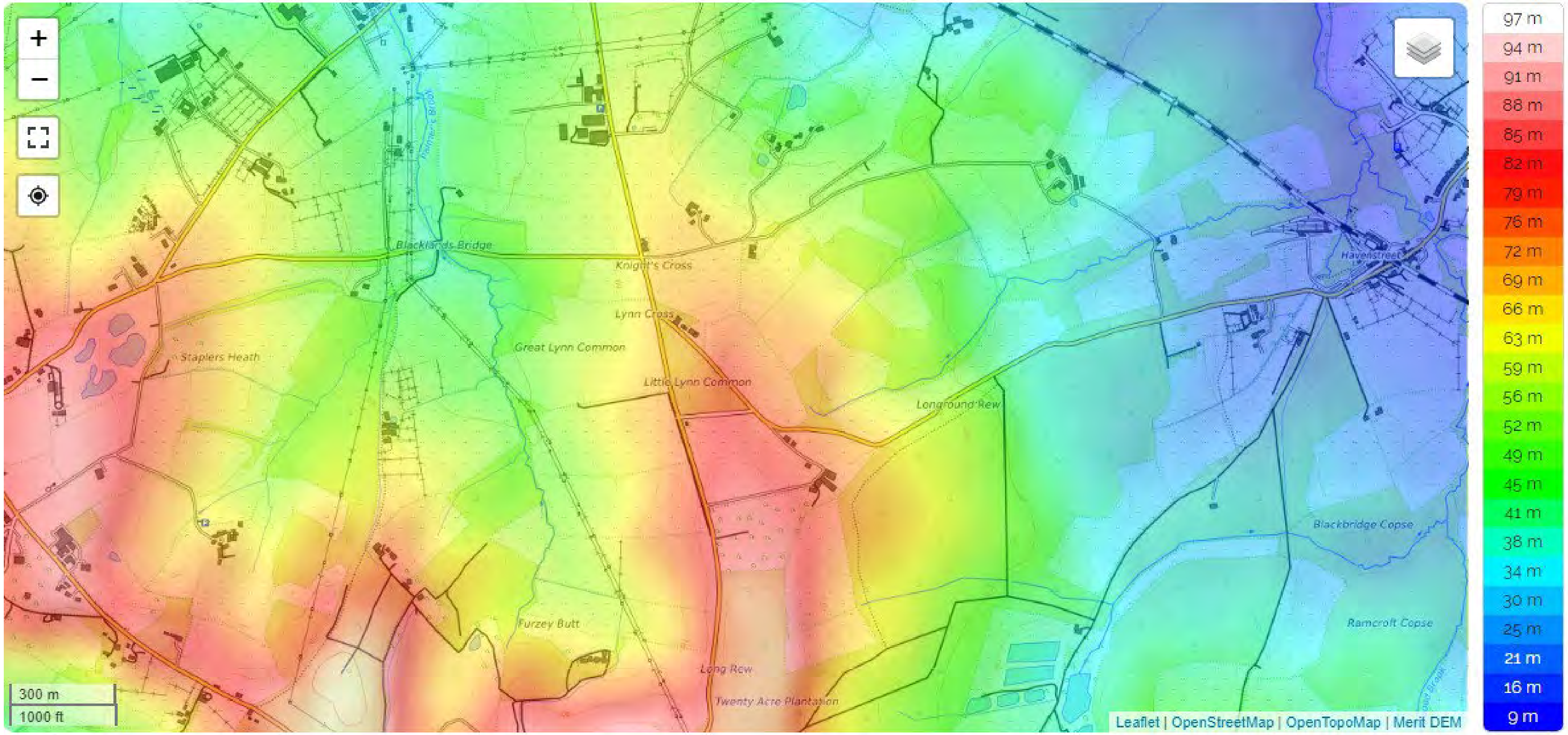
Abbreviation	Identification for Dataset	Units
SQ	Lettering for 100 km grid square	—
E	National Grid easting (four significant figures)	$m \times 10^2$
N	National Grid northing (four significant figures)	$m \times 10^2$
ALT	Height above mean sea level	m
AAR	Average annual rainfall (1941–70)	mm
LR_AAR	Lapse rate of average annual rainfall	mm/m
ASR	Average summer rainfall (April to September 1941–70)	mm
AT0	Accumulated temperature above 0°C — median value (January to June 1961–80)	day degree C
ATS	Accumulated temperature above 0°C — median value (April to September 1961–80)	day degree C
MDMWHT	Moisture deficit, winter wheat	mm
MDMPOT	Moisture deficit, potatoes	mm
FCD	Duration of field capacity median value (1941–70)	day

SY	900	850	39000850	17	931	0.3	380	1561	2508	108	102	188
SY	900	900	39000900	28	870	0.5	360	1547	2492	110	105	179
SY	900	950	39000950	51	891	0.8	375	1518	2460	105	98	182
SY	950	750	39500750	0	808	0.3	330	1584	2535	120	117	169
SY	950	800	39500800	86	918	0.5	375	1484	2424	102	94	188
SY	950	850	39500850	17	939	0.4	375	1560	2509	109	103	191
SY	950	900	39500900	4	829	0.5	350	1573	2523	115	111	173
SY	950	950	39500950	61	889	0.7	370	1506	2449	105	98	182
SZ	000	750	40000750	0	838	0.3	325	1583	2536	121	119	175
SZ	000	800	40000800	34	900	0.6	375	1542	2491	107	101	183
SZ	000	850	40000850	10	861	0.6	370	1567	2518	111	106	175
SZ	000	900	40000900	2	810	0.5	335	1574	2526	118	115	169
SZ	000	950	40000950	46	846	0.5	360	1522	2468	108	102	175
SZ	050	800	40500800	0	791	0.2	335	1579	2534	119	116	164
SZ	050	850	40500850	0	785	0.5	335	1577	2532	119	116	161
SZ	050	900	40500900	20	794	0.5	340	1552	2504	115	111	164
SZ	050	950	40500950	57	833	0.8	355	1508	2455	108	102	171
SZ	100	900	41000900	0	790	0.6	335	1574	2530	119	115	163
SZ	100	950	41000950	14	822	1.4	360	1556	2510	112	107	168
SZ	150	900	41500900	0	754	0.8	320	1573	2531	122	119	157
SZ	150	950	41500950	18	793	1.4	340	1550	2506	116	111	163
SZ	200	900	42000900	0	740	0.5	320	1572	2532	122	119	155
SZ	200	950	42000950	25	809	0.7	350	1541	2498	113	108	167
SZ	250	900	42500900	0	766	0.3	335	1570	2532	119	116	159
SZ	250	950	42500950	30	817	0.7	365	1534	2492	109	104	171
SZ	300	850	43000850	82	719	0.1	330	1478	2432	112	106	150
SZ	300	900	43000900	0	780	0.6	325	1569	2533	121	118	162
SZ	300	950	43000950	12	811	1.2	360	1553	2515	112	108	168
SZ	350	850	43500850	0	790	0.2	335	1570	2536	119	116	162
SZ	350	900	43500900	3	757	0.6	325	1565	2531	121	118	157
SZ	350	950	43500950	4	773	0.9	345	1561	2526	116	112	160
SZ	400	850	44000850	103	818	0.7	340	1452	2408	108	100	170
SZ	400	900	44000900	14	790	0.7	335	1551	2517	117	114	164
SZ	400	950	44000950	0	762	0.8	320	1565	2533	122	120	158
SZ	450	800	44500800	30	765	0.3	320	1536	2503	120	116	164
SZ	450	850	44500850	103	881	0.6	370	1451	2409	102	93	183
SZ	450	900	44500900	17	808	0.6	370	1546	2514	110	105	168
SZ	450	950	44500950	0	774	0.8	330	1564	2534	120	117	160
SZ	500	750	45000750	6	872	0.2	330	1564	2536	120	117	180
SZ	500	800	45000800	79	920	0.2	330	1479	2442	113	107	189
SZ	500	850	45000850	23	923	0.3	390	1541	2511	106	100	190
SZ	500	900	45000900	13	870	0.4	380	1550	2521	109	104	179
SZ	500	950	45000950	6	799	0.5	350	1556	2527	115	111	164
SZ	550	750	45500750	0	775	0.2	335	1570	2545	120	117	166
SZ	550	800	45500800	78	941	0.5	335	1479	2444	112	106	193
SZ	550	850	45500850	17	890	0.9	395	1546	2518	106	100	186
SZ	550	900	45500900	16	872	1.1	360	1545	2517	112	108	179
SZ	550	950	45500950	0	777	1.3	335	1561	2535	119	116	161
SZ	600	800	46000800	0	860	0.3	325	1567	2544	122	120	178
SZ	600	850	46000850	9	828	0.7	360	1554	2529	113	109	172

SZ	600	900	46000900	23	840	0.9	350	1536	2509	114	109	172
SZ	600	950	46000950	0	745	2.2	325	1560	2536	121	119	153
SZ	650	850	46500850	0	770	0.0	325	1563	2541	122	119	159
SZ	650	900	46500900	0	765	0.0	330	1561	2539	120	118	156
SZ	800	950	48000950	0	689	0.0	300	1556	2540	127	126	138
SZ	850	900	48500900	0	669	0.0	300	1557	2543	127	126	136
SZ	850	950	48500950	2	707	0.0	310	1552	2537	125	123	142
SZ	900	950	49000950	0	704	0.0	310	1553	2541	125	123	142
TA	000	000	50004000	5	630	0.2	325	1411	2387	109	102	135
TA	000	050	50004050	4	630	0.2	325	1410	2386	109	102	137
TA	000	100	50004100	6	630	0.2	310	1406	2382	112	105	135
TA	000	150	50004150	10	641	0.3	320	1399	2374	109	102	136
TA	000	200	50004200	73	630	0.3	305	1325	2292	106	97	137
TA	000	250	50004250	1	655	0.3	325	1405	2381	109	101	144
TA	000	300	50004300	63	680	0.4	340	1332	2300	99	88	151
TA	000	350	50004350	55	691	0.6	345	1339	2307	99	88	158
TA	000	400	50004400	44	680	0.7	340	1349	2318	100	90	160
TA	000	450	50004450	13	674	1.1	350	1382	2355	101	92	164
TA	000	500	50004500	13	680	1.5	350	1380	2353	101	92	166
TA	000	550	50004550	19	689	1.1	345	1371	2343	101	92	169
TA	000	600	50004600	69	720	0.6	350	1312	2277	95	83	180
TA	000	650	50004650	132	751	0.5	350	1238	2195	89	74	190
TA	000	700	50004700	116	770	0.4	360	1254	2213	88	73	194
TA	000	750	50004750	149	759	0.2	350	1214	2169	86	71	190
TA	000	800	50004800	28	680	0.4	325	1350	2320	104	94	172
TA	000	850	50004850	40	715	0.7	335	1334	2302	100	90	173
TA	000	900	50004900	61	750	0.8	350	1308	2273	95	83	184
TA	000	950	50004950	120	789	0.6	370	1238	2195	85	69	195
TA	050	000	50504000	17	635	0.5	315	1396	2373	110	103	136
TA	050	050	50504050	10	640	0.4	320	1402	2379	110	102	139
TA	050	100	50504100	29	641	0.4	325	1378	2353	106	98	139
TA	050	150	50504150	55	647	0.3	325	1346	2317	104	94	139
TA	050	200	50504200	25	636	0.4	305	1378	2353	111	103	138
TA	050	250	50504250	0	640	0.7	310	1405	2383	112	105	139
TA	050	300	50504300	4	643	1.0	335	1398	2375	106	98	141
TA	050	350	50504350	6	655	0.9	325	1393	2369	108	100	146
TA	050	400	50504400	4	649	1.0	325	1393	2369	108	100	149
TA	050	450	50504450	4	639	1.4	335	1391	2367	105	97	149
TA	050	500	50504500	4	648	1.7	340	1389	2365	104	95	151
TA	050	550	50504550	8	641	1.1	335	1382	2357	105	96	150
TA	050	600	50504600	34	683	0.5	335	1350	2322	102	92	166
TA	050	650	50504650	45	721	0.5	315	1336	2306	105	95	181
TA	050	700	50504700	108	761	0.5	350	1262	2224	91	77	187
TA	050	750	50504750	96	741	0.4	350	1273	2236	92	78	184
TA	050	800	50504800	34	692	0.4	315	1342	2313	105	96	167
TA	050	850	50504850	84	655	0.5	315	1282	2246	100	89	152
TA	050	900	50504900	0	641	0.6	315	1376	2350	108	100	158
TA	100	000	51004000	38	640	0.6	325	1371	2347	106	97	144
TA	100	050	51004050	57	663	0.5	330	1347	2320	103	93	150
TA	100	100	51004100	27	640	0.4	330	1379	2356	106	97	143

APPENDIX 4

Gradient Data – Topographical Data Set

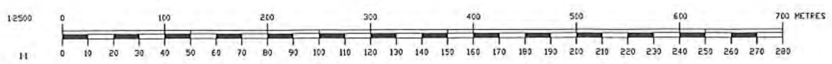


England, United Kingdom (52.53102 -1.26491)

APPENDIX 5

Land Use Data – LCM Mapping 2015

Location	Height (m)
1	26
2	28
3	33
4	34
5	43
6	27
7	33
8	39
9	33
10	39
11	45
12	42
13	40
14	37



Notes

1. The survey was carried out during March/April 2022, using Leica TS16 and GS18 instruments.
2. North relates to OS Grid North.
3. All co-ordinates relate to OS GB36 Datum at Stn 1. The rest of the site is orientated to OS Grid North but has been surveyed on a flat grid with no scale factor. All heights relate to OSGB 36 datum and have been computed using the OSTN(15) Geoid model.

LEGEND

Survey Station
IC - Inspection Cover
CA - Cable TV Cover
FH - Fire Hydrant
SV - Stop Valve
GV - Gas Valve
PB - Post Box
TCB - Call box
TC - TCSU Cover
PT - Parking Ticket Machine
ER - Earthing Rod
TB - Traffic Bollard
Litter Bin
Gully
MH - Manhole Triangular
MHC - Manhole Circular
PB - Post Box
P Gate Post
TP Telephone Pole
EP Electricity Pole
RS Road Sign (See Schedule)
TL Traffic Light
B Bollard
FP Flag Pole
LP Lamp Post
C Camera
Gate
Tree (Coniferous - girth and spread to scale)
Tree (Deciduous - girth and spread to scale)
Tree (Dead/diseased - girth and spread to scale)
Spot Level
Top of Wall Height
Apex Height
Eave Height

Kerb
Drop Kerb
Road Edge (no kerb)
Track Edge
Change of Surface
Road Centre Line
Double Yellow Lines

Wall
Fence
Edge of Hedge
Vegitation Edge
Iron Railings

Building
Apex Line
Eave Line
Parking Bay

Overhead Power Cable
Open Channel
Top of Bank
Bottom of Bank
Major Contour Interval - 1.0m
Minor Contour Interval - 0.2m

Overhead HV cable
Gas pipe alignment
Tree canopy overhang extent

rev.	amendment	date
A	Road survey added	26 May 22

WLS

Williams Land Surveys
The Everglades
Pitts Lane Isle of Wight PO33 3SU
Telephone 01983 339455
Mobile 07739743569

client
BCM

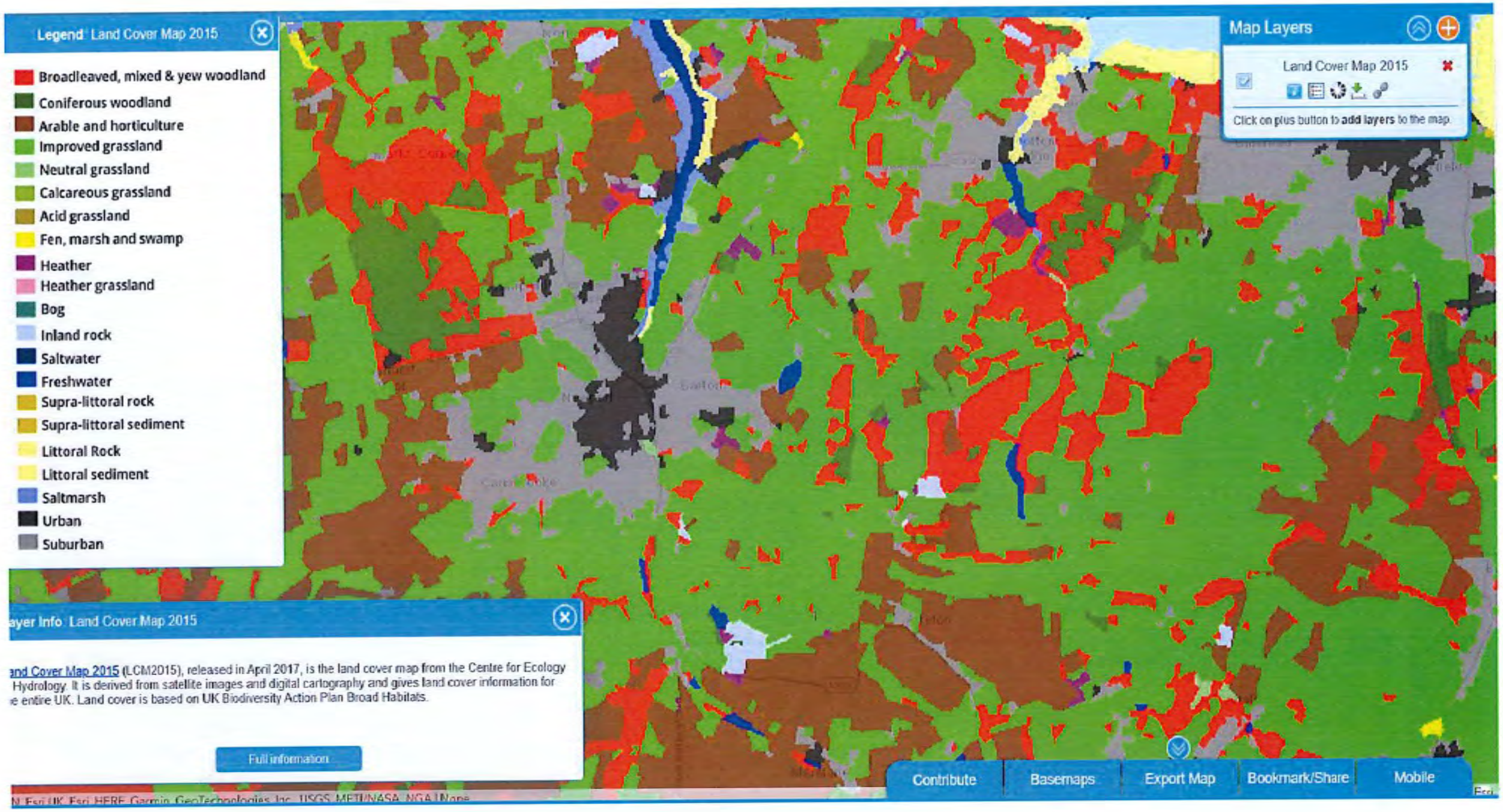
project
SUNNYOAKS PV SITE
BRIDDLESFORD WOOTTON

scale	drawn by	checked by
1:2500@a0	RPW	RPW

date	cad file
07 APRIL 2022	WLS.BCM.107.DWG

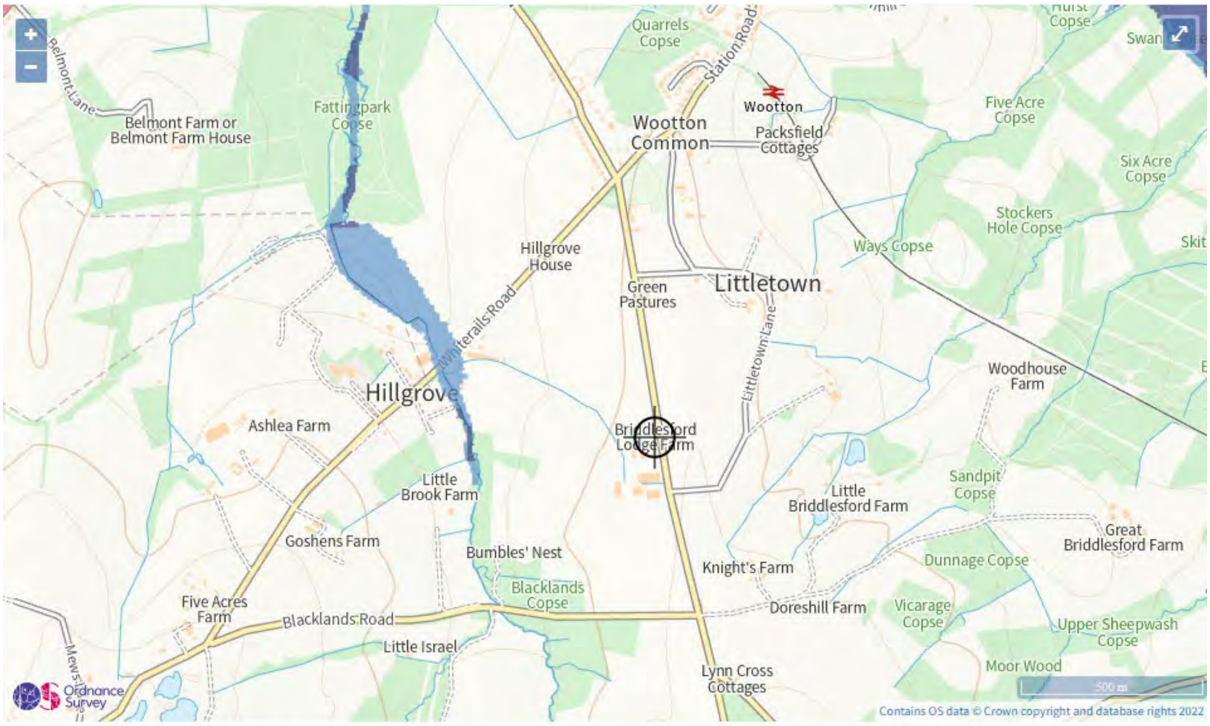
title
DETAILED TOPOGRAPHICAL
SURVEY

drawing number	rev.
WLS.BCM.107.6	A

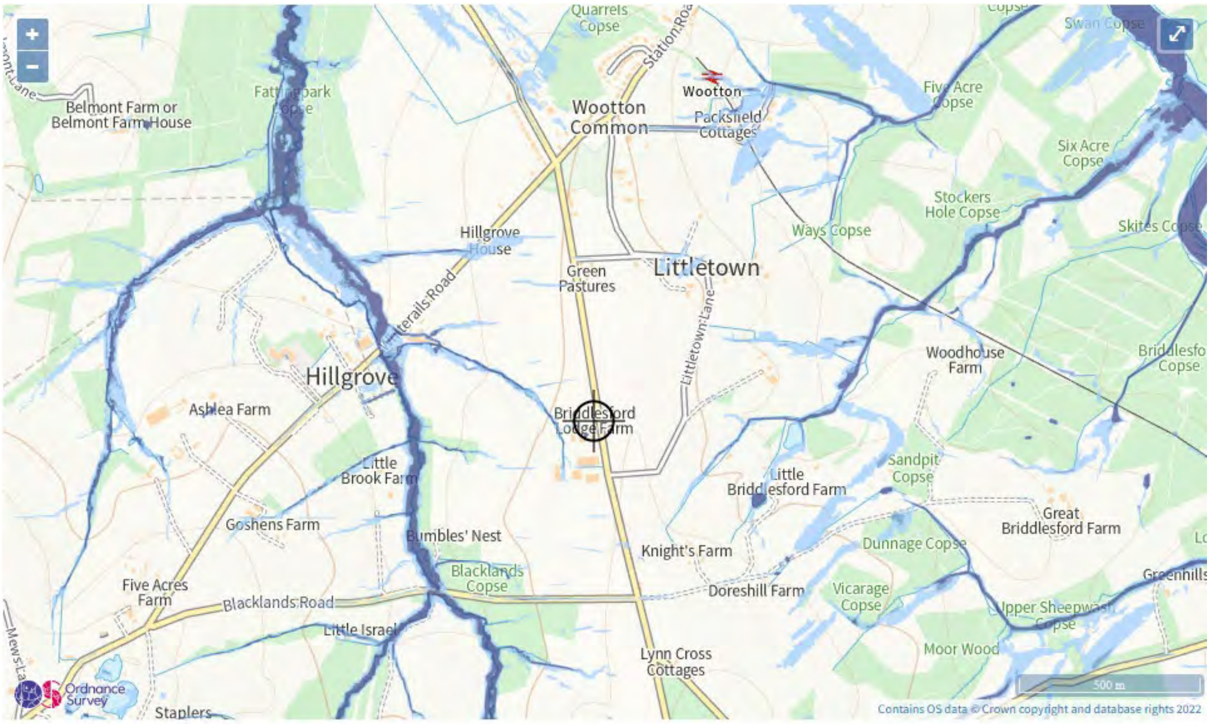

Legend: Land Cover Map 2015
Broadleaved, mixed & yew woodland
Coniferous woodland
Arable and horticulture
Improved grassland
Neutral grassland
Calcareous grassland
Acid grassland
Fen, marsh and swamp
Heather
Heather grassland
Bog
Inland rock
Saltwater
Freshwater
Supra-littoral rock
Supra-littoral sediment
Littoral Rock
Littoral sediment
Saltmarsh
Urban
Suburban
Map Layers
Land Cover Map 2015
Click on plus button to add layers to the map.
ayer Info: Land Cover Map 2015
and Cover Map 2015 (LCM2015), released in April 2017, is the land cover map from the Centre for Ecology
Hydrology. It is derived from satellite images and digital cartography and gives land cover information for
e entire UK. Land cover is based on UK Biodiversity Action Plan Broad Habitats.
Full information
Contribute
Basemaps
Export Map
Bookmark/Share
Mobile

APPENDIX 6

Flooding Data – EA Data Mapping



Extent of flooding from rivers or the sea



Extent of flooding from surface water

APPENDIX 7

Soil Analysis Results – NRM Testing Result Sheets

ANALYTICAL REPORT

Report Number	**13965-22**	**R600**	**ANALYSIS SERVICES DIRECT**	**Client BCM**
Date Received	**25-APR-2022**		**NRM LABORATORIES**	**RED BARN**
Date Reported	**18-MAY-2022**		**COOPERS BRIDGE**	**MERSTONE LANE**
Project	**SOIL**		**BRAZIERS LANE**	**MERSTONE**
Reference	**BCM**		**BRACKNELL**	**ISLE OF WIGHT**
Order Number			**BERKS**	**PO30 3DE**

Laboratory Reference		**SOIL559832**	**SOIL559833**	**SOIL559834**	**SOIL559835**	**SOIL559836**	**SOIL559837**	**SOIL559838**	**SOIL559839**	**SOIL559840**	**SOIL559841**
Sample Reference		**BRID 1**	**BRID 2**	**BRID 3**	**BRID 4**	**BRID 5**	**BRID 6**	**BRID 7**	**BRID 8**	**BRID 9**	**BRID 10**
Determinand	**Unit**	**SOIL**	**SOIL**	**SOIL**	**SOIL**	**SOIL**	**SOIL**	**SOIL**	**SOIL**	**SOIL**	**SOIL**
Textural Class		Silty Clay	Silty Clay	Clay	Silty Clay Loam	Silty Clay	Silty Clay Loam	Silty Clay Loam	Clay Loam	Silty Clay Loam	Silty Clay Loam
Sand 2.00-0.063mm	% w/w	3	11	2	9	6	12	11	21	19	11
Silt 0.063-0.002mm	% w/w	48	53	41	60	56	56	57	49	54	59
Clay <0.002mm	% w/w	49	36	57	31	38	32	32	30	27	30
Organic Matter LOI	% w/w	3.2	5.0	3.1	3.0	4.4	4.5	2.7	2.2	4.4	3.9

Notes

Analysis Notes	The sample submitted was of adequate size to complete all analysis requested. The results as reported relate only to the item(s) submitted for testing. The results are presented on a dry matter basis unless otherwise stipulated.
Document Control	**This test report shall not be reproduced, except in full, without the written approval of the laboratory.**

Reported by

Darren Whitbread
Natural Resource Management, a trading division of Cawood Scientific Ltd.
Coopers Bridge, Braziers Lane, Bracknell, Berkshire, RG42 6NS
Tel: 01344 886338
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ANALYTICAL REPORT

Report Number	**13966-22**	**R600**	**ANALYSIS SERVICES DIRECT**
Date Received	**25-APR-2022**		**NRM LABORATORIES**
Date Reported	**18-MAY-2022**		**COOPERS BRIDGE**
Project	**SOIL**		**BRAZIERS LANE**
Reference	**BCM**		**BRACKNELL**
Order Number			**BERKS**

Client BCM
RED BARN
MERSTONE LANE
MERSTONE
ISLE OF WIGHT
PO30 3DE

Laboratory Reference		**SOIL559842**	**SOIL559843**	**SOIL559844**	**SOIL559845**	**SOIL559846**	**SOIL559847**	**SOIL559848**	**SOIL559849**	**SOIL559850**	**SOIL559851**
Sample Reference		**BRID 11**	**BRID 12**	**BRID 13**	**BRID 14**	**BRID 15**	**BRID 16**	**BRID 17**	**BRID 18**	**BRID 19**	**BRID 20**
Determinand	**Unit**	**SOIL**	**SOIL**	**SOIL**	**SOIL**	**SOIL**	**SOIL**	**SOIL**	**SOIL**	**SOIL**	**SOIL**
Textural Class		Silty Clay	Silty Clay	Clay Loam	Silty Clay Loam	Silty Clay	Silty Clay	Silty Clay	Silty Clay Loam	Silty Clay	Silty Clay Loam
Sand 2.00-0.063mm	% w/w	5	8	28	14	6	7	6	17	2	11
Silt 0.063-0.002mm	% w/w	48	46	42	54	45	56	53	55	55	60
Clay <0.002mm	% w/w	47	46	30	32	49	37	41	28	43	29
Organic Matter LOI	% w/w	4.4	4.1	3.4	6.3	4.6	3.5	4.9	2.9	3.3	4.1

Notes

Analysis Notes
The sample submitted was of adequate size to complete all analysis requested.
The results as reported relate only to the item(s) submitted for testing.
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Document Control
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Reported by
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ANALYTICAL REPORT

Report Number	**13967-22**	**R600**	**ANALYSIS SERVICES DIRECT**	**Client BCM**
Date Received	**25-APR-2022**		**NRM LABORATORIES**	**RED BARN**
Date Reported	**18-MAY-2022**		**COOPERS BRIDGE**	**MERSTONE LANE**
Project	**SOIL**		**BRAZIERS LANE**	**MERSTONE**
Reference	**BCM**		**BRACKNELL**	**ISLE OF WIGHT**
Order Number			**BERKS**	**PO30 3DE**

Laboratory Reference		**SOIL559852**	**SOIL559853**	**SOIL559854**	**SOIL559855**	**SOIL559856**	**SOIL559857**	**SOIL559858**	**SOIL559859**	**SOIL559860**	**SOIL559861**
Sample Reference		**BRID 21**	**BRID 22**	**BRID 23**	**BRID 24**	**BRID 25**	**BRID 26**	**BRID 27**	**BRID 28**	**BRID 29**	**BRID 30**
Determinand	**Unit**	**SOIL**	**SOIL**	**SOIL**	**SOIL**	**SOIL**	**SOIL**	**SOIL**	**SOIL**	**SOIL**	**SOIL**
Textural Class		Silty Clay	Silty Clay Loam	Silty Clay Loam	Silty Clay Loam	Silty Clay Loam	Silty Clay Loam	Silty Clay Loam	Silty Clay	Silty Clay Loam	Silty Clay Loam
Sand 2.00-0.063mm	% w/w	7	10	10	13	15	12	14	6	13	12
Silt 0.063-0.002mm	% w/w	55	56	62	62	62	62	59	56	60	62
Clay <0.002mm	% w/w	38	34	28	25	23	26	27	38	27	26
Organic Matter LOI	% w/w	4.0	4.4	7.5	5.6	4.8	4.2	3.1	4.9	2.9	4.6

Notes

Analysis Notes

The sample submitted was of adequate size to complete all analysis requested.
The results as reported relate only to the item(s) submitted for testing.
The results are presented on a dry matter basis unless otherwise stipulated.

Document Control

Reported by

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ANALYTICAL REPORT

Report Number	**13968-22**	**R600**	**ANALYSIS SERVICES DIRECT**	**Client BCM**
Date Received	**25-APR-2022**		**NRM LABORATORIES**	**RED BARN**
Date Reported	**18-MAY-2022**		**COOPERS BRIDGE**	**MERSTONE LANE**
Project	**SOIL**		**BRAZIERS LANE**	**MERSTONE**
Reference	**BCM**		**BRACKNELL**	**ISLE OF WIGHT**
Order Number			**BERKS**	**PO30 3DE**

Laboratory Reference		**SOIL559862**	**SOIL559863**	**SOIL559864**	**SOIL559865**	**SOIL559866**	**SOIL559867**	**SOIL559868**	**SOIL559869**	**SOIL559870**	**SOIL559871**
Sample Reference		**BRID 31**	**BRID 32**	**BRID 33**	**BRID 34**	**BRID 35**	**BRID 36**	**BRID 37**	**BRID 38**	**BRID 39**	**BRID 40**
Determinand	**Unit**	**SOIL**	**SOIL**	**SOIL**	**SOIL**	**SOIL**	**SOIL**	**SOIL**	**SOIL**	**SOIL**	**SOIL**
Textural Class		Silty Clay	Silty Clay Loam	Silty Clay	Silty Clay	Silty Clay Loam	Sandy Loam	Silty Clay	Silty Clay Loam	Silty Clay	Silty Clay
Sand 2.00-0.063mm	% w/w	6	17	5	5	10	51	13	12	8	8
Silt 0.063-0.002mm	% w/w	52	57	50	51	65	31	51	54	56	55
Clay <0.002mm	% w/w	42	26	45	44	25	18	36	34	36	37
Organic Matter LOI	% w/w	4.0	3.1	6.3	4.7	3.8	3.2	3.7	4.4	4.1	6.2

Notes

Analysis Notes	The sample submitted was of adequate size to complete all analysis requested.
	The results as reported relate only to the item(s) submitted for testing.
	The results are presented on a dry matter basis unless otherwise stipulated.
Document Control	**This test report shall not be reproduced, except in full, without the written approval of the laboratory.**

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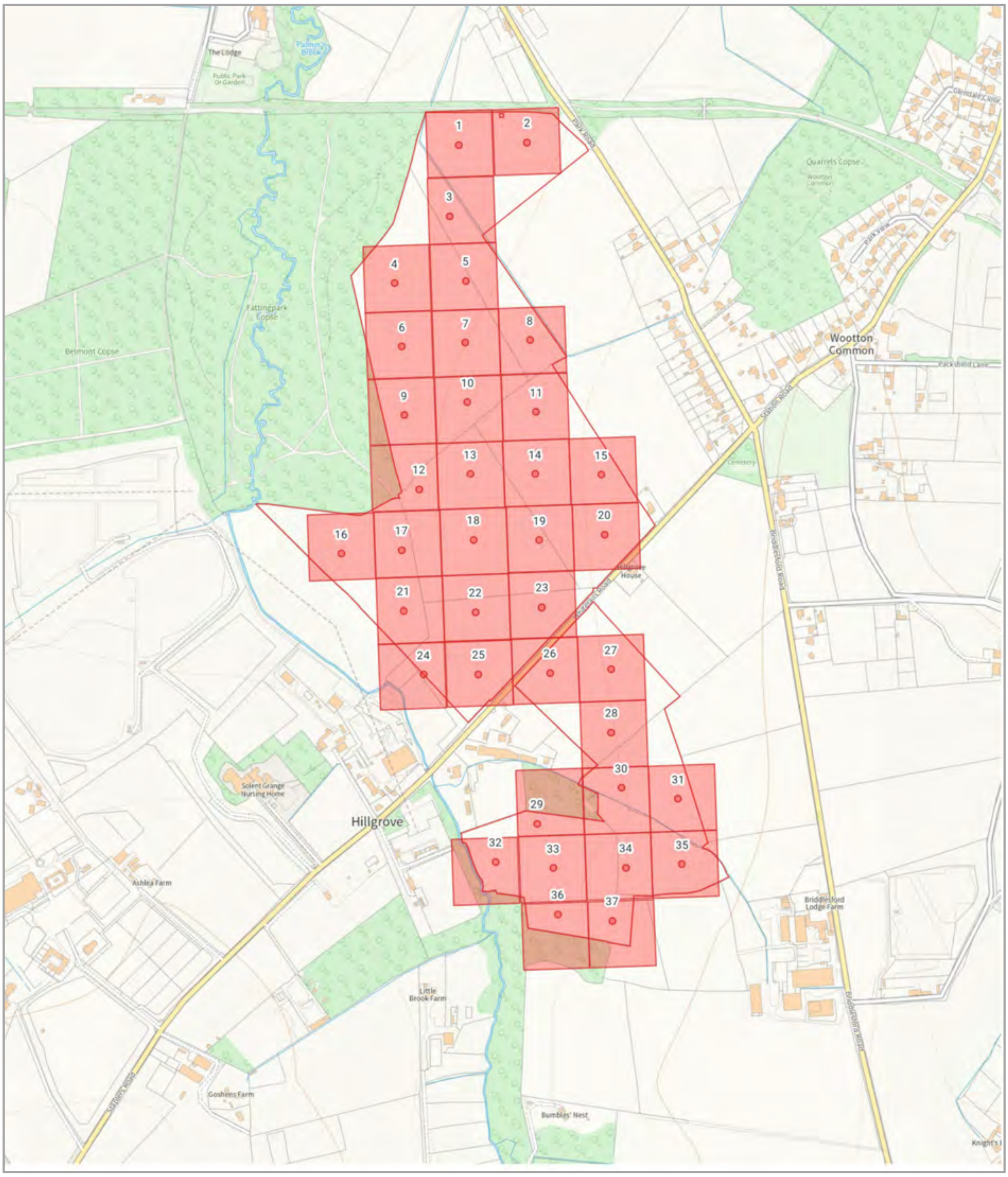
Fax: 01344 890972
email: enquiries@nrm.uk.com

APPENDIX 8

Site Map with Sampling Points



The Lodge
Public Park Or Garden
Fattingpark Copse
Belmont Copse
Quarrels Copse
Wootton Common
Park Road
Station Road
Briddlesford Road
Cemetery
Solent Grange Nursing Home
Hillgrove
Ashlea Farm
Little Brook Farm
Goshens Farm
Bumbles' Nest
Briddlesford Lodge Farm
1
2
3
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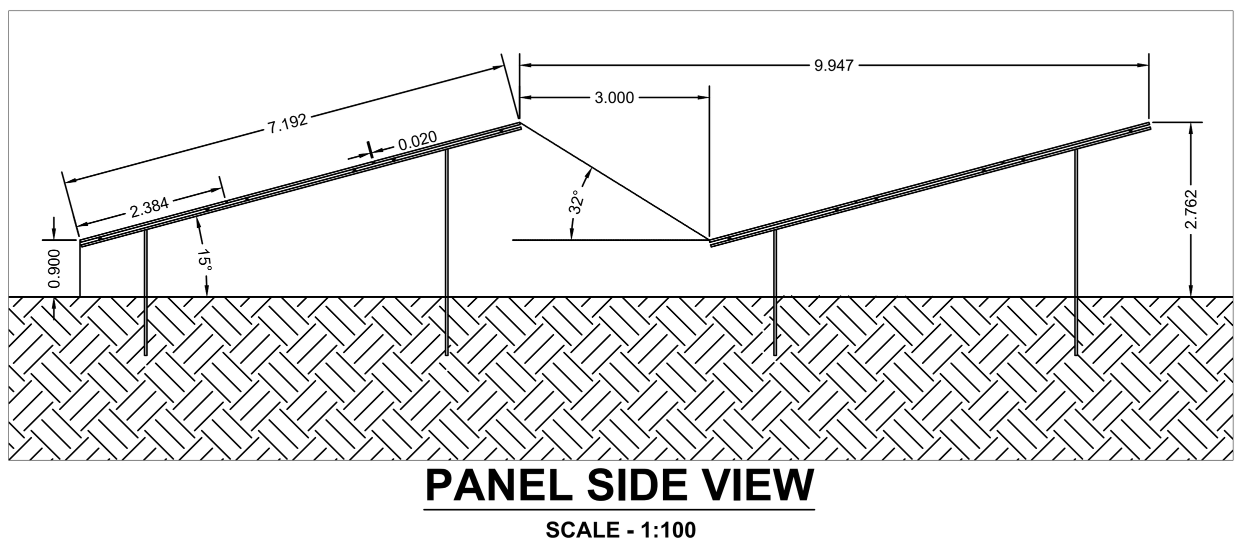
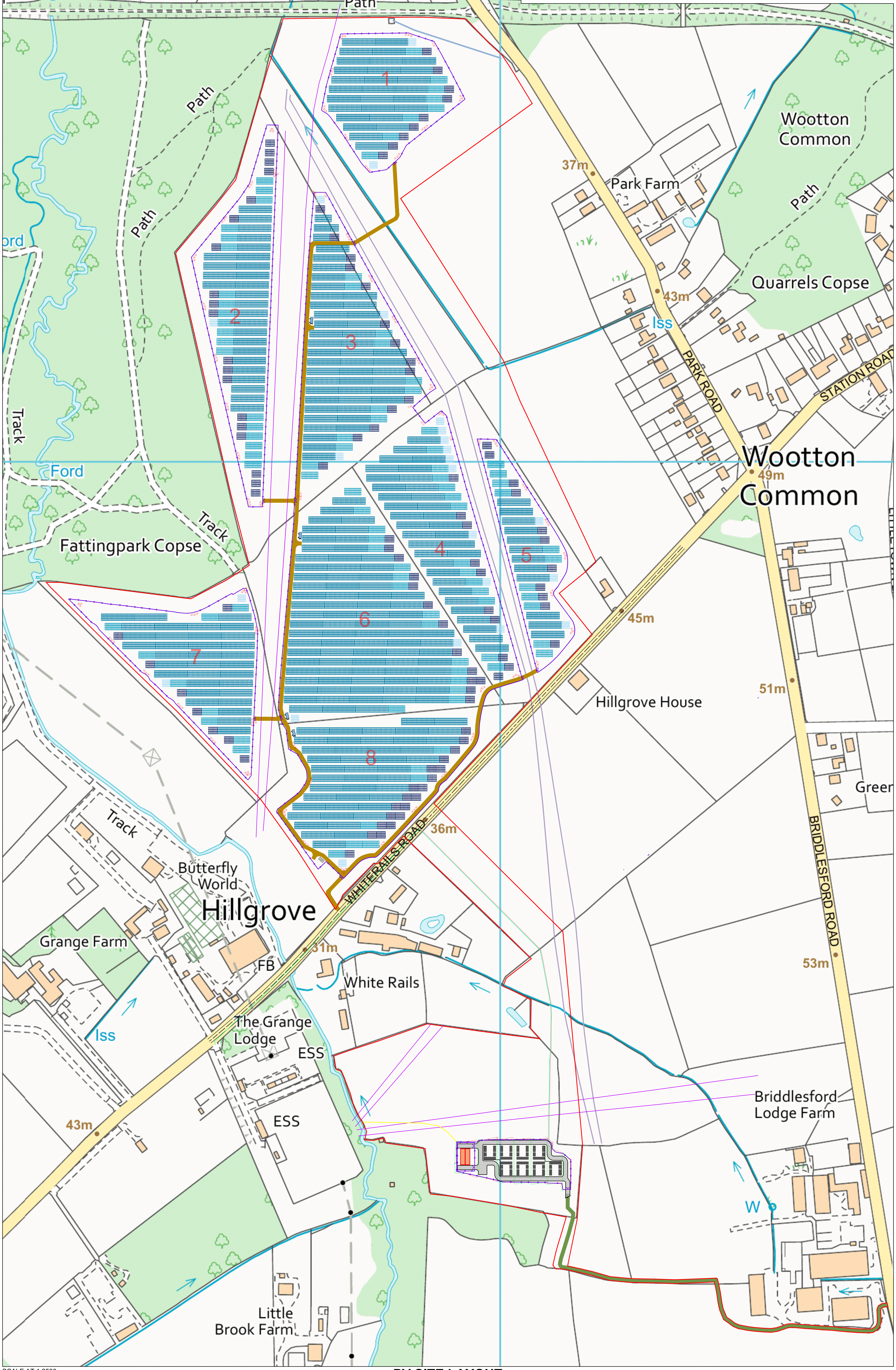


PANEL SIDE VIEW
SCALE - 1:100



PV SITE LAYOUT
SCALE - 1:2,500

NOTES:

1. ALL DIMENSIONS ARE IN METERS UNLESS NOTED OTHERWISE
2. ALL DIMENSIONS ARE INDICATIVE ONLY AND SHOULD BE CONFIRMED ON SITE PRIOR TO INSTALLATION

KEY:

- SITE BOUNDARY
- PERIMETER FENCE
- SOLAR PARK MAINTENANCE TRACKS
- ACCESS ROUTE TO BESS AND SUBSTATION
- BESS AND SUBSTATION ACCESS
- TRANSFORMER STATION
- CUSTOMER CABINET
- TABLE OF 78 MODULES (285 PCS.)
- TABLE OF 39 MODULES (93 PCS.)
- TABLE OF 21 MODULES (41 PCS.)
- TABLE OF 18 MODULES (41 PCS.)
- GATE
- SUBSTATION
- BATTERY CONTAINER/TRANSFORMERS
- 2.0M HEIGHT CCTV
- SGN INTERMEDIATE PIPELINE
- SGN MEDIUM PIPELINE
- 33KV OVERHEAD POWER LINE
- INDICATIVE ROUTE A FOR EXPORT CABLE
- INDICATIVE ROUTE B FOR EXPORT CABLE
- CABLE ROUTE FROM SOLAR PANELS TO THE BESS AND SUBSTATION

ELECTRICAL INFORMATION:

DC POWER (KWp)	20069
AC POWER (KW)	17150
MODULE TYPE	CANADIAN SOLAR CS7N-670MS (670WP)
MODULE DIMENSIONS	2384X1303X35MM
NO OF MODULES	29955
NO OF MODULES PER STRING	16
NO OF STRINGS	1584
SUBSTRUCTURE TYPE	3 MODULES IN PORTRAIT
TILT ANGLE (DEGREES)	15
SHADING ANGLE (DEGREES)	32
AZIMUTH FROM SOUTH (DEGREES)	0
INVERTER MODEL	HUAWEI SUN2000-185KTL-H1
INVERTER POWER (KW)	175
NO OF INVERTERS	98
DC/AC RATIO	1.17

ALL EQUIPMENT DETAILS ARE TO BE CONFIRMED PRIOR TO INSTALLATION

REV	DESCRIPTION	BY	CH	APP	DATE
E	SITE BOUNDARY UPDATE	GC	JL	CG	16/08/22
D	SUBSTATION AND CABLES	GC	JL	CG	15/08/22
C	INCLUSION OF CCTV	GC	JL	CG	10/08/22
B	LANDSCAPE AREA MODIF	GC	JL	CG	03/08/22
A	INITIAL DWG ISSUE	GC	JL	CG	25/07/22

CLIENT: THE RIDGE GROUP

NATURAL POWER CONSULTANTS LTD.
OCHIL HOUSE
SPRINGKERSE BUSINESS PARK
STIRLING
FK7 7XE
SCOTLAND,UK
TEL: +44 (0) 1786 542 300
WWW.NATURALPOWER.COM

IFS DOC NO.: 1288295	IFS ACTIVITY: 304.30405
SCALE: VARIOUS @ A1	SHEET NO.: 1 OF 1

STATUS: **FOR INFORMATION**

PROJECT: SUNNY OAK

DRAWING TITLE: SUNNY OAK CONCEPTUAL DESIGN

DRAWING NO.: 17432_LAY_1000

REVISION: E

APPENDIX 9

Schedule of Sampling Points with Map References and Soil Test Results

Soil Sample Results

2224-9963

		Textural Class (Unit %w/w)			
Sample Ref	Soil Type	Sand 2.00 - 0.63mm	Silt 0.63 – 0.002mm	Clay < 0.002mm	Organic Matter LOI
BRID 1	Silty Clay	3	48	49	3.2
BRID 2	Silty Clay	11	53	36	5.0
BRID 3	Clay	2	41	57	3.1
BRID 4	Silty Clay Loam	9	60	31	3.0
BRID 5	Silty Clay	6	56	38	4.4
BRID 6	Silty Clay Loam	12	56	32	4.5
BRID 7	Silty Clay Loam	11	57	32	2.7
BRID 8	Clay Loam	21	49	30	2.2
BRID 9	Silty Clay Loam	19	54	27	4.4
BRID 10	Silty Clay Loam	11	59	30	3.9
BRID 11	Silty Clay	5	48	47	4.4
BRID 12	Silty Clay	8	46	46	4.1
BRID 13	Clay Loam	28	42	30	3.4
BRID 14	Silty Clay Loam	14	54	32	6.3
BRID 15	Silty Clay	6	45	49	4.6
BRID 16	Silty Clay	7	56	37	3.5
BRID 17	Silty Clay	6	53	41	4.9
BRID 18	Silty Clay Loam	17	55	28	2.9
BRID 19	Silty Clay	2	55	43	3.3
BRID 20	Silty Clay Loam	11	60	29	4.1
BRID 21	Silty Clay	7	55	38	4.0

Soil Sample Results

2224-9963

		Textural Class (Unit %w/w)			
Sample Ref	**Soil Type**	**Sand 2.00 - 0.63mm**	**Silt 0.63 – 0.002mm**	**Clay < 0.002mm**	**Organic Matter LOI**
BRID 22	Silty Clay Loam	10	56	34	4.4
BRID 23	Silty Clay Loam	10	62	28	7.5
BRID 24	Silty Clay Loam	13	62	25	5.6
BRID 25	Silty Clay Loam	15	62	23	4.8
BRID 26	Silty Clay Loam	12	62	26	4.2
BRID 27	Silty Clay Loam	14	59	27	3.1
BRID 28	Silty Clay	6	56	38	4.9
BRID 29	Silty Clay Loam	13	60	27	2.9
BRID 30	Silty Clay Loam	12	62	26	4.6
BRID 31	Silty Clay	6	52	42	4.0
BRID 32	Silty Clay Loam	17	57	26	3.1
BRID 33	Silty Clay	5	50	45	6.3
BRID 34	Silty Clay	5	51	44	4.7
BRID 35	Silty Clay Loam	10	65	25	3.8
BRID 36	Sandy Loam	51	31	18	3.2
BRID 37	Silty Clay	13	51	36	3.7
BRID 38	Silty Clay Loam	12	54	34	4.4
BRID 39	Silty Clay	8	56	36	4.1
BRID 40	Silty Clay	8	55	37	6.2

A P P E N D I X 10

Photographic Record – Site

 Depth on Auger at BRID 34	 Depth on Auger at BRID 34
 BRID 32	 BRID 32
 Condition at BRID 12, 13, 18 & 19	 Waterlogged/Surface water land at BRID 11, 14, 15 & 20

APPENDIX 11

Photographic Record – Sampling Points
(Representative number)

Sample Depth at BRID 3

Soil Type Change at BRID 8