Soil Assessment and Agricultural Land Classification for Proposed Landfill Site, Chicheley Hill

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1. SUMMARY

1.1 Agricultural Land Classification of the proposed landfill site at Chicheley Hill indicates that 9.80 ha (56%) are grade 2; 1.39 ha (8%) grade 3a, and 6.26 ha (36%) grade 3b. Locally steep gradients (7 to 10°) and minor soil wetness problems are the main limitations to agricultural land quality.

1.2 The soils are derived from loamy clayey drift over Oxford Clay on lower slopes and calcareous boulder clay parent material on higher ground. Topsoils are mainly slightly calcareous to calcareous heavy clay loams or occasionally medium clays or heavy silty clay loams. Upper subsoils are of similar texture, usually increasing in clay content with depth. Stone content is low. There is some variation in these soil profile characteristics which are related to the difference in parent material according to altitude.

1.3 Infilling the site could reduce the gradient limitation affecting some of the slopes within the proposed area. Existing topsoils have good pH and nutrient status.

1.4 If planning approval is subsequently given for the landfill proposal, it is recommended that the soils should be stripped and replaced to give a 1.2 metre depth of restored soil. Topsoil depth varies across the site and stripping depth can be adjusted according to the information provided in this report. The spatial variability in depth and minor texture differences between upper and lower subsoil horizons presents significant practical difficulties in attempting to manage separate stripping and replacement operations for these subsoil layers. A single stripping operation for the whole subsoil layer to 1.2 metre depth would be more appropriate.

1.5 General guidelines on soil management and handling during stripping, storage and replacement of soils are given in the report, also information on aspects of agriculture aftercare for land restoration.

2. INTRODUCTION

2.1 A joint undertaking between Mr M J Cook of Manor Farm, Sherington and Barton Plant Ltd of Kettering has been proposed for a landfill project on a site of approximate 17.45 hectares at Chicheley Hill. The proposed site spans parts of two adjacent fields which have areas of locally steep slopes and it was considered that a landfill operation could improve the topography. Several landscaping features would also be included in the proposal. Imported infill material would consist primarily of soil spoil.

2.2 Mr H Barker, Soil and Water Engineer at the ADAS Oxford Office, was subsequently contacted to outline the range of services which ADAS could offer in connection with the agricultural implications and allied considerations associated with this proposal. As a result of these discussions, ADAS was requested to carry out a comprehensive soil assessment of the proposed landfill site, including appropriate analysis results, and to provide an Agricultural Land Classification. General information on soil management and handling for earth-working operations was also required. The fieldwork was undertaken by Mr A Chalmers and Mrs J Holloway, ADAS, Reading in September, utilising soil pits dug by machine to at least 120 cm depth.

3. AGRICULTURAL LAND CLASSIFICATION

3.1 A detailed Agricultural Land Classification (ALC) Survey of the 17.45 ha site was undertaken on 19 September 1990. The Agricultural Land Classification system 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.

3.2 The principal physical factors influencing agricultural production are climate, site and soil. These factors together with interactions between them from 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 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 Appendix 1.

3.3 Further details of the Agricultural Land Classification System are contained in the MAFF publication "Agricultural Land Classification of England and Wales - Revised guidelines and criteria for grading the quality of agricultural land" (MAFF, 1988).

3.4 In connection with the detailed ALC survey work at the Chicheley Hill Site 23 soil pits were excavated to depths of about 1 m or more on a regularly spaced grid with pits at approximately 100 m intervals. A detailed record of the soil profile was made at each location. Additional data were obtained from a number of slope measurements taken with an optical reading clinometer.

3.5 At the time of survey the land was in arable use and comprised parts of two enclosures.

PHYSICAL FACTORS AFFECTING LAND QUALITY

Relief

3.6 The site lies at altitudes between 65 and 95 m above ordnance datum (A.O.D.) with moderate north to west facing slopes into the valley of the River Great Ouse. Gradient is a locally significant factor affecting land quality on the steepest parts of these slopes where gradients between 7° and 10° were recorded. Away from the steepest middle slopes, gradients are 5° or less and place no significant limitation on agricultural land quality.

Climate

3.7 Interpolation of climatic variables to obtain site estimates from surrounding grid point data (Met. Office, 1989) gives the following data for two representative altitudes in the survey area.

Site Altitude	65 m	95 m
Accumulated Temperature (day °C)	1413	1379
Average Annual Rainfall (mm)	605	608
Field Capacity Days	120	120
Moisture deficit - Wheat (mm)	114	110
- potatoes (mm)	107	103

3.8 The important parameters in assessing an overall climate limitation are accumulated temperature (a measure of the relative warmth of a locality) and average annual rainfall (a measure of wetness). In overall climatic terms the above data for the site indicates no limitation on land quality with the area being one of relative warmth and dryness in a national context. However, interactions between soil and climate factors, namely wetness and droughtiness are an important consideration.

Geology and Soils

3.9 There is no published solid and drift edition geological map sheet at 1:50,000 or similar scale for the site. However less detailed information on the solid geology can be obtained from the Geological Survey Ten Mile Map (South Sheet) (IGS, 1979). This indicates that the underlying solid geology of the site is Oxford Clay close to the boundary with the Cornbrash. Detailed inspection of the site indicates that a superficial capping chalky boulder clay till (of glacial origin) occurs on the middle and upper slopes masking the solid deposits. This is confined by extrapolation of the published geological map sheet covering the area immediately to the south (IGS, 1974).

3.10 The 1:250,000 Soil Survey Map of England and Wales (Sheet 6: South East England) SSEW (1983) maps the Hanslope Soil Association. In the accompanying Legend this is described as "slowly permeable calcareous clayey soils. Some slowly permeable non-calcareous clayey soils. Slight risk of water erosion."

3.11 Detailed examination of the soils on the site broadly confirms this description.

Topsoils are predominantly slightly calcareous to calcareous (>1% $CaCO_3$) heavy clay loams or occasionally medium clays or heavy silty clay loams. These rest over similar textured clayey upper subsoils, usually increasing in clay content with depth. Stone content is low, usually about 1-2% v/v of small to medium sized flints.

3.12 Soils can roughly be divided into two groups based on altitude. On lower slopes (below about 80 m A.O.D.) soils are believed to be derived from loamy clayey drift over Oxford Clay. The associated soils typically comprise calcareous heavy clay loams overlying a similar upper subsoil. Sand content may increase below this giving, in some cases, a distinct sandy clay loam or sandy loam lower horizon. This in turn may pass to a heavy non-calcareous silty clay believed to represent the underlying Oxford Clay. This silty clay horizon is usually below 80 cm but may occasionally form the immediate subsoil.

3.13 On the higher land on the site (above 80 m A.O.D.) the soils are derived from a highly calcareous boulder clay parent material. Topsoils are again predominantly slightly calcareous to calcareous heavy clay loams but subsoils comprise pale, yellowish or olive coloured chalky clays and heavy clay loams. At occasional locations sand horizons were noted within the boulder clay subsoil.

3.14 Soil on the site have slowly permeable subsoils with gleying (an indication of drainage imperfections) usually confined to depths below 40 cm. The majority of soils are allocated to wetness class II with a few examples in wetness class III (see Appendix 2).

Although the soils are heavy textured, the majority are naturally calcareous and are better structured especially in the upper profile than wholly non-calcareous clay soils. They are consequently better drained and more workable, particularly in the dry climate which exist in the Ouse Valley and the immediately surrounding areas.

3.15 A combination of heavy soil textures and moderately high moisture deficits causes some of these soils to be slightly droughty. However, this is of less significance in terms of land quality than the wetness restrictions outlined above.

AGRICULTURAL LAND CLASSIFICATION

3.16 The accompanying plan illustrates the Agricultural Land Classification grades found on the site. A breakdown of the area and relative proportions of the grades is given below:-

Grade	Ha	%
2	9.80	56
3a	1.39	8
3b	6.26	36
Total	17.45	100

The main limitations to the agricultural land quality are locally steep gradients and minor wetness restrictions.

Grade 2

3.17 Land of this quality occurs in both the upper and lower parts of the site and represents those situations where soils are moderately well drained (wetness class II) and gently sloping (<7°). Soils comprise representatives of both of the broad types outlined in paras 2.12 and 2.13. Minor wetness restrictions including heavy soil textures reduce the flexibility of cultivations so timeliness of cultivations is important. A variety of cropping is possible but, as indicated above, there may be reduced flexibility due to difficulties with the harvesting of, for example, arable root crops.

Grade 3

Subgrade 3a

3.18 Small areas of land graded 3a are identified on upper slopes to the south of the site. These represent areas where soils are slightly less well drained (wetness class III) than those identified as grade 2 above. They have a slightly calcareous to calcareous heavy clay loam topsoil resting over a strongly gleyed poorly structured slowly permeable clay or heavy clay loam upper subsoil. Lower subsoils are calcareous clay which may contain sand horizons.

Subgrade 3b

3.19 Land of this quality is associated with strongly sloping land running through the centre of the site. Gradients of 7-10° were measured in this area. A plan supplied by Barton Plant Hire Ltd indicating the existing contours of the site at 1:2500 scale was used to assist in the delineation of the steeper slopes.

In accordance with ALC criteria gradients between 7° & 11° are appropriately placed in subgrade 3b (MAFF, 1988).

3.20 Gradient has a significant effect on the efficiency, flexibility and safety of mechanised farm operations. Slopes of 7°-10° may present difficulties with precision seeding, and the use of harvesting equipment such as combine harvesters and root crop harvesters.

4. CHEMICAL AND PHYSICAL SOIL ANALYSES

4.1 Topsoil and upper subsoil samples were taken for laboratory analysis from three areas within the overall proposed landfill site.

Samples were taken separately from the northern and southern halves of Field 1141, the third set of samples were taken from the area of Field 4539 which would be included within the landfill scheme. The topsoil samples were analysed for pH, available phosphorus (P), potassium (K) and magnesium (Mg) to assess their lime and major nutrient status. Lower plastic limits (LPL), as a guide to soil moisture content limitations on soil moving operations were determined on all the topsoil and subsoil samples.

Soil analysis results, Chicheley Hill

Area Reference	Sample	pH	P	K	Mg	LPL
				mg/l (Index)		% mc
Field 1141 - North	Topsoil	7.8	27(3)	223(2)	84(2)	26.4
	Upper subsoil	-	-	-	-	23.0
- South	Topsoil	7.9	18(2)	217(2)	65(2)	31.7
	Upper subsoil	-	-	-	-	24.8
Field 4539 - West	Topsoil	8.0	24(2)	191(2)	75(2)	31.5
	Upper subsoil	-	-	-	-	23.2

The Index ranges for the P, K and Mg mg/l figures are given in Appendix III.

4.2 The routine topsoil analyses show alkaline pHs across the whole site, as would be expected for chalky boulder clay or similar drift cover deposits. Soil P and K reserves are all at or above the target "maintenance" levels of Index 2 for an arable rotation, so that P and K fertiliser dressings need only balance the crop offtake of these nutrients. The soil Mg status is also very satisfactory and Mg fertiliser is not required for any crops grown on these soils. Further analyses of re-instated topsoils would however be advisable on completion of a landfill operation, mainly in case of mixing and dilution with inherently less fertile subsoil during previous soil handling operations. Phosphate availability can also change with long term storage.

4.3 The lower plastic limit represents the percentage moisture content at which the soil is susceptible to smearing, deformation and compaction during cultivations or soil movement operations. The heavy clay loam topsoils have higher LPL values, owing to the combined effects of their slightly lower clay and/or greater organic matter contents, compared with the heavy clay loam to clayey textural upper subsoils. The range of moisture contents within which the soils can be handled without causing mechanical damage is therefore slightly more limited for the subsoil materials.

5. SOIL HANDLING AND MANAGEMENT FOR INTENDED LANDFILL SCHEME

5.1 This section gives general guidelines on soil management and handling at the stripping, storage and replacement phases of a landfill operation. The guidelines are intended to minimise the risk of soil damage by compaction and to maintain practical soil handling methods. It is assumed that Associated Surveying Consultants will be responsible for detailed planning and specification of soil movement and storage within the proposed landfill site. A phased landfill operation, with direct placement of stripped soil onto completed fill material would minimise the amount of soil materials requiring long term storage and enable progressive restoration of the worked site. This would also reduce the total amount of soil handling required. The main alternative approach is to strip and stockpile all the topsoil and subsoil materials for replacement after the landfill operation with imported spoil has been completed. This however increases the risk of soil damage.

5.2 Topsoil depths vary to some extent across the site, as shown in the appropriate map at the end of this report. Guidelines on soil stripping operations are given in the following section. Subsoil horizons to 1.2 metre depth from the existing soil surface are variable in both depth and texture across the site. The majority of soils have calcareous heavy silty clay loam upper subsoil to at least 65 cm before changing to a calcareous clay or silty clay lower subsoil horizon, but the distribution of these soils across the site is variable. Other soils tend to have clayey upper subsoils as well as lower subsoils. It is therefore questionable whether there is any merit in attempting to strip and replace upper subsoil layers to 65 cm depth from the existing surface separately from the lower subsoil horizon at 65 to 120 cm depth. The simpler and more practical soil management option would be to strip the whole subsoil layer to 1.2 metre depth as a single operation. It would however be advisable to strip and stockpile the drift material over Oxford clay and chalky boulder clay subsoils separately.

5.3 Topsoil Stripping Operations

The topsoil should only be stripped when its moisture content is moderately dry, at least 5% less than the lower plastic limit. Ideally the moisture content should be determined by some form of rapid oven drying facility, such as microwave or portable soil moisture meter, eg "Speedy" model, to check that the topsoil is sufficiently dry before stripping operations commence. As a rough practical guide however the soil is in a plastic state, and hence prone to compaction and smearing, if:

- it smears when rubbed between finger and thumb, or
- the soil can readily be moulded and formed into a roll 4 cm long and 6 mm or less thick which will support its own weight when dangled.

The stripping should normally only be carried out during the spring to early autumn period as and when soil and weather conditions permit. Soil movement should be stopped during or after moderately high rainfall, eg 5-10 mm in 12 hours until the soil has dried out sufficiently. Soil movement in wet conditions will cause compaction and structural damage, restricting subsequent plant rooting and causing waterlogging problems. The topsoil should be stripped to a depth of 25 to 30 cm, according to location within the site as indicated in the topsoil map. Care should be taken to prevent topsoil from being contaminated by subsoil.

Use of a hydraulic excavator ("back-acter" or similar digging machine) and dump truck system to remove and transport the topsoil to the storage heap will minimise the risk of any topsoil compaction during stripping operations. These machines should only run over already exposed subsoil, to prevent wheeling compaction of the undisturbed topsoil. Alternatively a mechanical scraper can be used for soil removal, but there is a greater risk of soil damage. All soil movement operations should be properly supervised by a suitably qualified person.

5.4 Subsoil Removal

Subsoil which is similarly stripped for storage should be kept separate from stockpiled topsoil material. The moisture content limitations for movement of subsoil layers are the same as for topsoils. Again, wheeling compaction in undisturbed upper subsoil should be avoided during the stripping operation. Sufficient depth of subsoil should be stripped to provide a final replaced soil depth (top-plus subsoil) of 1.2 metre over the whole site on top of the consolidated fill.

5.5 Topsoil and Subsoil Storage

Stripped topsoil should be stored on adjacent undisturbed topsoil to reduce the risk of stockpile contamination with subsoil material when the soil is subsequently spread. As the soil may be stored for an extended period of time, a 2 m mound height would be preferable as this should not cause any significant anaerobism within the heap provided the soil is not compacted as it is tipped and heaped during construction of the mound. Maximum topsoil mound height should not exceed 3 m.

Stripped subsoil should be stored on exposed but undisturbed upper subsoil, a maximum mound height of 3.5 m would be satisfactory.

5.6 Weed Control

Allowing the development of a weed cover on the storage heap, or seeding to grass, would help to protect the sides from erosion due to heavy rainfall, and also maintain a drier state within the heap. The first option would however increase the weed seed burden in the soil and the risk of subsequent weed control problems after spreading of topsoil in particular.

The following specification, if needed, would maintain a satisfactory total weed control on the storage heap, if significant amounts of both perennial and annual weeds are present in the existing topsoil:

- Allow the grass and weeds to grow an adequate leaf cover and spray with Glyphosate (Roundup) at 5 l/ha 3 weeks before stripping the topsoil.

- Within 14 days of completing the storage heap, apply Paraquat (Gramoxone) at 3 l/ha plus Oxydiazon (Ronstar) liquid formulation at 4 l/ha. This treatment should control weeds for a period of about 10 weeks.

- Assuming that the soil is stockpiled in April, repeat the Paraquat plus Oxydiazon treatment during the end July-early August period. Alternatively either:-

- omit the Paraquat and use Glyphosate if perennial weeds are present at that stage, or

- omit the Paraquat plus Oxydiazon late summer application so that perennial weed growth can more easily be controlled by using Glyphosate in September.

- Use the Paraquat plus Oxydiazon treatment early in the following spring to control overwinter weed growth and spring weed seedlings.

- More than one treatment may be needed, at appropriate intervals, the final treatment should be applied no later than 10 to 12 weeks before the stored soil is spread.

- Alternative weed control strategies are possible, depending on the weed spectrum that develops.

Weed control on the subsoil storage heap is less critical, as any seed burden resulting from surface weed growth would be buried below the depth of topsoil cover after soil replacement. Weed growth other than grasses should however be controlled by appropriate herbicide applications, not least to avoid possible wind-blown spread of weed seeds onto adjacent land.

5.7 Replacement of Topsoil and Subsoil

Soil material should only be moved out of a mound and spread when its moisture content is at least 5% below the lower plastic limit. Spreading operations should be stopped during or after moderately heavy rainfall as outlined in the earlier section on soil stripping. Drying time required will vary according to rainfall and evaporative conditions afterwards.

If the moisture content inside the soil heap is close to field capacity, according to the extent of vegetative cover, evapotranspiration and preceding amounts of rainfall, the soil should be allowed to dry for at least 2 weeks after spreading before further spreading operations or cultivations are carried out, the latter to level the surface and prepare any required topsoil seedbed.

Compaction during spreading operations can be minimised by

- again using dump trucks and hydraulic excavators for loading and transporting topsoil or subsoil from the storage heaps, keeping to fixed roadways where possible and
- working from the surface of the fill as far as possible rather than from the spread soil surface.

The following sequence of operations should be used to replace subsoil and topsoil:

(1) Starting at the furthest point from the storage heaps, to avoid machinery running over replaced soil, a strip of suitable width for soil replacement should be selected to suit site conditions, working methods and machinery available.

(2) The fill surface is likely to be compacted after previous working operations, this first strip should initially be loosened with "ripping" tines, preferably fitted with wings, at appropriate tine spacing and depth for maximum effect in sufficiently dry conditions. The loosened surface may need blading with a tracked machine to gently level it prior to topsoil placement.

(3) Transported subsoil should be tipped in a line of heaps along this loosened strip and then spread and levelled with a tracked hydraulic excavator working from the fill surface using a wide bucket.

Sufficient depth of subsoil should be placed to provide approximately 90-95 cm uniform depth after settlement of the soil.

(4) Once the first strip of subsoil has been levelled, topsoil should be transported and tipped in heaps on the fill surface alongside the replaced subsoil. The topsoil can then be lifted and spread over the subsoil by means of the excavator, to give a final topsoil depth of about 25 cm after allowance for settlement.

(5) Once the topsoil has been laid over the first strip, a second strip should be started using the same cycle.

(6) When a sufficiently large area has been topsoiled, a light bulldozer or tracked loader can be used for final levelling or grading of the replaced soil surface.

5.8 Seedbed Preparation

After completion of topsoil spreading and levelling operations, heavy disc and/or chisel plough cultivations will probably be needed to break down large aggregates of soil. Spring tine cultivation should be carried out to re-level the soil. Such cultivations should however be delayed to allow the topsoil to dry sufficiently if it is initially in a "plastic" state after spreading.

Usually a topsoil tilth can be allowed to develop by natural weathering due to alternate wetting and drying cycles over a period of time, if there is no urgency to establish a crop quickly once the soil has been re-instated. Normal cultivations for final seedbed preparation can then be carried out.

There would however still be some steep slopes within the proposed landscape contours after infilling and to avoid any risk of water erosion a following should be established as soon as possible.

6. AGRICULTURAL AFTERCARE

6.1 Drainage

The general raising of the land level is not expected to improve the naturally drainage characteristics of these heavy textured soils. A comprehensive piped drainage system with permeable fill to within 300 mm of the restored land surface level, will be needed as part of the land restoration process. A specification for and under-drainage scheme is however outside the remit of this report.

Once installed, a secondary drainage treatment such as mole drainage or subsoiling would also be required to help the efficiency of the underdrainage system and to encourage the development of structure in the soil profile.

6.2 Fertiliser Requirements

Experimental work on the restoration of opencast coal sites has shown no benefit from placement of additional phosphate fertiliser on the subsoil surface prior to spreading of topsoil and is therefore not recommended as part of the soil reinstatement process.

Routine topsoil sampling and analysis would be advisable once spreading is completed, to check pH and determine fertiliser requirements for subsequent cropping. This is a more reliable approach than basing requirements solely on the analysis results given earlier in this report for undisturbed topsoil samples, soil mixing and possible "dilution" of fertility by subsoil contamination, and changes which can occur in soil phosphate availability over a long term storage period (particularly if anaerobic conditions develop within the storage heap), can alter nutrient status.

Phosphate fertiliser rates may need to be 10 to 30 kg/ha higher than normal, depending on crop and soil Index level, to compensate for any initial poor topsoil structure on root development and associated uptake of this immobile element in the soil. Normal Potash rates should be used as given in ADAS fertiliser recommendations (MAFF 1988a).

Nitrogen fertiliser recommendations are usually based on previous cropping and any use of bulky organic manures (N Index), soil type and, for some crops, yield level. Although the site was cropped with field beans in 1990, the long term soil nitrogen fertility of these arable fields is likely to be only moderate. If appropriate, nitrogen rates for cropping in the first year at least after reinstatement should be increased by 20% above the normal recommendation to compensate for the effects of prolonged topsoil storage on the soil nitrogen cycle.

6.3 Bulky Organic Manures

Farmyard manure, if available, could add useful amounts of organic matter for the improvement of topsoil structure if applied evenly in one or two dressings at a total rate of 50 to 75 t/ha when soil conditions are suitably dry for seedbed incorporation.

6.4 Initial Cropping after Topsoil Re-instatement

Winter wheat would be the preferred "pioneer" crop rather than grass in the first year after soil replacement, as the area is relatively dry and a potentially deep rooting cereal crop would benefit soil structure. Early sowing when hopefully soil conditions are relatively dry would give less risk of compaction from to wheelings or cultivation passes. Winter barley is less tolerant than winter wheat to poor soil structure and is therefore less suitable. Winter beans and especially winter oilseed rape should not be grown in the first few years because of their sensitivity to compaction.

Otherwise the replaced soil should be grassed down for a period of at least five years, managed with a cutting regime to encourage the development of good soil structure. Subsequently light grazing at a low stocking rate with beef cattle or sheep during the spring to autumn period could be included provided stock were removed, when wet weather predisposed the soil to poaching damage.

These soils are poorly suited to spring cropping and should not be attempted as this would also greatly increase the risk of soil compaction. Failure to develop a satisfactory soil structure over a period of years would cause significant yield reductions or even crop failure due to the associated problems of surface waterlogging and poor root growth.

7. CONCLUSIONS

7.1 The underlying solid geological deposit is considered to be Oxford Clay; there is a superficial capping of chalky boulder clay till (of glacial origin) on the middle and upper slopes of the proposed landfill site.

7.2 The soils within the site, which are grouped in the Hanslope Association, fall into two main groups, depending on altitude. On the lower slopes (below @ 80 m A.O.D.), the soils comprise calcareous heavy clay loam or similar textured topsoils over upper subsoils with similar texture. In some places the sand content below these horizons increases with depth, giving a distinct sandy clay loam or sandy loam lower horizon, which may in turn change to a heavy non-calcareous silty clay. This latter horizon, probably representing the Oxford Clay is usually below 80 cm but may occasionally form the immediate subsoil.

7.3 On higher land, the topsoils are also mainly slightly calcareous to calcareous heavy clay loams derived from chalky boulder clay. The subsoils are chalky clays and/or heavy clay loams in texture, sand horizons were found at several points within the boulder clay subsoil.

7.4 All the soils have very low stone content, subsoils are slowly permeable with gleying usually confined to depths below 40 cm and are mostly Wetness Class II, occasionally III. As the majority of the soils are naturally calcareous, they have better structure, especially in the upper profile, than non-calcareous clayey soils. Their drainage and workability characteristics are consequently also better. Some of the soils are slightly droughty, this however is not a major limitation.

7.5 The Agricultural Land Classification grading of the site comprises 9.80, 1.39 and 6.26 ha of the total area in grades

2, 3a and 3b respectively. Locally steep gradients between 7 and 10, and minor wetness restrictions are the main limitations to agricultural land quality. A landfill operation could reduce the gradient limitations over the present steeply sloping areas of this site.

7.6 Topsoil analyses show that the site has a good pH and nutrient status, further analysis would however be advisable on completion of a landfill operation in case topsoil fertility had been "diluted" by contamination and mixing with subsoil material during soil movement phases and/or affected by soil storage

7.7 The Lower Plastic Limits of the topsoils are slightly greater than those of the upper subsoil horizons, due to differences in organic matter content and/or texture, giving slightly more flexibility in moisture conditions suitable for movement of topsoils. The heavy textured nature of all these soils however limit the range of moisture contents within which they can be handled without causing smearing and compaction damage.

7.8 Soil handling and storage procedures would depend on the proposed method of landfill operation and subsequent restoration. Soil strippage and storage as soon as possible after harvest is most likely to coincide with suitably dry soil conditions for these operations, otherwise they should be carried out during the spring to autumn period as and when soil and weather conditions allow.

7.9 Topsoil depths vary to some extent across the site and should be stripped accordingly. Subsoil removal prior to infilling should aim to provide a final replaced topsoil plus subsoil depth of 1.2 metre across the site. Use of a hydraulic excavator and dump truck system for stripping and subsequent replacement of topsoil and subsoil horizons would help to minimise the risk of compacting soils during earth-working operations.

7.10 Soil storage heaps of 2 metre height, formed under suitably dry conditions, would reduce the risk of anaerobism developing subsequently within the heaps, particularly for topsoils. Grassing down the heaps would help to retain the stored soils in a drier state for subsequent replacement and reduce the risk of any erosion by heavy rainfall occurring on the sides of the heaps. Total weed control of the heaps, more especially for stored topsoils, would only be needed if there is a major existing perennial and/or annual weed problem over the proposed site.

7.11 An underdrainage system with permeable backfill and secondary drainage treatments of moling or subsoiling would be required as an integral part of land restoration after a landfill operation. Winter wheat would be the preferred "pioneer" crop in the first year after soil replacement on this particular site. Otherwise initial cropping at that stage could be grass managed with a cutting regime and subsequently light grazing. Higher nitrogen and phosphate fertiliser rates than normally recommended may be needed for cropping in the first year at least after soil replacement, depending on the length of time and conditions of soil storage.

8. SOURCES OF REFERENCE

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INSTITUTE OF GEOLOGICAL SCIENCES (1979). Geological Survey Ten Mile Map (South Sheet) Scale 1:625,000.

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MAFF (1988a). Fertiliser Recommendations. RB209 HMSO, London.

METEOROLOGICAL OFFICE (1989). Climatological Data for Agricultural Land Classification.

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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.

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.

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 (eg 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 (eg 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, eg 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.

SOIL INDEX CLASSIFICATION

Classification of mg/l into soil indices

	Phosphorus	Potassium (mg/l)	Magnesium
Index 0	0-9	0-60	0-25
Index 1	10-15	61-120	26-50
Index 2	16-25	121-240	51-100
Index 3	26-45	241-400	101-175
Index 4	46-70	401-600	176-250
Index 5	71-100	601-900	251-350
Index 6	101-140	901-1500	351-600

Soil analysis reports give the quantity of available phosphorus, potassium and magnesium in terms of milligrams per litre (mg/l). These amounts are also expressed as Indices which indicate the relative amounts of nutrients in the soil that are available to the crop, and range from 0 (deficient) to 9 (excess).