Land at Bardling's Drove, Sutton St James, Lincs:

The Soil Resources and Agricultural Land Classification

Survey and Report by
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NOTE BY BE RENEWABLES LIMITED

This planning application is a resubmission of the documents for planning application ref: H20-0017-14 which was unanimously rejected at the South Holland District Council (SHDC) Planning Committee Meeting under Decision Notice dated 11th July 2014.

Following the rejection of the application – BE Renewables Limited (BERL) held a meeting with SHDC's Mr Richard Fidler and Mr Paul Jackson. BERL proposed an amended development boundary. It was agreed that rather than proceed to an appeal against the rejection of the previous planning application, BERL would prepare a revised scheme based upon the amended boundary for consideration by SHDC Planning Department and subsequent Planning Committee.

This report was prepared to accompany and assess the area of land associated within the development land boundary area for the previously submitted application. As this is a resubmission, with an amended development boundary (a reduced area from within the original boundary) it is appropriate to retain the use of this ALC survey and the analysis.

Please note: BERL has **not** changed or amended any of the survey assessments or ALC conclusions.

The report is submitted simply to accompany the amended planning application as the overall findings are still relevant and applicable to the resubmission.

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EXECUTIVE SUMMARIES

The Soil Resources

A soil survey of 'silt' fenland between Bardling's Drove in the north, Old Fen Dike in the east and Broad Gate to the south in the parish of Sutton St James, Lincs., was undertaken in March 2014 on a site of a proposed development project for a photo-voltaic panel farm, 'Fenndyke Solar Farm' (Map 1). The Site was in arable production cropped with winter wheat at the time of survey. There was surface ponding observed in low places in the fields in the western part of the Site.

The solid geological strata of Ampthill Clay mudstones are entirely covered by Quaternary deposits from the Post-glacial period – variable thicknesses of marginal-marine and estuarine silts and clays deposited during a marine transgression into The Wash bay and across much of the Fenland. The silts and clays are here classed as 'Terrington Beds' saltmarsh and tidal creek deposits by the British Geological Survey. Very thin freshwater organic layers occur within some of the clays.

The Site totals about 33 ha divided into four rectangular fields and lies between +2.4 m OD on a low ridge in the east, and +0.7 m OD in the concave parts of the fields in the centre and west (Map 4).

Hand auger borings were made to depths of 1.20 to 1.90 metres at a total of 36 investigation sites arranged at the intersects of a 100-m grid to avoid bias in selecting sites to study (Map 5). The key soil profile data are summarised in tabular format (Appendix 3, Table A3.1).

As an illustrative aid to explaining and understanding the soil resources, a cross-section transect is presented showing soil profile characteristics in detail (Figure 2). The formation and implications of slowly permeable layers (SPL), stratigraphical relationships and strongly acid subsoils are discussed.

The findings are refinements of reconnaissance (1:250,000-scale) and semi-detailed (1:50,000-scale) soil maps published by the Soil Survey of England and Wales (later the Soil Survey and Land Research Centre) (Maps 3 & 4), and agree with those soil distributions but offer a more detailed view.

Agricultural Land Classification (ALC)

The 'silt' fens are traditionally an area of excellent land quality (Grade 1 in the ALC scheme) on the light silts and very good land quality (Grade 2) on the medium silts; both are noted for being able to grow a wide range of high-value crops. South Holland District has almost exclusively land in these two classes (Map 6) at the 1:250,000 scale of the 'Provisional' ALC map published before the soil surveys were undertaken. The investigation of the soil resources at one soil profile observation per hectare has enabled a more detailed land quality assessment to be made.

Following the guidelines and criteria for classification published by MAFF in 1988, there are no climatic, site and direct soil limitations to agricultural use. Soil interactive limitations for wetness and topsoil texture, and droughtiness for the standard wheat and potato crops are limiting in various degrees, from Grade 2 to Subgrade 3a, good quality land, and to Subgrade 3b moderate quality land (Map 7).

Of the total 32.56 ha the division into the Grades and Subgrades is given below (Table 5):

Grade	ha	%
1	3.14	9.64
2	8.10	24.88
3a	5.26	16.15
3b	16.06	49.32

32.56	100.00

Best and most versatile land (BMV) is defined as Grades 1, 2 and 3a and this comprises 16.50 ha or 50.68% of the proposed Site. Land in Subgrade 3b with some inclusions of 3a occurs on low-lying ground in the centre and west, while better quality Grade 1 and Grade 2 land is largely confined to higher ground in the east. The proposed development constitutes a 'soft' use where the land can be easily returned to agriculture.

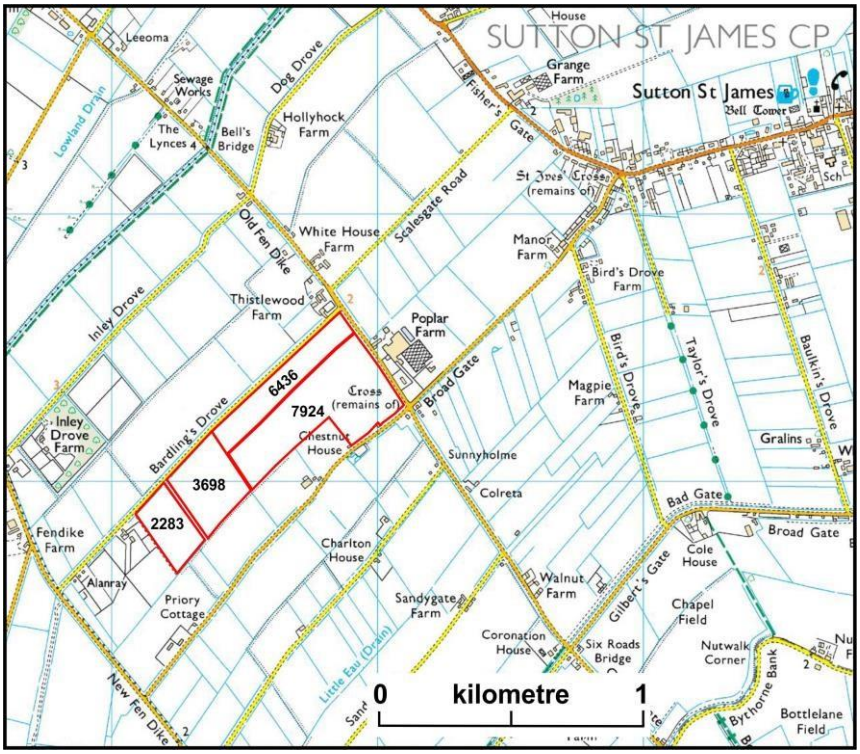
FENNDYKE SOLAR LIMITED

The SOIL RESOURCES and AGRICULTURAL LAND CLASSIFICATION of land at Bardling's Drove, Sutton St James, Lincs.

Rodney Burton, Cambridge, March 2014

1. INTRODUCTION

Independent soils consultant Rodney Burton was commissioned in March 2014 by Fenndyke Solar Limited, to undertake a study of about 33 ha in one block of fields adjacent to Bardling's Drove in the parish of Sutton St James in South Holland, Lincolnshire (Map 1). It lies between 0.7 and 1.4 miles (1.2–2.2 km) south west of the main settlement of Sutton St James. Bardling's Drove is accessed from the west along New Fen Dike and from the east along Old Fen Dike. The block of land is centred at Ordnance Survey (OS) Grid Ref. TF 3750 1750 (easting 537500, northing 317100) and is divided into four rectangular fields.



Map 1. Location of the proposed solar farm in the numbered fields outlined in red.
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The land was entirely down to winter wheat except for a thin strip of maize cover in Field 3698. At the time of the survey there was surface ponding observed in low places in the fields in the central and western parts of the Site (Photos 1–3). Higher land in Fields 6436 and 7924 at the north-eastern end of the Site was without this wet surface (Photo 4).



Photo 1. Field 2283, view SE from bore 2.



Photo 2. Field 3698, view S from near Bardling's Drove.



Photo 3. Field 7924, view NE from bore 14 towards higher ground.



Photo 4. Field 7924, view NE from bore 2 towards Old Fen Dike on some of the highest ground.

Monthly rainfall totals provided online by North Level IDB (2014) for nearby Sutton St Edmund show the preceding October and January to have been very wet, as follows:

2013	Oct	Nov	Dec	*2014*	Jan	Feb	
	106	47	23		98	51	mm

The main purpose of the study is to determine the '**Agricultural Land Classification (ALC) Grade**' at the proposed solar farm Site for planning purposes. An examination of the wider '**soil resources**' related to the national soil classification scheme would allow direct comparisons of the soils with other areas within South Holland District that have been surveyed. Additionally, investigations of the deeper stratigraphy below the standard depth of 1.2 metres would give a clearer understanding of the distribution and relationships of soils across the Site, and hence land Grades, through knowledge of the processes of deposition and land formation, and also help inform the project.

2. BACKGROUND INFORMATION

2.1 Geology

The Site is mainly situated on low-lying ground to the south of the broad ridge of the 'Townlands' upon which the main settlements have been long established. In some parts of the 'Silt Fens' such an area is referred to as 'Lowgrounds'.

The '**solid geology**', which nowhere crops out at the ground surface in the district because of a thick cover of drift, consists of Ampthill Clay mudstones of Jurassic age.

The '**drift geology**' consists of Quaternary deposits from the Post-glacial (Flandrian) period. These are variable thicknesses of marginal-marine and estuarine silts and clays deposited during a later marine transgression into The Wash bay and across much of the northern Fenland. The silts and clays are here classed as '**Terrington Beds**' saltmarsh and tidal creek deposits by the British Geological Survey (BGS). Very thin freshwater organic layers occur within and between some of the clays. These beds overlie the **Fen Clay** (Barroway Drove Beds of BGS) deposited by one or more earlier marine transgressions, commonly with a distinct band of freshwater **peat** separating them. A detailed view of the recent geology and stratigraphy of Fenland has been given by Waller (1994).

In plan, the Fen Clay has a dendritic pattern of raised, sinuous '**roddons**' or '**silt hills**', which represent the levées and eventual silty infilling material of the former creek systems draining the former marsh. Figure 1 is a cross-section through a typical sequence where the Terrington Beds are thin over Fen Clay to show the relationship of the deposits expected in the area being studied – light silts (ZL and fSL) on and beneath the roddon ridges, medium silts (ZCL) on the roddon flanks, and clays (ZC) in the low-lying former marsh areas. In places the roddon ridge contains a small, final channel which allowed more clayey material to cap the ridge.

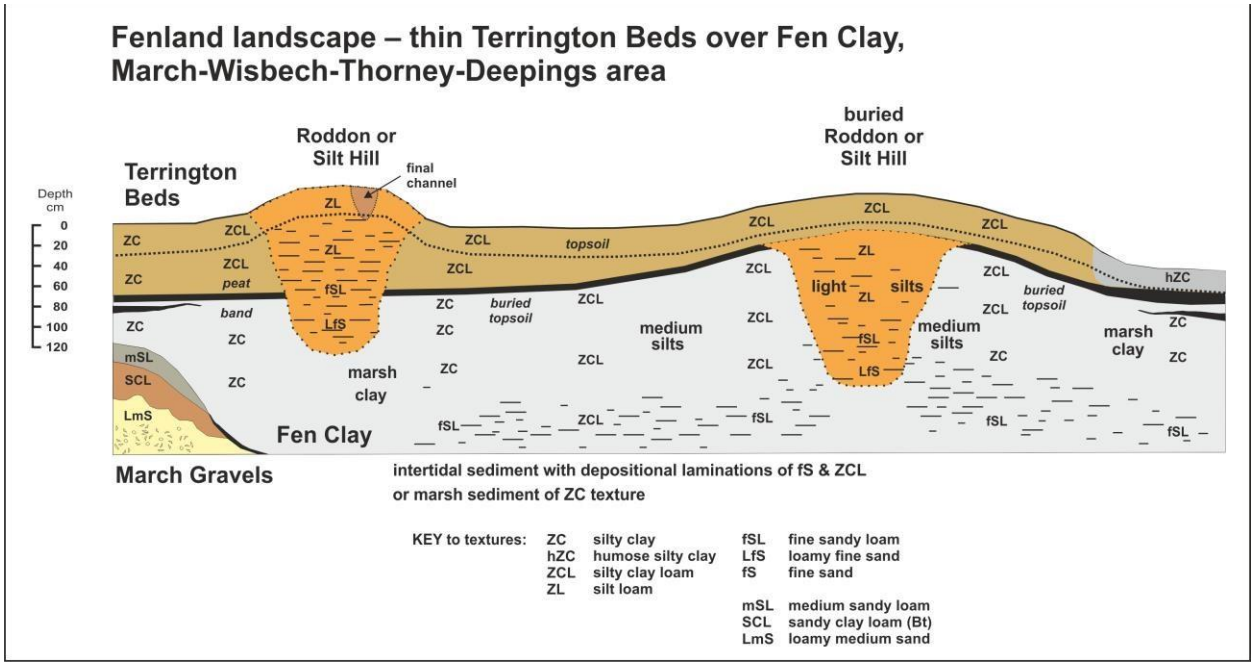


Figure 1. Geological cross-section through a typical sequence of Fenland deposits in the South Holland- North Cambs area.

The two main clay divisions can usually be separated on colour with the older Fen Clay being dominantly grey with rusty-coloured mottles and the Terrington Beds more brownish with reddish ferruginous mottles around vertical pores and channels. In nearby Tydd St Giles Fen (TF 390

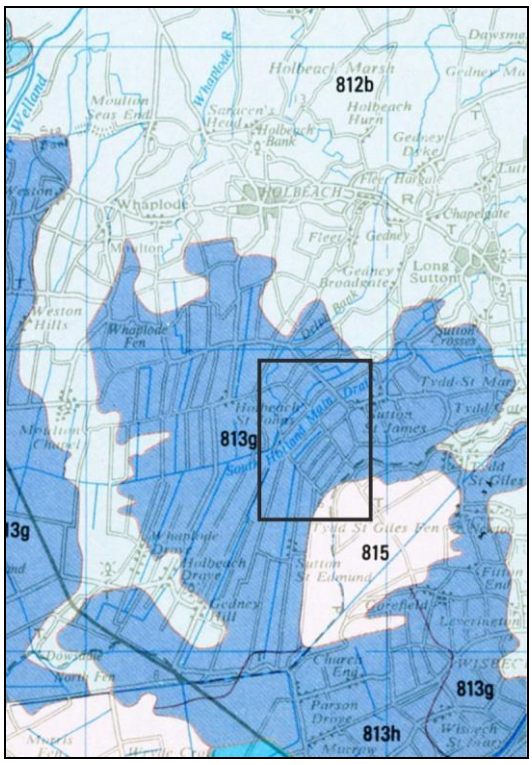
145) an enclave of Fen Clay exists where the peat was sufficiently thick to prevent deposition of any overlying Terrington Beds marsh clay (as in the right margin of Figure 1).

2.2 Soils

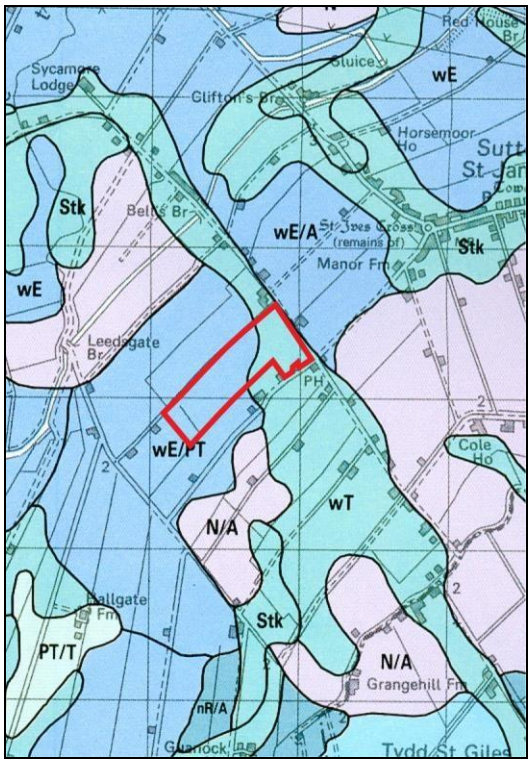
Two published soil information sources were consulted prior to the field survey:

- the reconnaissance map '*Soils of England and Wales, Sheet 4 Eastern England*', (SSEW 1983) at 1:250,000 scale (Map 2) and the accompanying book '*Soils and their use in Eastern England*' (Hodge *et al.* 1984);

- the semi-detailed map '*Soils of the Boston and Spalding district, Sheet 131*' (Burton *et al.* 1989) at 1:50,000 scale (Map 3) and the accompanying book of the same name (Robson 1990);



Map 2. Extract from the soil map 'Soils of England and Wales, Sheet 4 Eastern England' © SSEW 1983, extent of Map 3 shown by the rectangle.



Map 3. Extract from the soil map 'Soils of the and Boston and Spalding district' © Cranfield University with the 1989, showing the location of the Site outlined in red.

The reconnaissance soil map (Map 2) shows the 'light silts' on the higher 'townlands' in the north mapped as 812b Wisbech association, and the lower-lying ground to the south, where the study Site is situated in the centre of the rectangle, as 813g Wallasea 2 association. The dominant soil in this association is Wallasea series, a non-calcareous clayey soil in marine alluvium with ancillary calcareous clayey soils and calcareous silty soils on low ridges (known locally as roddons or silt hills).

In the map legend the soils are described thus:

Map Symb	Soil Association	Ancillary subgroups and soil series	Geology	Soil and site characteristics	Cropping and Land Use

813g	WALLASEA 2	814 Newchurch 532 Blacktoft 812 Wisbech	Marine alluvium	Deep stoneless clayey soils, calcareous in places. Some deep calcareous silty soils. Flat land often with low ridges giving a complex soil pattern. Groundwater controlled by ditches and pumps.	Winter cereals and some sugar beet. potatoes. cereals and field vegetables.

In the later semi-detailed soil map (Map 3), following a more intensive field survey supported by a study of aerial photographs, the large Wallasea 2 association within the rectangle has been subdivided into its component parts. There are two soil map units that occupy the Site outlined in red, labelled wE/PT and wT. Even at this scale the complex soil pattern cannot be delimited by single soil types (called soil series), as wE/PT represents two of a range of series, **wE** for the clayey **Wallasea series** and **PT** for the **Pepperthorpe series** in medium silts, the main soils for low areas and the minor roddon ridges, respectively. The area labelled **wT** in the east has soils of the **Wisbech series** with deep light silts on a larger roddon ridge.

The definitions of the main soil types in the SSEW classification are as follows:

8.1 Alluvial gley soils

8.11 Typical alluvial gley soils
PEPPERTHORPE series PT
medium silty over clayey marine alluvium

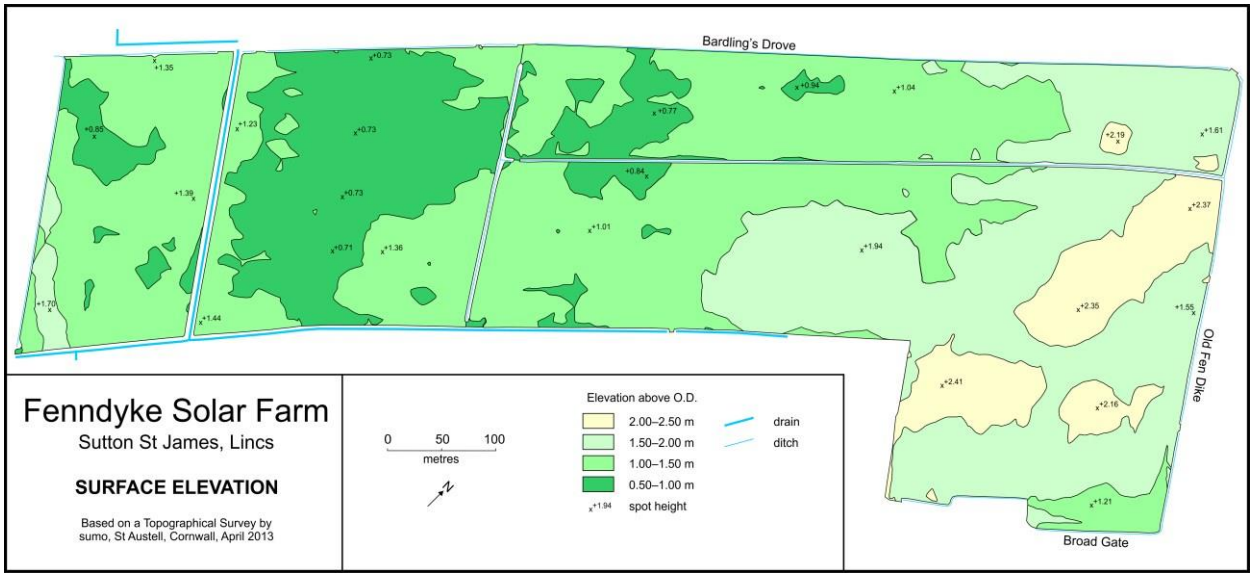
8.12 Calcareous alluvial gley soils
WISBECH series wT
light silty marine alluvium

8.13 Pelo-alluvial gley soils
WALLASEA series wE clayey marine alluvium

(the full range of soil types found during the survey is explained in Appendix 3)

2.3 Topography

A topographical survey for Fenndyke Solar Limited has been reproduced in Map 4, with contours at half-metre intervals and spot heights at elevation extremes within each delineation.

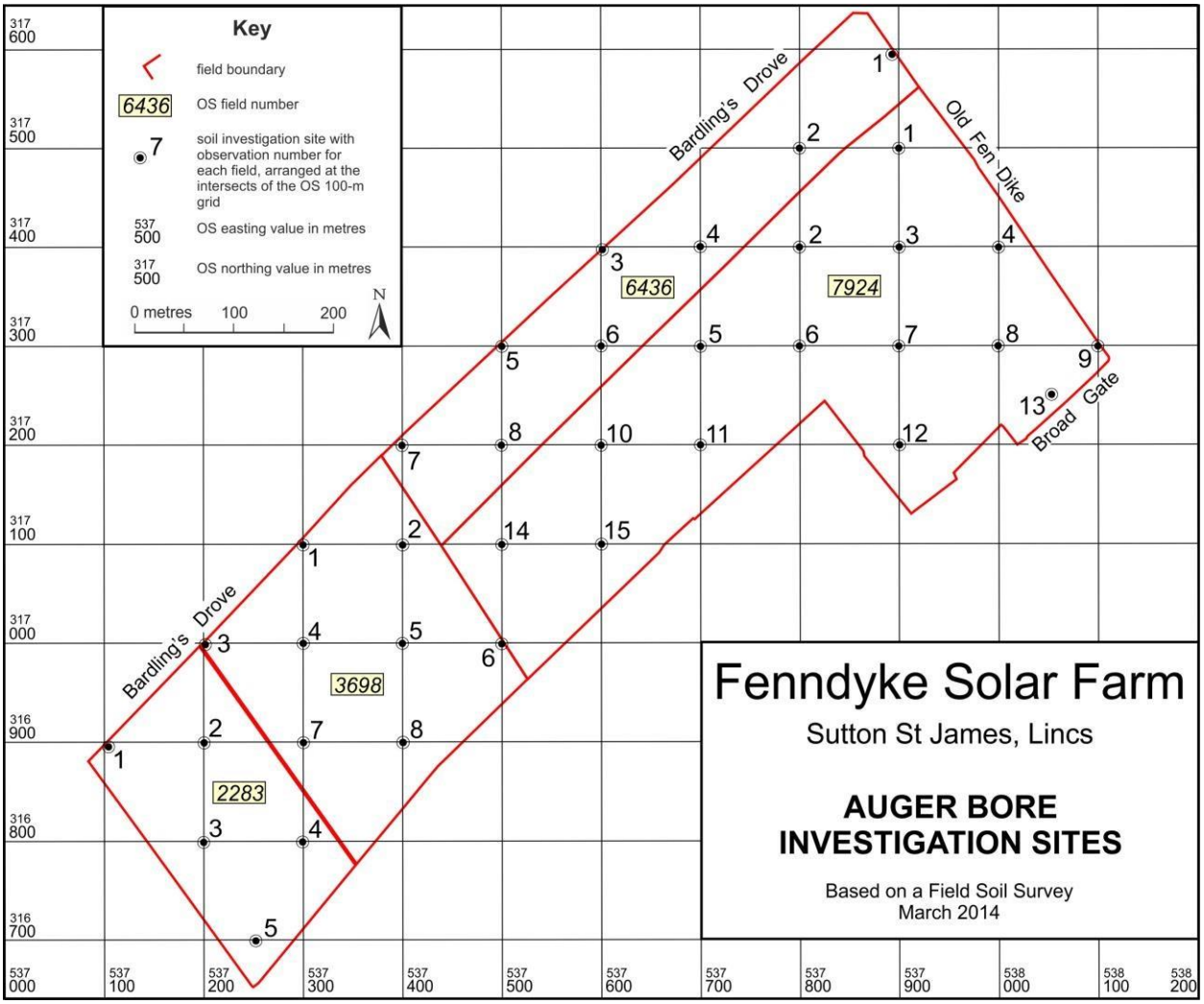


Map 4. Ground surface elevation determined by topographical survey.

A roddon ridge forming the highest ground can be clearly seen extending north–south at the north-eastern end of the Site, outlined by the 2-metre contour. The 1.5-metre contour separates the higher, drier ground in the north east and on a minor roddon ridge in Field 2283 in the south west. The lowest land is between +0.5 and +1.0 metres and highlights the areas where most of the surface ponding was seen in March 2014. As well as rain falling directly on to the ground here, these low spots receive surface and sub-surface runoff from the surrounding higher areas. The highest point of the Site is at 2.41 m OD and the lowest at 0.71 m OD.

3. METHODS

The investigation approach has been to undertake a survey at the 100-metre intersects of the Ordnance Survey's national grid with at least one observation point per hectare to give an unbiased, independent assessment without subjective selection of points to study; this has generated 36 points in total (Map 5). Some investigation points falling in ditches or just outside of the area of interest have been moved slightly into the adjacent field.



Map 5. Plan of the site showing the location of the 36 auger bore investigation points.

Points were located in the field using a Garmin etrex 30 hand-held GPS receiver accurate to within 2–5 metres. At each point the upper 120 cm were sampled using a 4-cm-wide Edelman (Dutch) auger and below this, a 25-mm wide, 1-metre long gouge auger to depths up to 190 cm to enable an understanding of the stratigraphy and relationship to the soils.

At each investigation point a record was made of the **depths** and **soil profile characteristics** for each distinctive layer. Descriptions and interpretations followed the methods laid down in the Soil Survey Field Handbook (Hodgson 1997), with special reference made to the requirements of the Agricultural Land Classification criteria and guidelines (MAFF 1988). Brief explanations of terminology are given in Appendix 1.

Soil **texture** was determined by hand texturing by an experienced operative, rubbing a moist sample of soil between the thumb and fingers to detect proportions of sand, silt, clay and organic matter.

Soil and mottle **colours** were compared with the Munsell Color Charts.

Calcium carbonate content was assessed by applying weak (10%) hydrochloric acid, observing the effervescence and relating this to the scheme in the Soil Survey Field Handbook (p.66).

Subsoils were sampled that appeared to be strongly acid based on the occurrence of yellow mottles of the basic sulphate 'jarosite'. Such soil layers may reduce rooting depth or have an

environmental impact following draining. Field-moist samples for **pH determination** were collected in a small polythene bag and evaluated by a 'field method', a 1:1 soil:deionised water ratio slurry measured using a Lutron PH-212 digital pH meter. Results were recorded to two decimal places and rounded to one decimal place.

Special note was made of the depth to a **slowly permeable layer (SPL)** and its thickness, for determining soil **Wetness Class** (Appendix 1). At each point a record was also made of the stabilised **water-table** height after boring; below the ground surface this is prefixed by a – sign.

All depth measurements can be related to ground surface **elevation** (Map 4) above Ordnance Datum (OD), using spot heights recorded in the topographical survey.

4. RESULTS

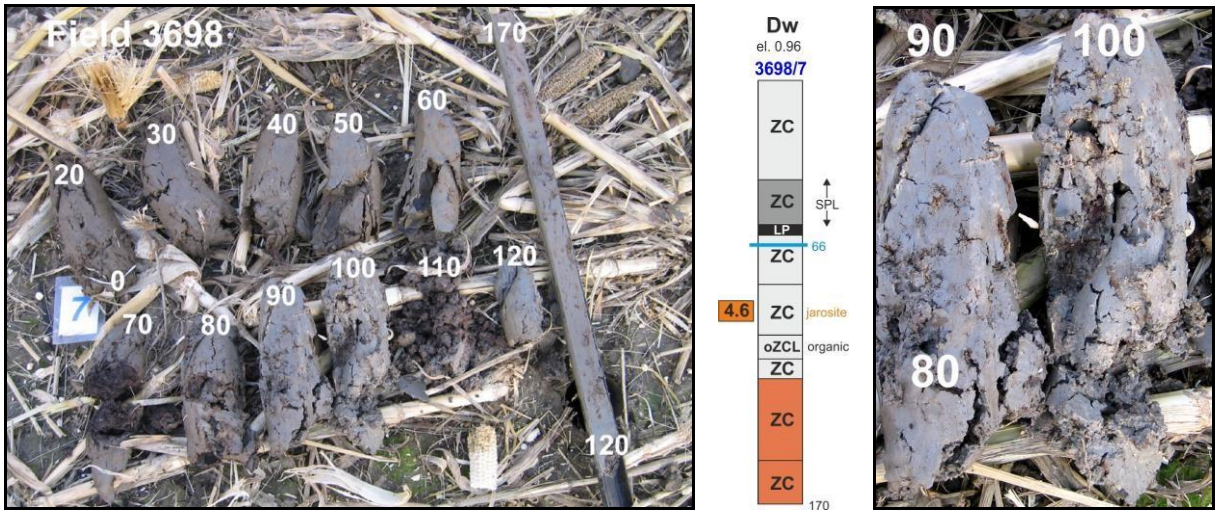
The remainder of the Report is in two sections. Firstly there follows an assessment of the **Soil Resources**, including topsoil texture, the texture of successive layers down the soil profile, calcareousness, acidity and the depth to clay, gleying and to a slowly permeable layer. Each soil profile is allocated a soil series name from the classification scheme devised by the Soil Survey of England and Wales allowing easy comparison with soil types recorded elsewhere. The soil resource components are also relevant to the **Agricultural Land Classification** assessment, which forms the second part of the Report, and which has additional specific criteria to be considered. Data for both are tabulated in Appendix 3.

4.1 The Soil Resources

4.1.1 The Soil Profile

At each soil investigation site the samples extracted by Dutch auger were arranged on the soil surface for detailed examination; most were photographed along with the soil surface from above and the landscape (light levels permitting).

Photo 5 is an example of a clayey soil of **Dowels series** (symbol **Dw**) with the soil surface at 0.96 m OD. The textures are silty clay (ZC) throughout except for a peaty and an organic band at 58–62 and 102–112 cm, respectively. Above 120 cm the colours are dominantly grey (5Y5/1 Munsell colour code) and below 120 cm a brownish grey (7.5YR5/1 to 4/3) with strong brown (7.5YR5/8) and yellowish red (5YR5/8) mottles. The topsoil (plough layer) is 40 cm thick. Between 40 and 58 cm depth a grey, very firm, slowly permeable layer (SPL) has poor, massive structure with few mottles or fissures and no channels. In the lower subsoil, below 62 cm depth, the silty clays are more open with common vertical channels lined with ferruginous mottles, with moderately weak strength.



(a) (b) (c)

Photo 5. (a) Soil auger samples arranged on the soil surface in Field 3698, site 7. The first sample is labelled 0-20 representing the top 20 cm from the ground surface; following samples are in 10-cm increments down to 120 cm and labelled with their lower depth accordingly. The dense, grey Slowly Permeable Layer (SPL) occurs between 40 and 58 cm depth. On the right of the main picture is a deep sample from 120 to 170 cm still in place in the gouge auger. (b) The soil profile presented diagrammatically with a measured pH of 4.6 (moderately acid) where jarosite occurs at 80–100 cm and the extent of the SPL shown. (c) a close-up of the zone of yellow mottles of jarosite formed in fissures and channels in the more open silty clay.

At the other end of the spectrum are soils of the **Wisbech series** (symbol **wT**) that only occur on the roddon ridge at the north-eastern end of the Site. Photo 6 shows a similarly arranged profile with yellowish brown colours with faint mottling between the base of the topsoil at 37 cm depth and 92 cm. The whole profile is friable with moderately weak soil strength, permeable with no slowly permeable layer, and calcareous throughout. The textures are classed as light silty with a silt loam plough layer over a fine sandy loam upper subsoil and a loamy fine sand lower subsoil. The water table stood at 86 cm and the soil material in the gouge auger can be seen to be runny.

Photo 7 shows the cultivated soil surface to have some residual small cobbles which have slaked with the wet winter weather and then capped as the surface dried out.



Photo 6. A light silty soil from bore 7924/7 on the roddon ridge at 1.96 m OD elevation.



Photo 7. The slaked soil surface at site 7924/7.

An example of an intermediate soil profile between deep clays and light silts is given in Photo 8. The soil type is **Pepperthorpe series** (**PT**) which has a medium silty (silty clay loam) topsoil and upper subsoil over a clayey lower subsoil. The slowly permeable layer (SPL) is naturally formed and not created by mechanical compaction as it starts at the top of the lower subsoil at 58 cm

depth, beyond the influence of trafficking. The soil surface condition in Photo 9 reflects the heavy silty clay loam texture which is more likely to suffer compaction when trafficked.

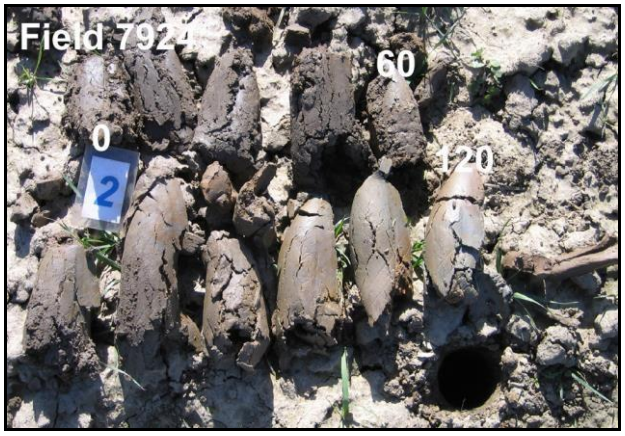


Photo 8. A heavy silty clay loam texture extends to 58 cm depth where a slowly permeable massive silty clay lower subsoil supports a water table at 55 cm.



Photo 9. The more resilient cobbles of this medium silty topsoil have slaked and capped to a lesser extent than in the light silts.

Other intermediate soils occur where medium silts are deep or overlie light silts, usually in areas flanking the main roddon ridge.

4.1.2 Soil Distribution

A distribution map of the soil series has not been produced for this study, however, a transect of soil profile diagrams has been compiled to illustrate the relationships between the soils and relief (Figure 2).

Several features can be noted from the Figure:

- the roddon ridge (bore 7924/1) has deep, calcareous light silty soils;
- apart from the roddon ridge, marsh clays form the lower subsoil across most of the site;

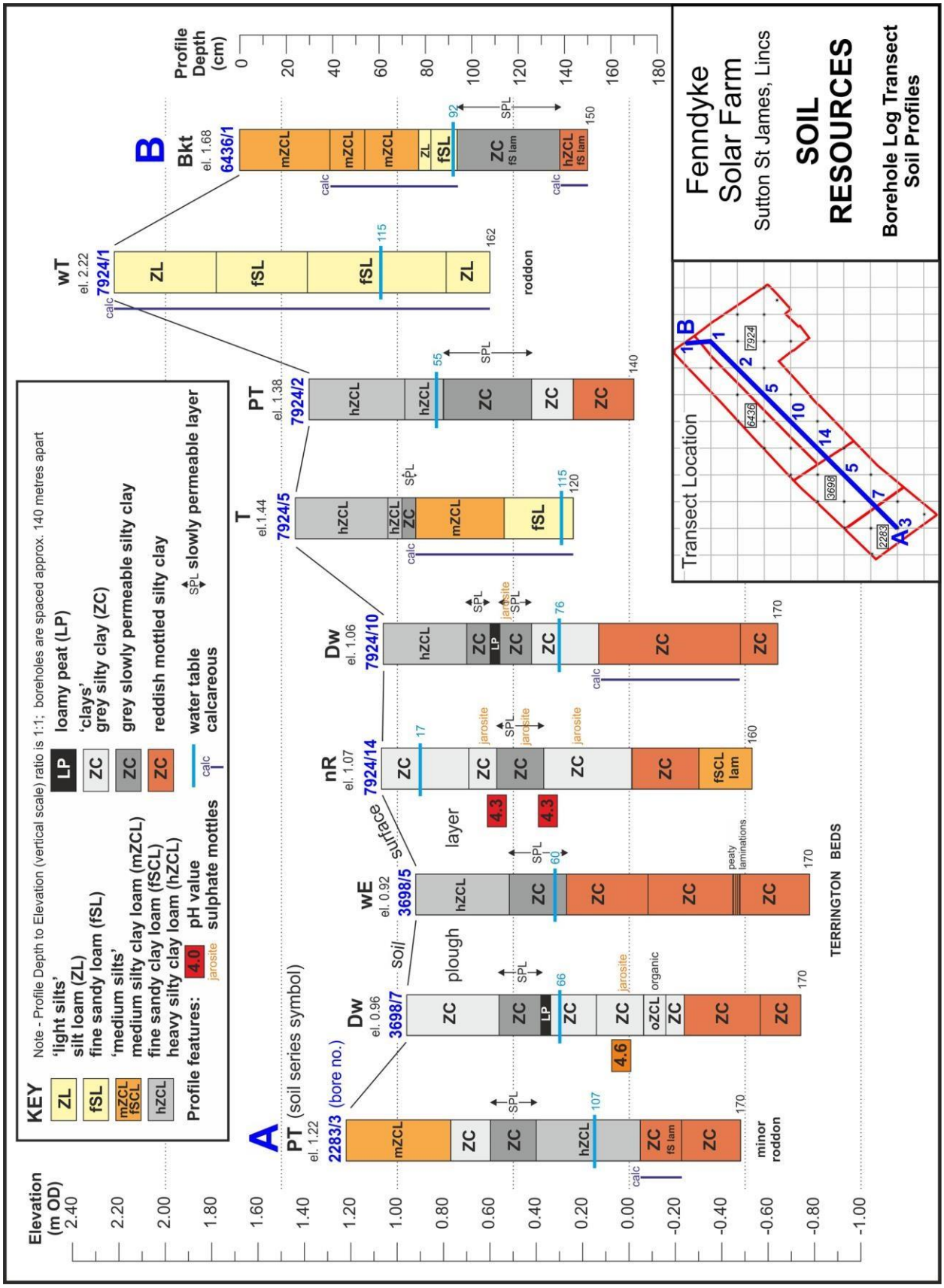


Figure 2. Selected borehole log with Soil Profiles illustrated - Transect A–B, from the south-western side towards the north-east corner. For definitions of soil series see Appendix 3.

- medium silts tend to form the topsoil and sometimes the upper subsoil where influenced by roddon (originally marsh creek) conditions;

- even on the roddon ridge in the north east there are medium silty topsoils and upper subsoils, presumably where the final channel (Figure 1) has spilled over covering the lighter silts;
- the plough layer at 30 of the 36 investigation sites is 35 cm or more thick;
- practically all soil layers away from the roddon ridges are non-calcareous, a state which does not promote soil structure in heavy soils;
- the slowly permeable layer usually occurs in the upper subsoil, sometimes immediately beneath the deep plough layer of with an intervening layer;
- upper subsoils even in Terrington Beds material tend to be grey and the traditional browner colours start in the lower subsoil or deeper;
- one or more thin peat and organic bands occur in the subsoils of clayey soils in low-lying areas, but do not seem to represent one continuous layer;

4.1.3 Slowly Permeable Layer (SPL)

The depth to a slowly permeable layer (SPL) determines where water draining by gravity from the surface is held up in the relatively permeable layers above; where there is a subsurface gradient then water will tend to flow through these relatively permeable layers and collect in lowlying areas. The depth to an SPL has relevance in drainage design for agriculture, for retaining water in wetland creation and as a criterion in determining wetness class and wetness limitations in ALC assessment where it occurs within 80 cm depth.

A Slowly Permeable Layer for ALC purposes is defined as requiring to be at least 15 cm in thickness with a combination of structure, texture and consistence as defined in MAFF (1988, p.32-33 & Figure 5), and with a lateral hydraulic conductivity of less than 10 cm a day. Since the potential depth for loosening naturally or artificially compacted layers in the drier parts of the country is considered 35 cm, no soil within this depth is considered an SPL as it can be removed by cultivation.

Not all heavy subsoils (C, ZC, HCL and HZCL textures) form slowly permeable layers – "*soils developed in marine alluvium can have very porous subsoils due to the presence of vertical channels and such soils do not have slowly permeable horizons*" (MAFF 1988, p.34). Such porous soils tend to occur in the lower subsoils in marine alluvium in the study area, in the browner clays.

What is clear from the observations and is partially illustrated in Figure 2, is that the SPL is a consistent feature across the low-lying areas. From the grey colour with few macropores or channels and associated mottles, massive structure and mostly very firm soil strength (Hodgson 1997, p.59), this layer was formed naturally during deposition in low energy conditions on the former marsh, with the settlement of well-sorted fine particles. It is not formed by subsurface compaction from trafficking or as a plough pan – it is commonly too deep and too thick. It does mean, however, that the land is more difficult to manage, and can be more easily damaged by traffic when the soil is at field capacity or waterlogged. This is, therefore, recognised in the land classification grading.

4.1.4 Soil pH

The samples taken for analysis were from subsoil layers displaying pale yellow mottles and concentrations of the mineral jarosite. From the visual evidence strong subsoil acidity was suspected, associated with brackish water flooding at a time of fluctuating tides and sea level. This phenomenon extends across much of the Fenland with the Fen Clay usually being more seriously affected than the Terrington Beds, though the acidity is commonly strongest at the junction between the two where there are peat bands.

These are so-called '**acid-sulphate soils**' (see Appendix 1 for further explanation and problems associated with the condition), which have near-neutral pH in the natural waterlogged state (potential acid-sulphate soils) but when drained for agriculture they acidify slowly on oxidation of sulphides (pyrites) derived from the brackish water incursions across the marsh, and convert these sulphides to sulphates and sulphuric acid; when exposed to air by excavation such as in ditch spoil, they can acidify rapidly, within a few weeks. Ochre in field drains and ditches is associated with this process, as is shallow rooting that then doesn't allow the subsoils to dry out and form good structure. Natural release of sulphuric acid in the subsoil will maintain low pHs for decades, but eventually the finite sulphide resource will be exhausted and with liming the pH can slowly increase again.

Table 1 shows the pH results for subsoil samples. The shallow samples in bores 3698/1 and /4 have returned to neutral; that in 3698/2 is moderately acid, but the samples from the low-lying part of field 7924 qualify as strongly acid.

Table 1. pH analysis results for subsoils containing yellow mottles of jarosite.

Investigation site	Depth (cm)	pH	pH class
3698/1	40–50	7.0	neutral
3698/2	65–80	4.6	moderately acid
3698/4	40–55	7.2	neutral
3698/7	80–100	4.6	moderately acid
7924/14	40–60	4.3	strongly acid
7924/14	60–80	4.3	strongly acid
7924/15	70–90	4.4	strongly acid
7924/15	100–125	4.4	strongly acid

Soil profiles with a pH below 4.5 (in water) within 80 cm depth are termed sulphuric. Such soils are classed as **Normoor series** (**nR**) and have been recognised at investigation sites 7924/14 and /15. Normoor soils are extensive locally in Tydd St Giles and St Mary's Fens and immediately east of Sutton St Edmund (Burton *et al*. 1989, Robson 1990). In an inventory of soils in the Fenland in the early 1980s Burton and Hodgson (1987) found 30 per cent. of the soils examined to be acid sulphate soils, covering 7,000 ha.

With regard to the proposed development of the solar farm, any below-ground concrete assets would be prone to sulphate corrosion.

In order to improve soil structure a permanently transpiring crop such as grass should be maintained. It will help to dry out the problem low areas and promote soil structure formation, otherwise further slumping and extension of these areas is likely.

4.1.5 Drainage and Water-table Depth

After making each auger bore during the survey, the hole would be allowed to fill with the local groundwater while the soil profile description was being made. The depth of the water table was then measured and noted.

The results in Appendix 3, Table A3.1 and in Figure 2 give an indication of water-table levels and several observations can be made:

- the depth to the slowly permeable layer (SPL) determines where water draining by gravity from the surface is held up in the relatively permeable layers above;
- where the SLP is shallow, water rapidly fills the hole from near the top, as ponding has been caused in the surface layer which was alleviated by drilling the borehole;
- even on high ground with freely draining soil profiles (Wisbech and Butterwick series) the water table was measured as high as 86 cm.

Soils with a large silt content are unstable and can slake and slump when wet. This can give problems draining these soils effectively. Mixing and disturbing the natural soil structure can cause stability problems if water levels are not controlled effectively.

The Site is within the South Holland Internal Drainage District, catchment G (South Holland IDB 2014). Deep, well maintained drains bound the Site on the southern side feeding a drain (Photo 11) that passes between fields 2283 and 3698, which is bridged by Bardling's Drove and continues northwards. As seems to be the tradition in the neighbourhood, other field boundaries are mainly formed by shallow ditches, as are those beside Bardling's Drove
(Photo 10) and Old Fen Dike (Photo 13) and internally between Fields 3698, 6436 and 7924 (Photo 12). These are currently too shallow to drain the lower subsoil to encourage drawdown in the upper subsoils, and the ditch that should empty into the drain near the underpass beneath Bardling's Drove does not seem to perform this function (Photo 11). They probably exacerbate the wetness conditions within the low-lying fields but do not cause it.



Photo 10. Shallow ditch beside Bardling's Drove, view SW.



Photo 11. Junction of ditch with drain as it passes under Bardling's Drove.



Photo 12. Junction of shallow, filled ditches between Fields 3698, 6436 and 7924.



Photo 13. Shallow, filled ditch at the corner of Old Fen Dyke and Bardling's Drove.

4.2 Agricultural Land Classification (ALC)

4.2.1 ALC Background

The assessment has been made in accordance with the revised guidelines and criteria (MAFF 1988) for Agricultural Land Classification. The scheme provides a framework for classifying land according to the extent to which its physical or chemical characteristics impose long-term limitations on agricultural use. It allows the relative potential of land for agricultural use to be assessed and compared. 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 with Grade 3 subdivided into Subgrades 3a and 3b (Appendix 2). Grades 1, 2 and Subgrade 3a form the **Best and Most Versatile (BMV) land**, the most flexible land in terms of the range of crops that can be grown, the level and consistency of yield and the cost of obtaining it. BMV policy has been designed to ensure the retention and protection of the most productive soil resource by directing development decisions made by planning authorities away from these categories of productive land, where possible.

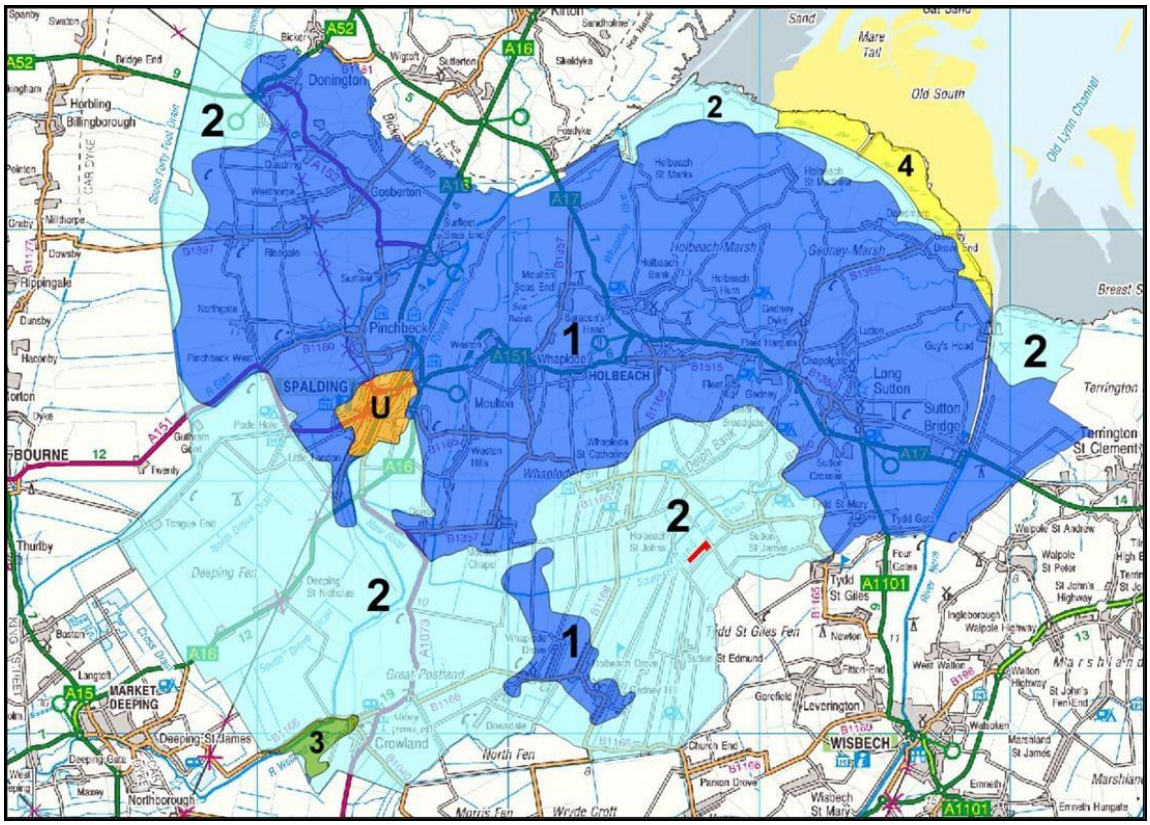
The grading does not necessarily reflect the current economic value of land, land use, range of crops, suitability for specific crops or level of yield. Likewise, the size, structure and location of farms, the standard of fixed equipment and the accessibility of land do not affect grading although they may influence land-use decisions. Grading is assessed on the land's capability at a good but not outstanding standard of management; where elements are sub-standard, as for example lacking an appropriate underdrainage system, grading disregards the shortfall and is based on the severity of the remaining limitations. Likewise, actions seen to be dereliction are disregarded.

A *Provisional* Agricultural Land Classification for England at 1:250,000 scale is published on the Internet as a downloadable map (Natural England 2010) and within an online viewer by the Multi-Agency Geographic Information for the Countryside (MAGIC). The 1:250,000 maps were compiled from the original published 1 inch to 1 mile (1:63,360-scale) maps. It must be stressed that this series of maps is '*intended for strategic uses. These maps are not sufficiently accurate for use in assessment of individual fields or sites and any enlargement could be misleading*' (Natural England 2010). Additionally, the maps do not show subdivisions of Grade 3 which are normally mapped by more detailed survey work.

An extract from this map (Map 6) indicates that the area of lower-lying ground south of the townlands on which Holbeach is situated, and the whole of the area occupied by the proposed solar farm Site, was considered at the time of survey in the late 1960s to be Grade 2, very good quality land. In fact, South Holland District is shown to have almost exclusively land in Grades 1 and 2, before the later more detailed soil surveys were undertaken (Maps 2 & 3). The only Grade 3 land (undivided) is on the Welland floodplain west of Crowland and coastal marsh off Holbeach St Matthew was mapped as Grade 4.

This survey of the soil resources at one soil profile observation per hectare has enabled a detailed land quality assessment to be made at each soil investigation site. A limitation for each component in the ALC system is calculated and one overall Grade is allocated to the profile on the basis of the most-limiting principle. These profile assessments have been combined by interpolation with reference to other factors here such as topography and aerial photography, to

form a detailed ALC classification for the whole Site. This detailed re-assessment, if approved, supersedes the 'provisional' version.



Map 6. Extract from the Provisional 1:125,000-scale ALC map for South Holland District, with the location of the proposed solar farm indicated in red; © Crown Copyright and database rights 2014, base map © Ordnance Survey 0100031673.

4.2.2 Climatic Limitations

Climatic details for the centre of the block of land are provided in Table 2. Average annual rainfall for the area is calculated at 564 mm. There is a winter field capacity period, when the soil is fully recharged with water and susceptible to trafficking and structure damage, of 99 Field Capacity Days (FCD). During the growing season a large moisture deficit builds up, the mean maximum deficit for wheat and potatoes being 122 mm and 118 mm, respectively. Climatic conditions are not limiting with the whole Site able to qualify as Grade 1.

Table 2. Climate Data for ALC. Interpolated site values for Grid Ref TF 375 171, altitude 2 m O.D.

Grid Ref	ALT m	AAR mm	LAAR mm/m	ASR mm	LASR mm/m	AT0	ATS	MDM WHT	MDM POT	FCD	BEST GRADE
TF 3750 1710	2	564	0.00	289	0.00	1442	2438	122	118	99	1

KEY

ALT	Altitude in metres
AAR	Average annual rainfall in mm
LAAR	Lapse rate for average annual rainfall in mm/metre
ASR	Average summer rainfall (April to September) in mm

LASR	Lapse rate for summer rainfall in mm/metre
AT0	Accumulated temperature above 0° C (January to June)
ATS	Accumulated temperature above 0° C (April to September)
MDM WHT	Moisture deficit for winter wheat in mm (from regressions on ATS and ASR)
MDM POT	Moisture deficit for potatoes in mm (from regressions on ATS and ASR)
FCD	Median duration of field capacity in days, when the soil moisture deficit is zero

The BEST GRADE gives the overall climatic assessment in terms of most limiting ALC Grade for the site.
FCD data are used in calculations for soil wetness.
MDM figures are used in assessments for droughtiness.

The local climatic factor that may be considered to modify the overall climatic consideration, where evidence can be supplied, is **frost risk**. With radiation frosts, katabatic flow of cold air descending from the high-albedo silty soils on raised ground can collect in fields which are saucer shaped with naturally low centres or where the margins are raised from application of ditch spoil. This may be a factor to consider where sensitive horticultural crops are grown but is not considered a grading limitation in this situation.

4.2.3 Site Limitations

Site conditions such as **gradient** and **microrelief** are not limiting. The Environment Agency (EA) map of flood risk (EA 2014) shows the area to be designated as 'Flood Zone 3', land assessed as having a 1 in 100 or greater annual probability of river flooding (>1%), or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year. Flood risk is discussed in more detail elsewhere in the Planning Application's Environmental Statement and **flooding** is not considered a limitation for the low-lying land, in terms of frequency and duration of winter and summer events, if the land and arterial drainage are maintained and effective.

4.2.4 Soil Limitations

At none of the observation sites is there a direct limitation from **topsoil texture** and **structure**, **soil depth** or topsoil **stone** content – all soils are naturally stoneless. **Chemical conditions** are not directly limiting (MAFF 1988, p.14). The strong subsoil acidity encountered in the lowlying western part of the Site does not limit the grade of the soil by any specific level of pH occurring within any specific depth; *i.e.* there is not a soil depth limitation as there would be with hard rock, or by chemical pollution. In areas already in agriculture the consideration is that subsoil acidity will affect the rooting depth of the crop and the limitation could be one of droughtiness. Any new field drainage work undertaken may generate ochre blockages but not severe enough to warrant downgrading, or that affect the flexibility and productivity of the land.

4.2.5 Soil and Interactive Limitations

Many observation sites, however, are affected to variable degrees by 'soil and interactive limitations', including soil (subsoil) texture and structure, soil wetness and soil droughtiness.

Soil texture and structure: These features have a major influence on water retention and movement in a soil, and on workability, trafficability and suitability as a growing medium. They are significant parameters in the assessment of wetness and droughtiness and are included in the soil datasets in Appendix 3.

Soil wetness and topsoil texture: A soil wetness and topsoil texture interactive limitation exists where the soil water regime adversely affects plant growth or imposes restrictions on cultivations, made more difficult by heavy topsoil texture. Permeable soils are 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 partly on the depth at which the soil becomes slowly permeable, forming a **slowly permeable layer** (**SPL**), and responsible for maintaining a perched water table.

The first step is to determine the soil's **Wetness Class** (**WC**) on a scale of I to V (Appendix 1). To assess the wetness class the guidelines use the depth to an SPL and distinguish soils with different 'gleying' features (a 'g' horizon, evident as greyish or pale colours with ochreous mottles or dominantly grey colours without mottles), but in Fenland alluvial soils that have been waterlogged for centuries and then drained, the gleying features are mostly relict. Instead, reliance has had to be on a combination of soil structural conditions, texture and consistence (MAFF 1988, Figure 5), but consideration has also been taken of observations on the winter water table at the time of survey (summarised in Appendix 3, Table A3.1). Table 3 contains the relevant cut-offs to determine Wetness Class obtained from tables in the guidelines (MAFF 1988, Figures 7 & 8) in which the local climate (as the number of Field Capacity Days) is taken into account. For each investigation site the allocated Wetness Class is given in Appendix 3.

Table 3. Wetness Class assessments for 99 Field Capacity Days (FCD).

Determination of Wetness Class (WC) –

using depth to gleying ('g' horizon with dominantly grey colours or distinct or prominent mottling) and to a slowly permeable layer (SPL) at least 15 cm thick starting at 35 cm depth or below

for 99 Field Capacity Days (FCD)

where gleying starts within 40 cm depth, and where SPL is within 80 cm depth (MAFF 1988 Fig 7)		where gleying starts between 40-70 cm depth, and where SPL is within 80 cm depth (MAFF 1988 Fig 8)	
SPL within 54 cm	= WC III	SPL within 80 cm depth	= WC II
SPL deeper than 54 cm	= WC II		

Determination of Wetness Class (WC) – mineral and organic mineral soils with no SPL within 80 cm depth

using depth to gleying ('g' horizon) with no slowly permeable (SPL) within 80 cm and whether subsoil is coarse textured (<18% clay)

for 99 Field Capacity Days (FCD)

where gleying starts within 40 cm depth, and where no SPL within 80 cm depth (MAFF 1988 Tab 13)		where gleying starts within 70 cm depth, and where no SPL within 80 cm depth (MAFF 1988 Tab 13)	
coarse textured subsoil	= WC I	coarse textured subsoil = WC I other soils	= WC I
other soils	= WC I		

The second step is to determine the interactive soil wetness/topsoil texture limitation. An example is shown in Table 4 taken from the MAFF guidelines (1988, Table 6) for a typical soil of the Wallasea series. This determination also takes into account the local climate (as the number of Field Capacity Days); the column '<126' is used for the 99 FCDs at the Site. The appropriate soil wetness class is selected in the left-hand column, in this case 'III', and the texture of the topsoil is selected in the Texture column, in this case 'HZCL' for heavy silty clay loam. Reading across to the <126 FCD column there are two possible Subgrades, 3b and (3a); as the topsoil is non-calcareous the 3b is the correct Subgrade for this limitation. For a Wallasea series soil with a non-calcareous topsoil of silty clay (ZC), as also occurs at the Site, the same limitation of 3b is also allocated to it.

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
I	S[2] LS[3] SL SZL	1	1	1	1	2
	ZL MZCL MCL SCL	1	1	1	2	3a
	HZCL HCL	2	2	2	3a	3b
	SC ZC C	3a(2)	3a(2)	3a	3b	3b
II	S[2] LS[3] SL SZL	1	1	1	2	3a
	ZL MZCL MCL SCL	2	2	2	3a	3b
	HZCL HCL	3a(2)	3a(2)	3a	3a	3b
	SC ZC C	3a(2)	3b(3a)	3b	3b	3b
III	S[2] LS SL SZL	2	2	2	3a	3b
	ZL MZCL MCL SCL	3a(2)	3a(2)	3a	3a	3b
	HZCL HCL	3b(3a)	3b(3a)	3b	3b	4
	SC ZC C	3b(3a)	3b(3a)	3b	4	4
IV	S[2] LS SL SZL	3a	3a	3a	3b	3b
	ZL MZCL MCL SCL	3b	3b	3b	3b	3b
	HZCL HCL	3b	3b	3b	4	4
	SC ZC C	3b	3b	3b	4	5
V	S LS SL SZL	4	4	4	4	4
	ZL MZCL MCL SCL	4	4	4	4	4
	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 11).

[2] Sand is not eligible for Grades 1, 2 or 3a (see page 11).

[3] Loamy sand is not eligible for Grade 1 (see page 11).

Table 4. Determination of Grade for a typical soil of the Wallasea series.

Droughtiness: To achieve full yield potential, a crop requires an adequate supply of soil moisture throughout the growing season. Droughtiness becomes a limitation in areas of low rainfall and where the soil has only small reserves available to plants. The ALC system uses calculations for two reference crops, winter wheat and maincrop potatoes, assuming a full crop rooting depth (120 cm for wheat and 70 cm for potatoes) for the two crop models. Assessments (Appendix 3, Table A3.3) were calculated layer by layer for the investigation sites using cropadjusted available water capacity (AP) and moisture deficit (MDM), based on the actual soil profile characteristics (texture, structure and stone content) recorded in the field.

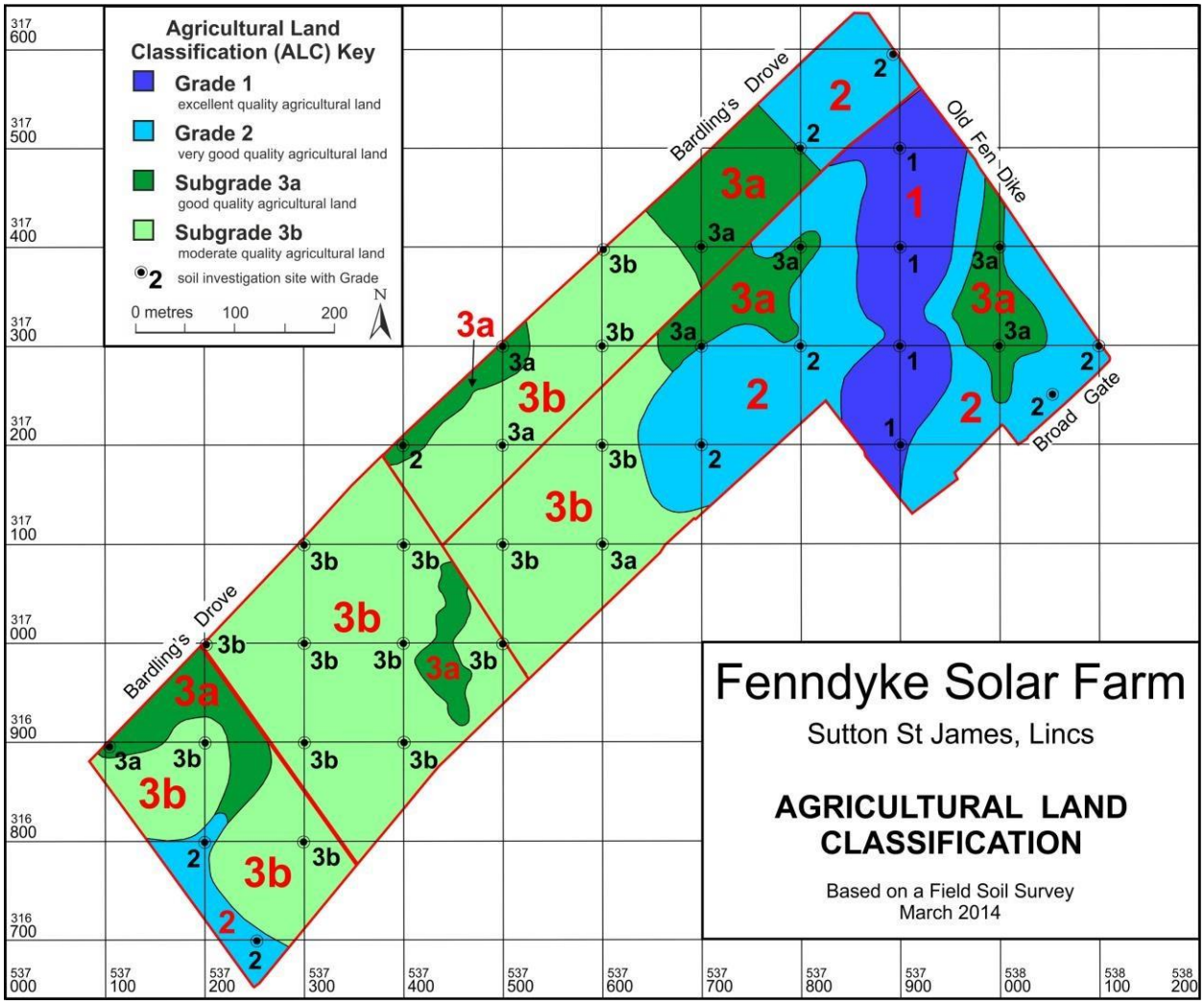
Where rooting extends to near the water table, additional moisture reserves may be available by capillary rise, but this has not been factored into the calculations. Irrigation may be available, subject to licence, with abstraction points possible in the IDB main drains. This would enhance yields and reduce the risk of droughtiness in the potato crop and the limitation would then be lessened.

The droughtiness calculations provide a **moisture balance** that is compared to the limiting values for grades in the MAFF guidelines and criteria (1988, Table 8). Six of the 36 profiles examined fall within the requirements for Grade 1 for both crops, mainly soils in Wisbech series with very large available water status; 26 are Grade 2 for one or both of the crops; the remaining four as graded 3b for the potato crop – these are all soils with a silty clay topsoil.

4.2.6 Summary and Conclusions

Each observation site has been assessed for its Grade according to all of the possible limitations, and an overall Grade has been allocated to each one based on the 'most limiting factor' principle. These allocations are given in Appendix 3 (Table A3.1) in tabular format.

The distribution of the Grades is shown in Map 7. In three cases the investigation site has a better Grade than for the area into which it falls. In this situation the better Grade is only localised or forms a pattern within a larger area which cannot be upgraded by its inclusion.



Map 7. Distribution of the Agricultural Land Classification Grades.

- **Grade 1** land, with no serious limitations, occurs on 3.14 ha of deep lights silts (silt loam texture, ZL) on the roddon ridge, mainly above 2.0 m OD (Map 4);

- **Grade 2** has been mapped on 8.10 ha flanking the roddon ridge, on land between 1.5 and 2.0 m OD, and on a minor roddon in the south west, mainly on medium silts of medium silty clay loam (MZCL) topsoil texture; subsoils can be heavier or lighter than this;

- **Subgrade 3a** occurs on 5.26 ha on part of the land below the 1.50 m contour, but not below the 1.0 m contour, and on relatively high ground adjacent to the roddon ridge in the east; limitations are wetness and texture where the topsoil is heavy silty clay loam (HZCL);

- **Subgrade 3b** is the largest mapped area of 16.06 ha on practically all of the land below 1.0 m OD and large parts of the land between 1.5 and 1.0 m OD; all topsoils that are silty clay (ZC) are within this Grade because of a wetness/texture limitation, as are some of those with a heavy silty clay loam topsoil (HZCL); no soil is Subgrade 3b because of droughtiness.

Of the total 32.56 ha the division into the Grades and Subgrades is given below with percentage of the Site involved (Table 5):

Grade	ha	%
1	3.14	9.64
2	8.10	24.88
3a	5.26	16.15
3b	16.06	49.32
	32.56	100.00

Table 5. Areas and proportions of land Grades

Best and Most Versatile land (**BMV**) is defined as Grades 1, 2 and 3a and this comprises 16.50 ha or 50.68% of the proposed Site. Land in Subgrade 3b with some small inclusions of 3a occurs on low-lying ground in the centre and west, while better quality Grade 1 and Grade 2 land is largely confined to higher ground in the east.

This assessment differs significantly from the *Provisional* Agricultural Land Classification for England published at 1:250,000 scale (Natural England 2010). This series of maps is '*intended for strategic uses. These maps are not sufficiently accurate for use in assessment of individual fields or sites and any enlargement could be misleading*' (Natural England 2010). Additionally, the maps do not show subdivisions of Grade 3 which are normally mapped by more detailed survey work. It is over-simplistic to expect maps at this scale with so little background surveying to provide valid evidence for a land quality assessment.

Whereas many developments may permanently remove land from agriculture in what is termed 'hard' uses with little potential for return to agriculture, establishment of a pv-panel solar farm represents a **'soft' use** of the land which could be returned relatively easily to agriculture.

5. REFERENCES

Avery, B.W. (1980). *Soil Classification for England and Wales (Higher Categories).* Soil Survey Technical Monograph No.14, Harpenden.

Burton, R.G.O. and Hodgson, J.M. (1987). *Lowland peat in England and Wales*. Soil Survey Special Survey No.15, Harpenden.

Burton, R.G.O., Cope, D.W., George, H., Heaven, F.W. and Robson, J.D. (1989). *Soils of the Boston and Spalding district.* Sheet 131, scale 1:50,000. Soil Survey and Land Research Centre, Silsoe.

Clayden, B. and Hollis, J.M. (1984). *Criteria for differentiating soil series.* Soil Survey Technical Monograph No.17, Harpenden.

Environment Agency (2014). Flood Map for Planning (Rivers and Sea). http://maps.environment-agency.gov.uk/wiyby/wiybyController?x=357683.0&y=355134.0&scale=1&layerGroups=default&ep=map&textonly=off&lang=_e&topic=floodmap#x=537505&y=317008&lg=1,&scale=9

Hodge, C.A.H., Burton, R.G.O., Corbett, W.M., Evans, R. and Seale, R.S. (1984). *Soils and their use in Eastern England*. Soil Survey of England and Wales Bulletin No.13. Harpenden.

Hodgson, J.M. (ed.) (1997). *Soil Survey Field Handbook*. Technical Monograph No. 5. Soil Survey and Land Research Centre, Silsoe.

MAGIC (2014). Landscape Classifications: Agricultural Land Classification - Provisional (England). http://www.natureonthemap.naturalengland.org.uk/MagicMap.aspx

Natural England (2010). Agricultural Land Classification Map East Midlands Region (ALC005). 10-111e East Midlands Region 250k ALC.pdf available at: http://publications.naturalengland.org.uk/publication/143027?category=2595819

Natural England (2012). Agricultural Land Classification: protecting the best and most versatile agricultural land. Technical Information Note TIN049, 2nd Edition. http://publications.naturalengland.org.uk/file/4424325

North Level IDB (2014). Rainfall data for Sutton St Edmund. http://www.northlevelidb.org/engineering/annual-rainfall-data/2014-5

Robson, J.D. (1990). *Soils of the Boston and Spalding district.* Memoirs of the Soil Survey of Great Britain, Silsoe.

South Holland IDB (2014). South Holland Internal Drainage Board register of drainage infrastructure. http://www.wlma.org.uk/uploads/210-SHIDB_Index.pdf

Waller, M. (1994). *The Fenland Project, Number 9: Flandrian environmental change in Fenland.* East Anglian Archaeology Report No. 70, Cambridgeshire Archaeological Committee, Cambridgeshire County Council.

NOTES

Appendix 1 Explanation of Terminology

A1.1 Soils and their Properties

Texture refers to the size of the individual particles that make up the soil and the proportions in which they occur. The coarsest particles are **sand**, and they give a gritty feel when aggregates that form the soil structure are wetted and broken down by rubbing between fingers and thumb. Sand can be divided into **fine**, **medium** and **coarse grades**. **Clay** particles are the finest of all and give the soil its body and stickiness. Particles intermediate in size between sand and clay are termed **silt**, which give the moist soil a silky smooth feel. The relative proportions of sand, silt and clay give a soil its textural or **particle-size class** (Figure A1.1). These classes can be combined into a smaller number of subgroups. A soil series, which forms the basic units on a soil map, is characterised by the main soil texture subgroup down the soil profile, or in the case of soils with contrasting layers, by a combination of two texture subgroups.

Peat soil material consists of more than 50% organic matter. It may be humified, semi-fibrous or fibrous depending on the degree of decomposition. **Loamy peat** or **sandy peat** has 50 to 35% organic matter content; **peaty loam** between 35 and 20%. Below this the mineral soil material is prefixed by **humose** or **organic** (Defra and ADAS terminology) down to 10% organic matter for clays and 6% organic matter for sands.

Mottles are ochreous or grey spots in a brown or grey soil matrix and can indicate degree and duration of waterlogging in a soil. In situations where effective drainage measures have been taken, mottling bears little relationship to the present soil moisture regime.

Soil reaction or **pH** is an estimate of the hydrogen-ion concentration in the soil solution, a measure of the degree of acidity or alkalinity. All plant species have a range of pH in which they will grow satisfactorily.

pH is normally determined in the laboratory but it can be determined in the field using a portable pH meter (field pH). The pH of a field-moist sample is obtained by mixing 10 ml of soil with 10 ml of deionized or distilled water (a 1:1 ratio) in a polythene bag or suitable clean container, and immersing the glass combination electrode of the meter into the suspension. The digital read-out is recorded.

pH is measured on a logarithmic scale so that a fall of one pH unit corresponds to a ten-fold increase in the hydrogen-ion concentration. The acidity or otherwise of the soil is described using the scale below.

Table A1.1. The soil reaction or pH classes with their limits and traditional colour scheme.

Soil reaction classes

Class	pH (in 1:1 field-moist soil/water suspension)
Very strongly acid	<3.6
Strongly acid	3.6 – 4.5
Moderately acid	4.6 – 5.5
Slightly acid	5.6 – 6.5
Neutral	6.6 – 7.5
Alkaline	>7.5

Calcium carbonate (lime) has a beneficial effect on soil structure and in maintaining a high pH. Soil material containing free carbonate is **calcareous**. It is tested in the field by applying dilute hydrochloric acid to a soil sample and observing the reaction (Table A1.2). Material containing more than 10% carbonate is termed **very calcareous**; that with more than 40% is **extremely calcareous**.

Table A1.2. Estimating calcium carbonate content up to 10 per cent.

Field description and $CaCO_3$ class limits	***Typical effects of HCl application at known $CaCO_3$ contents***		
	Audible *(held close to ear)*	***Visible***	***$CaCO_3$*** %
Non-calcareous (less than 0.5%)	None	None	0.1
Very slightly calcareous (0.5–1%)	Faintly increasing to slightly audible	None	0.5
Slightly calcareous (1–5%)	Faintly increasing to moderately audible	Slight effervescence confined to individual grains, just visible	1.0
	Moderately to distinctly audible, heard away from ear	Slightly more general effervescence visible on close inspection	2.0
Moderately calcareous (5–10%)	Easily audible	Moderate effervescence; obvious bubbles up to 3 mm diameter	5.0
Very calcareous (more than 10%)	Easily audible	General strong effervescence; ubiquitous bubbles to 7 mm diameter; easily seen	10.0

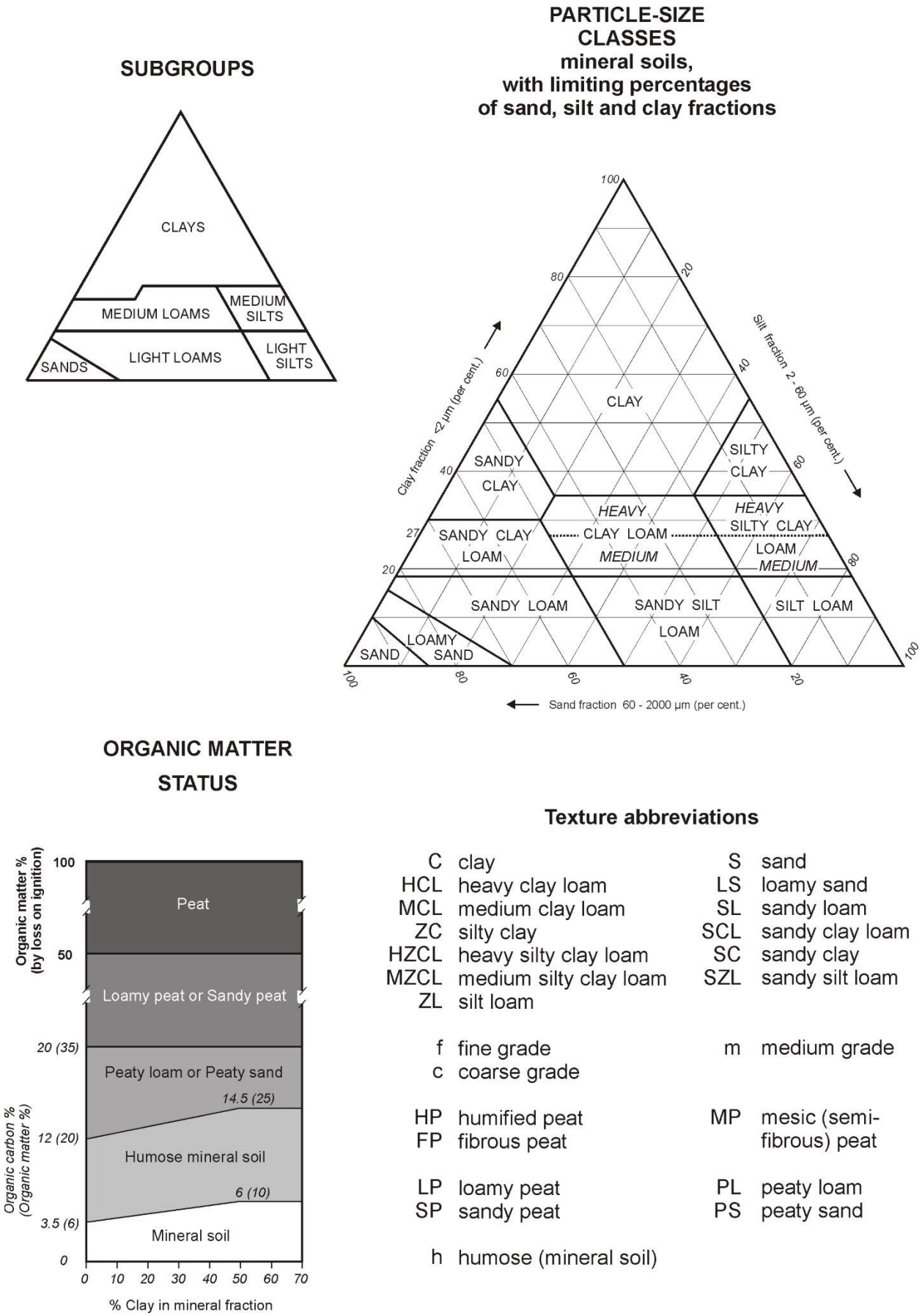


Figure A1.1. Texture classes, organic matter status and abbreviations used in soil descriptions in the Report.

A1.2 Acid Sulphate Soils (see also http://en.wikipedia.org/wiki/Acid_sulfate_soil)

Extreme examples of soil acidity occur in so-called **acid sulphate soils**. The source of the acidity is the release of sulphuric acid by the oxidation of sulphides (pyrites) in the soil. The sulphides formed in materials with a large organic matter content, usually during an invasion of the sea (supplying the sulphates) in the past, as during the deposition of the Fen Clay, but other sources such as the marine Ampthill Clay are possible. While these layers remain waterlogged and anaerobic, pH values remain around neutral (6.5–7.4) and the soils are termed **potential acid sulphate soils**.

Drainage for agriculture allows air to enter these layers where the following (simplified) reaction can take place:

$2FeS_2$	+	$7O_2$	+	$2H_2O$ ✱	$2FeSO_4$	+	$2H_2SO_4$
iron pyrites		oxygen		water	soluble ferrous sulphate		sulphuric acid

Aided by soil bacteria, pHs values fall below 4.5 but the resulting acidity level and duration will depend on

- the original sulphide content'
- the rate of aeration and oxidation, and
- whether the sulphide is being replenished all of which can be very variable.

Serious effects are associated with acid sulphate soils:

Aluminium toxicity. At low pHs (below 4.5) toxic aluminium becomes increasingly soluble and available to plants. In mineral soil material its concentration increases roughly ten-fold per unit pH decrease. It accumulates in root tissues, preventing cell division and elongation, producing a stunted, deformed root system. Soluble aluminium can also pass into drainage waters so that the quality of ditch water that might be used for irrigation can be poor at certain times of the year. The most common symptom of acidity and metal toxicity is severe susceptibility to water stress that cannot be fully compensated for by irrigation.

Crop tolerance. Acidity combined with aluminium toxicity can prevent root development, thus reducing the amount of soil water available to plants, and eventually the yield.

Nutrient uptake. Acidity affects the ease with which plants can extract nutrients from the soil (Figure A1.2). Manganese availability is increased but uptake of phosphate is inhibited by absorption by aluminium, both within the root and in the soil. Activity of micro-organisms which convert ammonium nitrogen to available nitrate nitrogen is reduced.

Ochre release. At low pHs soluble ferrous sulphate is mobilised in the soil forming a precipitate of iron oxide in drainage pipes and ditches and cementing any permeable fill. Ochre production is particularly prolific for the first few years following installation of a new drainage scheme and lasts until the iron sulphide content of the soil is exhausted. Drain jetting to clear the offending clogging material can be necessary if the underdrainage system is to remain effective and not require early replacement. Sacrificial mole channels in clay subsoils may be effective as an initial measure to supplement drainage by ditches.

Topsoils require frequent lime dressings, especially when ploughing brings to the surface the top of the acid subsoil. Leaching of lime from the topsoil neutralises the subsoil acidity to some extent, producing sugar-like crystals of gypsum ($CaSO_4$) but the process is very slow and is not

considered to be a solution to neutralising acidity in the subsoil. Only when the sulphide reserves are completely depleted can this source of lime begin to build up the pH level very slowly

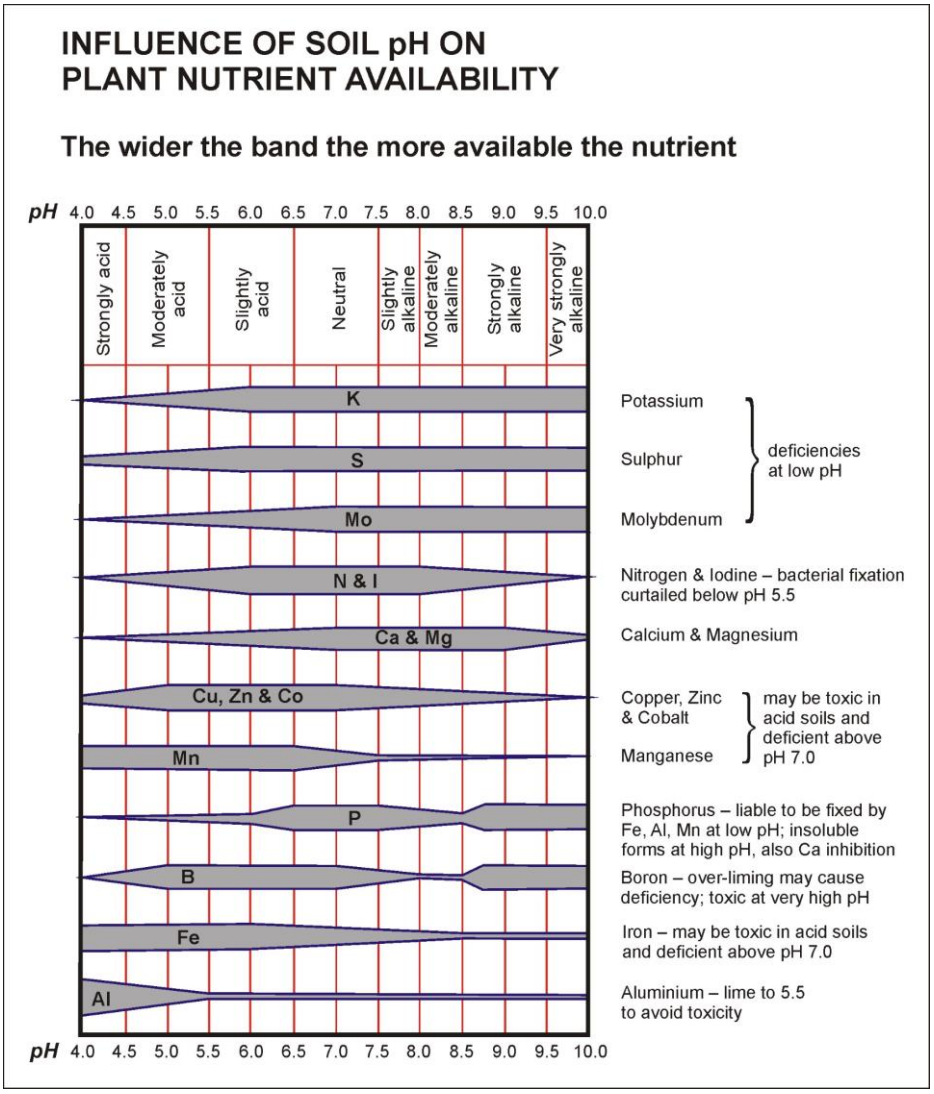


Figure A1.2. The influence of soil pH on plant nutrient availability. Source: after Truog, E. (1948) Lime in relation to availability of plant nutrients. *Soil Science* 65, 1–7.

A1.3 Soil Wetness Class

Table A1.3. Definitions of wetness classes.

Wetness Class	***Descriptive term****	***Duration of waterlogging***
I	*Rarely wet* (Well drained)	The soil profile is not wet within 70 cm depth for more than 30 days in most years.

II	*Seldom wet* (Slight seasonal waterlogging)	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	*Occasionally wet* (Seasonally waterlogged)	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	*Commonly wet* (Waterlogged for long periods in winter)	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 90-210 days in most years.
V	*Usually wet* (Severely waterlogged)	The soil profile is wet within 40 cm depth for 211-335 days in most years.
VI	*Permanently wet* (Permanently waterlogged)	The soil profile is wet within 40 cm depth for more than 335 days in most years.

* Alternative terms in brackets ( ) may be used depending on context.

****** The number of days specified is not necessarily a continuous period; 'in most years' is defined as more than 10 out of 20 years.

Appendix 2 Definitions of Agricultural Land Classification Grades

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, the yields of which are variable. The grade 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.

These gradings are based on certain assumptions, which include an appropriate underdrainage system and satisfactory outfalls.

Appendix 3 Soil Resource and ALC Data

Table A3.1. Location of soil investigation bores, site characteristics and summary of soil resources and limitations.

KEY

SITE

Field & Site	Easting	Northing	Elevation (m O.D.)
the number of the field and the consecutive number of the soil investigation site within each field	the OS 6figure Easting coordinate (usually along the top/bottom of the map), to 1 metre resolution	the OS 6-figure Northing coordinate (usually along the sides of the map), to 1 metre resolution	the elevation of the soil surface at the soil investigation site in metres Ordnance Datum (OD), interpolated from levelled data

SOIL CHARACTERISTICS

Soil Type Symbol	Depth to Clay (cm)	Depth to Gleying (cm)	Depth to SPL (cm)	Wetness Class	Topsoil Texture	Topsoil Thickness (cm)	Water Table Depth (m)
the soil type symbol given for the soil profile based on the National Soil Classification System (SSEW/NSRI)	depth in cm to the occurrence of clay, silty clay or sandy clay texture	depth in cm to first occurrence of distinct or grey mottling	depth in cm to Slowly Permeable Layer	soil Wetness Class from I to VI	abbreviation for texture determined by proportions of sand, silt, clay and organic matter; ca indicates the topsoil is calcareous (Appendix 1)	thickness in cm of the plough layer, usually darker in colour and with a larger organic matter content	depth in cm to which the water table recovers after completion of augering

– **LIMITATIONS** ALC Grade/Subgrade according to:

Climate *	Wetness /Texture	Drought Wheat	Drought Potatoes	Stones *	Overall ALC
Grade 1 for all sites based on climatic factors, with no limitation	Grade assessed from Wetness Class and Topsoil Texture for 99 Field Capacity (FCD) days	calculated Grade for Winter Wheat, to the full depth of 120 cm	calculated Grade for Potatoes, to the full depth of 70 cm	Grade 1 for all sites, lacking topsoil stones, with no limitation	most limiting Grade by the factors considered on the left

* column excluded from this assessment as all points qualify as Grade 1, as do other limitations such as flooding and gradient.

SITE					SOIL CHARACTERISTICS								LIMITATIONS			
Field	Site	Easting	Northing	Elevation (m O.D.)	Soil Type Symbol	Depth to Clay (cm)	Depth to Gleying (cm)	Depth to SPL (cm)	Wetness Class	Topsoil Texture	Topsoil Thickness (cm)	Water Table Depth (m)	Wetness /Texture Grade	Drought Wheat Grade	Drought Potatoes Grade	Overall ALC Grade
2283	1	537115	316885	1.25	wE	35	35	65	II	HZCL	35	-0.69	3a	2	2	**3a**
2283	2	537200	316900	1.05	wE	40	40	53	III	HZCL	40	-0.75	3b	2	2	**3b**
2283	3	537200	316800	1.22	PT	45	45	62	II	MZCL	45	-1.07	2	2	2	**2**
2283	4	537300	316800	1.05	wE	40	40	44	III	HZCL	40	-1.12	3b	2	2	**3b**
2283	5	537250	316700	1.69	T	>134	84	84	I	MZCL	40	>-1.34	2	1	1	**2**
3698	1	537300	317100	0.80	wE	0	35	35	III	ZC	35	-0.44	3b	2	3a	**3b**
3698	2	537400	317100	0.92	Dw	31	31	31	III	ZC	31	-0.24	3b	2	2	**3b**
3698	3	537223	317006	1.00	wE	0	38	40	III	ZC	38	-1.58	3b	2	3a	**3b**
3698	4	537300	317000	0.88	wE	40	40	40	III	HZCL	40	-0.24	3b	2	2	**3b**
3698	5	537400	317000	0.92	wE	40	40	40	III	HZCL	40	-0.60	3b	2	2	**3b**
3698	6	537500	317000	1.13	wE	0	40	40	III	ZC	40	>-1.20	3b	2	3a	**3b**
3698	7	537300	316900	0.96	Dw	0	40	40	III	ZC	40	-0.66	3b	2	2	**3b**
3698	8	537400	316900	0.94	wE	25	25	25	III	HZCL	25	-0.40	3b	2	2	**3b**
6436	1	537895	317595	1.68	Bkt	94	54	94	I	MZCL	39	-0.92	1	1	2	**2**
6436	2	537800	317500	1.66	PT	54	43	92	II	MZCL	43	>-1.50	2	2	2	**2**
6436	3	537600	317400	1.06	wE	38	38	38	III	HZCL	38	-0.74	3b	2	2	**3b**
6436	4	537700	317400	1.26	wE	38	38	62	II	HZCL	38	>-1.40	3a	2	2	**3a**
6436	5	537500	317300	1.20	PT	86	35	80	II	HZCL	35	-0.83	3a	1	2	**3a**
6436	6	537600	317300	1.15	wE	38	38	38	III	HZCL	38	-0.63	3b	2	2	**3b**
6436	7	537400	317200	1.28	dist	>90	55	>90	I	HZCL	37	>-0.90	2	1	2	**2**
6436	8	537500	317200	0.85	wE	30	30	78	II	HZCL	30	-0.50	3a	2	2	**3a**
7924	1	537900	317500	2.22	wT	>162	120	>120	I	ca ZL	44	-1.15	1	1	1	**1**
7924	2	537800	317400	1.38	PT	58	41	58	II	HZCL	41	-0.55	3a	2	2	**3a**
7924	3	537900	317400	2.22	wT	>130	105	>120	I	ca ZL	45	-0.95	1	1	1	**1**
7924	4	538000	317400	1.72	A	32	32	35	II	HZCL	32	-0.98	3a	1	2	**3a**
7924	5	537700	317300	1.44	T	46	46	46	II	HZCL	46	-1.15	3a	1	2	**3a**
7924	6	537800	317300	1.50	A	>120	33	>120	I	HZCL	33	-1.03	2	1	1	**2**
7924	7	537900	317300	1.96	wT	>120	92	>120	I	ca ZL	37	-0.86	1	1	1	**1**
7924	8	538000	317300	1.98	PT	68	42	60	II	HZCL	42	-0.97	3a	1	2	**3a**
7924	9	538100	317300	1.47	Stk	68	38	78	II	MZCL	38	-0.65	2	2	2	**2**
7924	10	537600	317200	1.06	Dw	36	36	50	III	HZCL	36	-0.76	3b	2	2	**3b**
7924	11	537700	317200	1.81	A	35	52	>120	II	MZCL	35	>-1.20	2	1	2	**2**
7924	12	537900	317200	1.94	Bwk	75	75	87	I	MZCL	41	-1.01	1	1	1	**1**
7924	13	538050	317250	1.36	Stk	71	29	71	II	MZCL	29	-0.48	2	2	2	**2**
7924	14	537500	317100	1.07	nR	0	38	50	III	ZC	38	-0.17	3b	2	3a	**3b**
7924	15	537600	317100	1.14	nR	38	38	60	II	HZCL	38	-0.54	3a	2	2	**3a**

Table A3.2. Fenndyke Solar Farm – Soil Types

based on the Soil Survey of England and Wales (National Soil Resources Institute) classification system (Avery 1980, Clayden and Hollis 1984).

5. BROWN SOILS

5.3 Brown calcareous alluvial soils

5.32	**Gleyic brown calcareous alluvial soils**	**BLACKTOFT**	**Bkt**	**medium silty marine alluvium**

5.6 Brown alluvial soils

5.62	**Gleyic brown alluvial soils**	**BUTTERWICK**	**Bwk**	**medium silty marine alluvium**

8. GROUND-WATER GLEY SOILS

8.1 Alluvial gley soils

8.11	**Typical alluvial gley soils**		
	PEPPERTHORPE	**PT**	**medium silty over clayey marine alluvium**
	TANVATS	**T**	**medium silty marine alluvium**
8.12	**Calcareous alluvial gley soils**		
	AGNEY	**A**	**medium silty marine alluvium**
	STOCKWITH	**Stk**	**medium silty over clayey marine alluvium**
	WISBECH	**wT**	**light silty marine alluvium**
8.13	**Pelo-alluvial gley soils**		
	DOWELS	**Dw**	**clayey over peaty marine alluvium**
	WALLASEA	**wE**	**clayey marine alluvium**
8.15	**Sulphuric alluvial gley soils**		
	NORMOOR	**nR**	**sulphuric-clayey marine alluvium**

KEY:

5. MAJOR SOIL GROUP

5.3 Soil group

5.32	Soil subgroup	SOIL SERIES	Symbol soil series definition

Table A3.3 Soil Profile details and calculations for Droughtiness assessments for the standard Wheat and Potato crops (after MAFF 1988, Appendix 4).

Profile: 2283/1 Adjusted Altitude 1.25

Profile Details							
Depth From (cm)	Depth To (cm)	Texture	Stone1 %	Stone1 Type	Stone2 %	Stone2 Type	Structure
0	30	ZCL	0	HR	0	CH	TS
30	35	ZCL	0	HR	0	CH	M
35	65	ZC	0	HR	0	CH	M
65	88	ZC	0	HR	0	CH	P
88	120	ZC	0	HR	0	CH	M

	MD	AP	MB	ALC
Potatoes:	118.0	116.5	-1.5	**G2**
Wheat:	122.0	141.7	19.7	**G2**

Profile: 2283/2 Adjusted Altitude 1.05

Profile Details							
Depth From (cm)	Depth To (cm)	Texture	Stone1 %	Stone1 Type	Stone2 %	Stone2 Type	Structure
0	30	ZCL	0	HR	0	CH	TS
30	40	ZCL	0	HR	0	CH	M
40	53	ZC	0	HR	0	CH	M
53	89	ZC	0	HR	0	CH	P
89	120	ZC	0	HR	0	CH	M

	MD	AP	MB	ALC
Potatoes:	118.0	113.9	-4.1	**G2**
Wheat:	122.0	141.4	19.4	**G2**

Profile: 2283/3 Adjusted Altitude 1.22

Profile Details							
Depth From (cm)	Depth To (cm)	Texture	Stone1 %	Stone1 Type	Stone2 %	Stone2 Type	Structure
0	30	ZCL	0	HR	0	CH	TS
30	45	ZCL	0	HR	0	CH	M
45	62	ZC	0	HR	0	CH	M
62	82	ZC	0	HR	0	CH	P
82	120	ZCL	0	HR	0	CH	M

	MD	AP	MB	ALC
Potatoes:	118.0	117.6	-0.4	**G2**
Wheat:	122.0	151.6	29.6	**G2**

Profile: 2283/4 Adjusted Altitude 156.85

Profile Details	

Depth From (cm)	Depth To (cm)	Texture	Stone1 %	Stone1 Type	Stone2 %	Stone2 Type	Structure
0	30	ZCL	0	HR	0	CH	TS
30	40	ZCL	0	HR	0	CH	M
40	44	ZC	0	HR	0	CH	M
44	75	ZC	0	HR	0	CH	P
75	88	ZC	0	HR	0	CH	M
88	120	ZC	0	HR	0	CH	M

	MD	AP	MB	ALC
Potatoes:	118.0	111.2	-6.8	**G2**
Wheat:	122.0	140.7	18.7	**G2**

Profile: **2283/5** Adjusted Altitude 160.1

Profile Details

Depth From (cm)	Depth To (cm)	Texture	Stone1 %	Stone1 Type	Stone2 %	Stone2 Type	Structure
0	30	ZCL	0	HR	0	CH	TS
30	40	ZL	0	HR	0	CH	M
40	58	ZL	0	HR	0	CH	M
58	84	ZCL	0	HR	0	CH	M
84	120	ZCL	0	HR	0	CH	P

	MD	AP	MB	ALC
Potatoes:	118.0	139.0	21.0	**G1**
Wheat:	122.0	159.8	37.8	**G1**

Profile: **3698/1** Adjusted Altitude 0.8

Profile Details

Depth From (cm)	Depth To (cm)	Texture	Stone1 %	Stone1 Type	Stone2 %	Stone2 Type	Structure
0	30	ZC	0	HR	0	CH	TS
30	35	ZC	0	HR	0	CH	M
35	62	ZC	0	HR	0	CH	P
62	87	ZC	0	HR	0	CH	M
87	116	ZC	0	HR	0	CH	M
116	120	ZC	0	HR	0	CH	P

	MD	AP	MB	ALC
Potatoes:	118.0	102.9	-15.1	**G3a**
Wheat:	122.0	130.9	8.9	**G2**

Profile: **3698/2** Adjusted Altitude 0.92

Profile Details

Depth From (cm)	Depth To (cm)	Texture	Stone1 %	Stone1 Type	Stone2 %	Stone2 Type	Structure
0	31	ZC	0	HR	0	CH	TS
31	52	ZC	0	HR	0	CH	P
52	61	ZC	0	HR	0	CH	M
61	65	LP	0	HR	0	CH	M
65	90	ZC	0	HR	0	CH	M
90	120	ZC	0	HR	0	CH	M

	MD	AP	MB	ALC
Potatoes:	118.0	112.9	-5.1	**G2**
Wheat:	122.0	138.5	16.5	**G2**

Profile: 3698/3 Adjusted Altitude 1

Profile Details							
Depth From (cm)	Depth To (cm)	Texture	Stone1 %	Stone1 Type	Stone2 %	Stone2 Type	Structure
0	30	ZC	0	HR	0	CH	TS
30	38	ZC	0	HR	0	CH	M
38	64	ZC	0	HR	0	CH	P
64	90	ZC	0	HR	0	CH	M
90	110	ZC	0	HR	0	CH	M
110	120	ZC	0	HR	0	CH	P

	MD	AP	MB	ALC
Potatoes:	118.0	103.2	-14.8	**G3a**
Wheat:	122.0	131.0	9.0	**G2**

Profile: 3698/4 Adjusted Altitude 0.88

Profile Details							
Depth From (cm)	Depth To (cm)	Texture	Stone1 %	Stone1 Type	Stone2 %	Stone2 Type	Structure
0	30	ZCL	0	HR	0	CH	TS
30	40	ZCL	0	HR	0	CH	M
40	56	ZC	0	HR	0	CH	P
56	96	ZC	0	HR	0	CH	M
96	120	ZC	0	HR	0	CH	M

	MD	AP	MB	ALC
Potatoes:	118.0	114.2	-3.8	**G2**
Wheat:	122.0	141.4	19.4	**G2**

Profile: 3698/5 Adjusted Altitude 0.92

Profile Details							
Depth From (cm)	Depth To (cm)	Texture	Stone1 %	Stone1 Type	Stone2 %	Stone2 Type	Structure
0	30	ZCL	0	HR	0	CH	TS
30	40	ZCL	0	HR	0	CH	M
40	65	ZC	0	HR	0	CH	P
65	100	ZC	0	HR	0	CH	M
100	120	ZC	0	HR	0	CH	M

	MD	AP	MB	ALC
Potatoes:	118.0	111.5	-6.5	**G2**
Wheat:	122.0	140.5	18.5	**G2**

Profile: 3698/6 Adjusted Altitude 1.13

Profile Details							
Depth From (cm)	Depth To (cm)	Texture	Stone1 %	Stone1 Type	Stone2 %	Stone2 Type	Structure
0	30	ZC	0	HR	0	CH	TS
30	40	ZC	0	HR	0	CH	M
40	59	ZC	0	HR	0	CH	P
59	105	ZC	0	HR	0	CH	M

	MD	AP	MB	ALC
Potatoes:	118.0	105.3	-12.7	**G3a**
Wheat:	122.0	133.1	11.1	**G2**

Profile: **3698/7** Adjusted Altitude 0.96

Profile Details							
Depth From (cm)	Depth To (cm)	Texture	Stone1 %	Stone1 Type	Stone2 %	Stone2 Type	Structure
0	30	ZC	0	HR	0	CH	TS
30	40	ZC	0	HR	0	CH	M
40	58	ZC	0	HR	0	CH	P
58	62	LP	0	HR	0	CH	M
62	82	ZC	0	HR	0	CH	M
82	120	ZC	0	HR	0	CH	M

	MD	AP	MB	ALC
Potatoes:	118.0	113.6	-4.4	**G2**
Wheat:	122.0	140.4	18.4	**G2**

Profile: **3698/8** Adjusted Altitude 0.94

Profile Details							
Depth From (cm)	Depth To (cm)	Texture	Stone1 %	Stone1 Type	Stone2 %	Stone2 Type	Structure
0	25	ZCL	0	HR	0	CH	TS
25	53	ZC	0	HR	0	CH	P
53	88	ZCL	0	HR	0	CH	M
88	102	ZC	0	HR	0	CH	P
102	120	ZC	0	HR	0	CH	M

	MD	AP	MB	ALC
Potatoes:	118.0	110.0	-8.0	**G2**
Wheat:	122.0	138.8	16.8	**G2**

Profile: **6436/1** Adjusted Altitude 1.68

Profile Details							
Depth From (cm)	Depth To (cm)	Texture	Stone1 %	Stone1 Type	Stone2 %	Stone2 Type	Structure
0	30	ZCL	0	HR	0	CH	TS
30	39	ZCL	0	HR	0	CH	M
39	54	ZCL	0	HR	0	CH	M
54	77	ZCL	0	HR	0	CH	M
77	82	ZL	0	HR	0	CH	M

82	94	FSL	0	HR	0	CH	M
94	120	ZC	0	HR	0	CH	M

	MD	AP	MB	ALC
Potatoes:	118.0	125.0	7.0	**G2**
Wheat:	122.0	161.4	39.4	**G1**

Profile: 6436/2 Adjusted Altitude 1.66

Profile Details							
Depth From (cm)	Depth To (cm)	Texture	Stone1 %	Stone1 Type	Stone2 %	Stone2 Type	Structure
0	30	ZCL	0	HR	0	CH	TS
30	43	ZCL	0	HR	0	CH	M
43	54	ZCL	0	HR	0	CH	M
54	60	ZC	0	HR	0	CH	M
60	92	ZC	0	HR	0	CH	M
92	120	C	0	HR	0	CH	P

	MD	AP	MB	ALC
Potatoes:	118.0	121.8	3.8	**G2**
Wheat:	122.0	145.0	23.0	**G2**

Profile: 6436/3 Adjusted Altitude 1.06

Profile Details							
Depth From (cm)	Depth To (cm)	Texture	Stone1 %	Stone1 Type	Stone2 %	Stone2 Type	Structure
0	30	ZCL	0	HR	0	CH	TS
30	38	ZCL	0	HR	0	CH	M
38	62	ZC	0	HR	0	CH	P
62	92	ZC	0	HR	0	CH	M
92	120	ZC	0	HR	0	CH	P

	MD	AP	MB	ALC
Potatoes:	118.0	111.4	-6.6	**G2**
Wheat:	122.0	137.0	15.0	**G2**

Profile: 6436/4 Adjusted Altitude 1.26

Profile Details							
Depth From (cm)	Depth To (cm)	Texture	Stone1 %	Stone1 Type	Stone2 %	Stone2 Type	Structure
0	30	ZCL	0	HR	0	CH	TS
30	38	ZCL	0	HR	0	CH	M
38	46	ZC	0	HR	0	CH	P
46	62	ZC	0	HR	0	CH	M
62	82	ZC	0	HR	0	CH	P
82	120	ZC	0	HR	0	CH	P

	MD	AP	MB	ALC
Potatoes:	118.0	113.8	-4.2	**G2**
Wheat:	122.0	136.4	14.4	**G2**

Profile: 6436/5 Adjusted Altitude 1.2

Profile Details							
Depth From (cm)	Depth To (cm)	Texture	Stone1 %	Stone1 Type	Stone2 %	Stone2 Type	Structure
0	30	ZCL	0	HR	0	CH	TS
30	35	ZCL	0	HR	0	CH	M
35	60	ZCL	0	HR	0	CH	M
60	86	ZCL	0	HR	0	CH	M
86	108	ZC	0	HR	0	CH	M
108	120	ZC	0	HR	0	CH	M

	MD	AP	MB	ALC
Potatoes:	118.0	125.0	7.0	**G2**
Wheat:	122.0	154.2	32.2	**G1**

Profile: 6436/6 Adjusted Altitude 1.15

Profile Details							
Depth From (cm)	Depth To (cm)	Texture	Stone1 %	Stone1 Type	Stone2 %	Stone2 Type	Structure
0	30	ZCL	0	HR	0	HR	TS
30	38	ZCL	0	HR	0	HR	M
38	54	ZC	0	HR	0	HR	P
54	88	ZC	0	HR	0	HR	M
88	120	ZC	0	HR	0	HR	M

	MD	AP	MB	ALC
Potatoes:	118.0	113.8	-4.2	**G2**
Wheat:	122.0	140.6	18.6	**G2**

Profile: 6436/7 Adjusted Altitude 1.28

Profile Details							
Depth From (cm)	Depth To (cm)	Texture	Stone1 %	Stone1 Type	Stone2 %	Stone2 Type	Structure
0	28	ZCL	0	HR	0	CH	TS
28	42	ZCL	0	HR	0	CH	M
42	60	C	0	HR	0	CH	P
60	85	ZCL	0	HR	0	CH	M
85	120	ZC	0	HR	0	CH	M

	MD	AP	MB	ALC
Potatoes:	118.0	112.9	-5.1	**G2**
Wheat:	122.0	142.9	20.9	**G1**

Profile: 6436/8 Adjusted Altitude 0.65

Profile Details							
Depth From (cm)	Depth To (cm)	Texture	Stone1 %	Stone1 Type	Stone2 %	Stone2 Type	Structure

0	30	ZCL	0	HR	0	CH	TS
30	45	ZC	0	HR	0	CH	P
45	47	OC	0	HR	0	CH	M
47	78	ZC	0	HR	0	CH	M
78	98	ZC	0	HR	0	CH	M
98	120	ZC	0	HR	0	CH	M

	MD	AP	MB	ALC
Potatoes:	118.0	114.1	-3.9	**G2**
Wheat:	122.0	140.1	18.1	**G2**

Profile: **7924/1** Adjusted Altitude 2.22

Profile Details							
Depth From (cm)	Depth To (cm)	Texture	Stone1 %	Stone1 Type	Stone2 %	Stone2 Type	Structure
0	30	ZL	0	HR	0	CH	TS
30	44	ZL	0	HR	0	CH	M
44	83	FSL	0	HR	0	CH	M
83	120	FSL	0	HR	0	CH	M

	MD	AP	MB	ALC
Potatoes:	118.0	146.6	28.6	**G1**
Wheat:	122.0	201.6	79.6	**G1**

Profile: **7924/2** Adjusted Altitude 1.38

Profile Details							
Depth From (cm)	Depth To (cm)	Texture	Stone1 %	Stone1 Type	Stone2 %	Stone2 Type	Structure
0	30	ZCL	0	HR	0	CH	TS
30	41	ZCL	0	HR	0	CH	M
41	58	ZCL	0	HR	0	CH	M
58	96	ZC	0	HR	0	CH	P
96	114	ZC	0	HR	0	CH	P
114	120	ZC	0	HR	0	CH	P

	MD	AP	MB	ALC
Potatoes:	118.0	119.0	1.0	**G2**
Wheat:	122.0	142.4	20.4	**G2**

Profile: **7924/3** Adjusted Altitude 2.22

Profile Details							
Depth From (cm)	Depth To (cm)	Texture	Stone1 %	Stone1 Type	Stone2 %	Stone2 Type	Structure
0	30	ZL	0	HR	0	HR	TS
30	45	ZL	0	HR	0	HR	M
45	79	FSL	0	HR	0	HR	M
79	105	LFS	0	HR	0	HR	M
105	120	LMS	0	HR	0	HR	M

MD	AP	MB	ALC

	118.0	147.0	29.0	**G1**
Potatoes:	122.0	191.5	69.5	**G1**
Wheat:				

Profile: **7924/4** Adjusted Altitude 1.72

Profile Details							
Depth From (cm)	Depth To (cm)	Texture	Stone1 %	Stone1 Type	Stone2 %	Stone2 Type	Structure
0	32	ZCL	0	HR	0	HR	TS
32	52	ZC	0	HR	0	HR	M
52	58	FSL	0	HR	0	HR	M
58	62	ZCL	0	HR	0	HR	M
62	90	ZCL	0	HR	0	HR	M
90	120	FSL	0	HR	0	HR	M

	MD	AP	MB	ALC
Potatoes:	118.0	122.0	4.0	**G2**
Wheat:	122.0	168.2	46.2	**G1**

Profile: **7924/5** Adjusted Altitude 1.44

Profile Details							
Depth From (cm)	Depth To (cm)	Texture	Stone1 %	Stone1 Type	Stone2 %	Stone2 Type	Structure
0	30	ZCL	0	HR	0	CH	TS
30	40	ZCL	0	HR	0	CH	M
40	46	ZCL	0	HR	0	CH	M
46	52	ZC	0	HR	0	CH	P
52	90	ZCL	0	HR	0	CH	M
90	120	FSL	0	HR	0	CH	M

	MD	AP	MB	ALC
Potatoes:	118.0	122.0	4.0	**G2**
Wheat:	122.0	167.4	45.4	**G1**

Profile: **7924/6** Adjusted Altitude 1.5

Profile Details							
Depth From (cm)	Depth To (cm)	Texture	Stone1 %	Stone1 Type	Stone2 %	Stone2 Type	Structure
0	33	ZCL	0	HR	0	CH	TS
33	54	ZCL	0	HR	0	CH	M
54	75	ZL	0	HR	0	CH	G
75	120	FSL	0	HR	0	CH	M

	MD	AP	MB	ALC
Potatoes:	118.0	135.2	17.2	**G1**
Wheat:	122.0	189.8	67.8	**G1**

Profile: 7924/7 Adjusted Altitude 1.96

Profile Details							
Depth From (cm)	Depth To (cm)	Texture	Stone1 %	Stone1 Type	Stone2 %	Stone2 Type	Structure
0	30	ZL	0	HR	0	CH	TS
30	37	ZL	0	HR	0	CH	M
37	53	FSL	0	HR	0	CH	M
53	92	FSL	0	HR	0	CH	M
92	108	LFS	0	HR	0	CH	M
108	120	LFS	0	HR	0	CH	M

	MD	AP	MB	ALC
Potatoes:	118.0	143.8	25.8	**G1**
Wheat:	122.0	198.8	76.8	**G1**

Profile: 7924/8 Adjusted Altitude 1.98

Profile Details							
Depth From (cm)	Depth To (cm)	Texture	Stone1 %	Stone1 Type	Stone2 %	Stone2 Type	Structure
0	30	ZCL	0	HR	0	CH	TS
30	42	ZCL	0	HR	0	CH	M
42	68	ZCL	0	HR	0	CH	M
68	107	ZC	0	HR	0	CH	M
107	120	FSL	0	HR	0	CH	M

	MD	AP	MB	ALC
Potatoes:	118.0	124.6	6.6	**G2**
Wheat:	122.0	157.1	35.1	**G1**

Profile: 7924/9 Adjusted Altitude 1.47

Profile Details							
Depth From (cm)	Depth To (cm)	Texture	Stone1 %	Stone1 Type	Stone2 %	Stone2 Type	Structure
0	30	ZCL	0	HR	0	CH	TS
30	38	ZCL	0	HR	0	CH	M
38	68	ZCL	0	HR	0	CH	M
68	105	ZC	0	HR	0	CH	P
105	120	ZC	0	HR	0	CH	M

	MD	AP	MB	ALC
Potatoes:	118.0	124.0	6.0	**G2**
Wheat:	122.0	146.9	24.9	**G2**

Profile: 7924/10 Adjusted Altitude 1.06

Profile Details							
Depth From (cm)	Depth To (cm)	Texture	Stone1 %	Stone1 Type	Stone2 %	Stone2 Type	Structure
0	30	ZCL	0	HR	0	CH	TS
30	36	ZCL	0	HR	0	CH	M

36	46	ZC	0	HR	0	CH	P
46	50	LP	0	HR	0	CH	M
50	93	ZC	0	HR	0	CH	P
93	120	ZC	0	HR	0	CH	M

	MD	AP	MB	ALC
Potatoes:	118.0	117.2	-0.8	**G2**
Wheat:	122.0	144.9	22.9	**G2**

Profile: **7924/11** Adjusted Altitude 1.81

Profile Details							
Depth From (cm)	Depth To (cm)	Texture	Stone1 %	Stone1 Type	Stone2 %	Stone2 Type	Structure
0	30	ZCL	0	HR	0	CH	TS
30	35	ZCL	0	HR	0	CH	M
35	52	ZC	0	HR	0	CH	M
52	71	ZCL	0	HR	0	CH	M
71	82	ZCL	0	HR	0	CH	M
82	120	FSL	0	HR	0	CH	M

	MD	AP	MB	ALC
Potatoes:	118.0	121.6	3.6	**G2**
Wheat:	122.0	169.0	47.0	**G1**

Profile: **7924/12** Adjusted Altitude 15.6

Profile Details							
Depth From (cm)	Depth To (cm)	Texture	Stone1 %	Stone1 Type	Stone2 %	Stone2 Type	Structure
0	30	ZCL	0	HR	0	CH	TS
30	41	ZCL	0	HR	0	CH	M
41	57	ZL	0	HR	0	CH	M
57	84	ZCL	0	HR	0	CH	M
84	93	FSL	0	HR	0	CH	P
93	120	FSL	0	HR	0	CH	M

	MD	AP	MB	ALC
Potatoes:	118.0	133.0	15.0	**G1**
Wheat:	122.0	177.3	55.3	**G1**

Profile: **7924/13** Adjusted Altitude 1.36

Profile Details							
Depth From (cm)	Depth To (cm)	Texture	Stone1 %	Stone1 Type	Stone2 %	Stone2 Type	Structure
0	29	ZCL	0	HR	0	CH	TS
29	43	ZCL	0	HR	0	CH	M
43	71	ZCL	0	HR	0	CH	M
71	102	ZC	0	HR	0	CH	P
102	120	ZC	0	HR	0	CH	P

MD	AP	MB	ALC
118.0	124.8	6.8	**G2**

Potatoes:	122.0	146.1	24.1	**G2**
Wheat:				

Profile: **7924/14** Adjusted Altitude 1.07

Profile Details							
Depth From (cm)	Depth To (cm)	Texture	Stone1 %	Stone1 Type	Stone2 %	Stone2 Type	Structure
0	30	ZC	0	HR	0	CH	TS
30	38	ZC	0	HR	0	CH	M
38	50	ZC	0	HR	0	CH	M
50	70	ZC	0	HR	0	CH	P
70	108	ZC	0	HR	0	CH	M
108	120	ZC	0	HR	0	CH	M

	MD	AP	MB	ALC
Potatoes:	118.0	105.0	-13.0	**G3a**
Wheat:	122.0	135.0	13.0	**G2**

Profile: **7924/15** Adjusted Altitude 1.14

Profile Details							
Depth From (cm)	Depth To (cm)	Texture	Stone1 %	Stone1 Type	Stone2 %	Stone2 Type	Structure
0	30	ZCL	0	HR	0	CH	TS
30	38	ZCL	0	HR	0	CH	M
38	70	ZC	0	HR	0	CH	M
70	100	ZC	0	HR	0	CH	P
100	120	ZC	0	HR	0	CH	P

	MD	AP	MB	ALC
Potatoes:	118.0	118.6	0.6	**G2**
Wheat:	122.0	139.6	17.6	**G2**

Appendix 4 The Author

Rodney Burton holds a BA degree in Geography (1970) and an MSc in Quaternary Studies (1978). He has been a Senior Research Officer with the **National Soil Resources Institute (NSRI)**, part of **Cranfield University** at Silsoe College in Bedfordshire, until his retirement in September 2006. The Institute incorporates the former **Soil Survey and Land Research Centre** (**SSLRC**) and prior to 1987 was the Rothamsted Experimental Station-based **Soil Survey of England and Wales (SSEW)**. The Institute continues to be responsible for producing soil maps and soil information for England and Wales. He has been employed since 1970 in Soil Survey and Land Evaluation with the same organisation, throughout England and Wales and overseas.

Consultancy work has involved the planning, advising and undertaking of detailed soil surveys and investigations for land and farm management, planning applications, pipeline routing, land purchase, rent negotiation, litigation and nature conservation. He is qualified to assess land quality using the Defra **Agricultural Land Classification (ALC)** grading system and has produced numerous client reports for planning purposes.

His **specialisations** include peat and peat soils, acid sulphate soils, saline soils, urban soils and soil sealing.

Soil mapping projects have included:

1:250,000 scale	National Soil Map, Eastern England (SSEW)
	soil survey for groundwater vulnerability assessment, Isle of Man (Cranfield Uni)
1:50,000 scale	Boston & Spalding, Sheet 131 (SSLRC)
	Land resource interpretation for potential radionuclide contamination assessment, Sizewell (1993), Sellafield & Drigg (1995), Hinkley Point (1997), Wylfa (1999), Berkley & Oldbury (2001) (MAFF, Food Safety (Radiation) Unit & Food Standards Agency)
1:25,000 scale	routine 100 km^2 Sheets TL18/28 Stilton, Cambs; TF00/10 Barnack, Cambs; TL54 Linton, Cambs; TG40 Halvergate, Norfolk (SSEW)
	Boughton Nitrate Sensitive Area, Notts (MAFF)
1:10,000 scale	Arthur Rickwood EHF, Mepal, Cambs (MAFF)
	Boxworth EHF, Boxworth, Cambs (MAFF)
other scales	Fenland Inventory, in Lowland Peat in England and Wales (SSEW)
	Nene Washes (RSPB)
	Ouse Washes Habitat Creation, Sutton Fen, Cambs (Atkins & EA)
	Soils & physical characteristics of the Falkland Islands' minefields. (MoD)
	Land and water resources for irrigated tea, Ngwazi, Tanzania (Unilever)
	field-scale soil zoning for precision farming company, including farms at Carrington, Sibsey, Louth & Uffington, Lincs, & Coldham, Burghley, & March, Cambs
	soil survey of Bosworth Field, Leics (Battlefields' Trust)

ALC assessments have included:

A14 re-alignment, 18 km through Cambs (Costain-Skanska & Highways Agency)
New high-speed rail route, 60 km through Warwicks & Staffs (Atkins & HS2)
Byley Gas Storage, Brine and Water Infrastructure, Cheshire (Scottish Power)
Ouse Washes Habitat Creation, Coveney Fen, Cambs (EA) Methwold Habitat Creation Site, Norfolk (Norfolk Wildlife Trust) rent reviews for Tenant Farmers' Association members

Research projects have included:

catchment soil structure surveys for the Wensum, Norfolk, and the Parrett, Culm and Frome catchments in the South-west (EA)
basic **soil training courses** to farmers, environmentalists and utility companies **professional training courses** for soil survey institutions in Ireland & Malta reclamation of **acid-sulphate soils** in Narathiwat, southern Thailand (FAO) **urban soil** characterisation for pipe corrosion risk (Thames Water) EuroPeat project for sustainable management of European **peat soils** (EU)