

AGRICULTURAL LAND CLASSIFICATION
& GAS MONITORING SURVEY

COLLINGWOOD FARM
SEVENTYHOLDS
ESSEX

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MINISTRY OF AGRICULTURE FISHERIES AND FOOD

REPORT ON AGRICULTURAL LAND CLASSIFICATION AND GAS MONITORING UNDERTAKEN AT
COLLINGWOOD FARM, SEVEYHOLDS ESSEX.

SUMMARY

Areas within this 19.7 ha site were believed to be affected by seepage of landfill gas from an adjacent landfill site. A detailed survey of the site was consequently undertaken in August 1991 and details of soils and gas concentrations collected from 45 pre determined sampling points. Significant levels of methane gas were recorded flanking the eastern site boundary, with a consequent detrimental effect on agricultural land quality, recorded in the gas affected area.

1.0 INTRODUCTION

1.1 Land on this 19.7 ha site was inspected on the 27th, 28th and 30th August 1991 at the request of Strutt & Parker, Chelmsford. The site, which comprises part of field number NG 7777 is located between a golf course in the south, and a small housing development in the north. It is flanked to the west by a working sand and gravel pit and to the east by a landfill site which at the time of survey was undergoing the final stages of restoration. At the time of inspection the site was under oilseed rape stubble, and due to seed shedding, had a fairly dense cover of volunteer oil seed rape plants in the early stages of establishment.

1.2 During the early part of the 1990-1991 cropping year areas of failed crop, and stunted or less vigorous crop growth had been reported appearing in the oilseed rape crop alongside the eastern site boundary flanking the landfill site. These areas were believed to be the result of landfill gas seepage from the adjacent landfill site. A detailed survey of the area shown in Annexes 2 to 5 was consequently undertaken to investigate gas levels within the soil and to assess the actual extent of any gas affected areas. Simultaneously full details of the soils physical characteristics were also collected to enable the site to be graded under the MAFF Agricultural Land Classification (ALC) system.

2.0 METHODOLOGY

2.1 During May 1991 the site was overflown by the MAFF Aerial Photography Unit and panchromatic (black and white) prints produced at a scale of 1:1800 (see Annex 5). These photographs, taken during a period of vigorous crop growth, provide an overview of relative crop performance across the site and assist in delineating any areas of irregular or stunted growth.

2.3 For purposes of soil inspection and gas monitoring (undertaken following harvest) the site was divided into two key areas (see Annex 2).

Within one hundred metres of the eastern site boundary, land was inspected on a 50m grid basis, giving an average auger boring density within the area of 4 per hectare. The remaining part of the survey area which extended to 11.7 ha, served as a Control. This land was inspected on a 100 metres grid, giving an average boring density of one per hectare. In total 47 soil inspections were made.

- 2.4 At each soil inspection soil cores were taken at 10cm intervals to a maximum depth of one metre, using a hand held Dutch soil auger. Gas monitoring was undertaken using a GMI Oxygas Gascoseeker calibrated for Methane (see Annex 1 for description and definitions). Gas readings were taken at 30cm depth and at 10cm intervals below this unless stopped by impenetrable gravel. Full details of soil horizon depth, texture, Munsell colour, stone content and gley morphology were also recorded for each profile sampled. In addition four soil profile pits were excavated to a minimum depth of one metre and details collected on soil structure, rooting depth, wetness class and any visible effects of landfill gas induced anaerobism (oxygen depletion).

3.0 PHYSICAL FACTORS AFFECTING LAND QUALITY

Climate

- 3.1 Site specific climate data was obtained by interpolating information contained in the 5km grid agro-climatic dataset produced by the Meteorological Office (Met Office, 1988).
- 3.2 This shows average annual rainfall to be 560mm (22.4 inches) which is low by national standards. Field capacity days at 102 per annum are also low. The accumulated temperature for the area is measured at 1463°C. This parameter measures the cumulative build up of warmth throughout the year and in conjunction with rainfall influences the development of soil moisture deficits (SMD)*. Soil moisture deficits of 125mm and 122mm are recorded for wheat and potatoes respectively.
- 3.3 Barometric pressure readings were obtained from the nearest Meteorological Recording station at Shoeburyness. On the three days of the survey relatively high values of 1028, 1030 and 1026 milliban were recorded respectively.
- 3.4 Temperatures ranged from 21.0°C to 22.1°C, and wind speeds from 10 to 16 knots, over the three days of survey period.

* SMD: represents the balance between rainfall and potential evapo-transpiration. For ALC purposes the soil moisture deficits developing under a winter wheat and maincrop potato crop are considered. These reference crops have been selected because they are widely grown and in terms of their susceptibility to drought are representative of a wide range of crops.

- 3.5 Overall, climatic conditions do not constitute a limitation to land quality. However local weather conditions can significantly affect the daily rates of landfill gas emissions. In particular the relatively high barometric pressure readings prevailing at the time of survey could impede the flow of landfill gases to the surface. Lower ground water levels can also affect the rate of gas emission by reducing microbial activity resulting in lower levels of gas production.
- 3.6 Together these factors may help to explain the generally lower level of readings taken in August, when compared with the earlier reconnaissance survey undertaken in late January, when barometric pressure and windspeeds were lower and water levels likely to be higher (see paragraph 4.7).

Relief

- 3.7 A maximum altitude of 30 metres AOD occurs on the level or gently undulating land towards the north of the site. The southern half of the site comprises an open dry valley feature which falls to a minimum altitude of a little over 20 metres AOD close to the electricity pylon by the track. Slopes from the east and west facing valley sides are very gentle, having a maximum gradient of 4°. Neither altitude nor relief constitute limiting factors to agricultural land quality.

Geology

- 3.8 The geology of this area is shown on the 1:50,000 scale solid and drift edition geological sheet number 257 (Geological Survey, 1976). This shows most of the higher northern ground to comprise Blackheath Beds with Woolwich and Reading Beds occurring over the majority of the gentle valley slopes to the south.
- 3.9 The Soil Survey and Land Research Centre have mapped this area at a very generalised scale of 1:250,000 (SSEW, 1984). This map shows the site to comprise coarse loamy and sandy soils of the Hucklesbrook Soil Association. Field survey confirms the existence of these soils over the slightly irregular valley slopes flanking the eastern site boundary to the south of the footpath. Elsewhere fine loamy soils over clay were identified. Both soil types are described more fully in paragraphs 4.1 and 4.2.

Landfill Gas

- 3.10 During decomposition of landfill materials, leachate and gases may be produced. The major gases produced are usually methane (CH_4) and carbon dioxide (CO_2). Other gases including hydrogen (H_2), hydrogen sulphide (H_2S) and ethylene (C_2H_4) may also be present.
- 3.11 Although methane itself is odourless, some of the trace gas constituents have an obnoxious smell at very low concentrations and are responsible for the characteristic odour of landfill gases.
- 3.12 The effects of landfill gases are not fully understood. One of the most obvious effects is soil anaerobism (oxygen depletion) by volumes of gases moving upward through the soil. At its most severe this anaerobism produces a foul smelling bluish grey or greenish subsoil.
- 3.13 Although methane itself is not thought to be toxic to plants, many of the trace gases (eg ethylene and, hydrogen sulphide) are known to be toxic and these may be an important factor in the adverse effects of landfill gases on vegetation, Parry (1982). In addition, gases may be modified by microbial action as they pass upwards through the soil. For instance, hydrogen may be oxidised to methane and carbon dioxide; and methane itself to carbon dioxide and water. Thus, in simple terms, elevated carbon dioxide levels may be a significant factor in causing adverse crop effects by, for example, lowering soil pH due to formation of carbonic acid. Furthermore, landfill gases may be hotter than ambient air temperatures resulting in vegetation dieback due to heat effects. Consequently, measurements of methane alone, although giving a good indication of the presence of and likely seriousness of a landfill gas problem, cannot be relied upon to accurately predict the precise adverse effects on crops (DOE, MAFF, SAGA, 1988).

RESULTS

Distribution of Soils

- 4.1 Two main soil types were identified on site. Firstly and most extensively are soils developed from clay. These occur over the majority of the central and western part of the site. Typical profiles are stoneless or very slightly stony, moderately well drained (wetness class II) and comprise sandy silt loam, clay loam or silty clay loam upper horizons overlying clay below 40-60cm depth. Occasionally the lighter loamy textures extend to depth on lower slopes or overlie clay at shallow depth in some upper slope locations.
- 4.2 Secondly, occurring over small areas are soils derived from sand and gravels. These principally occur on the irregular valley slopes flanking the eastern site boundary to the south of the footpath. Soils in these areas are slightly or moderately stony and comprise sandy loam or coarse sandy loam topsoils overlying similar or lighter textured subsoils which typically overlie sand, coarse sand or gravel below 70/80cm depth.

Distribution of Landfill Gas

- 4.3 Out of the 47 sampling points 5 recorded significant* levels of methane (ie in excess of .5 on the 10% LEL scale). These higher readings were concentrated in a fairly narrow (20-30 metre wide) ribbon flanking the eastern site boundary to the south of the footpath.

* For the purposes of this report "significant" levels of methane are considered to be those which exceed 0.5 on the 10% LEL scale. 0.5 is the smallest unit of measurement on this highly sensitive scale and represents concentrations of .025% methane in air.

- 4.4 At the majority of these sampling points, readings of .5 or more occurred within 40cm of the surface. Vegetation within these areas was significantly retarded, with the volunteer oilseed rape plants appearing thin, yellow, and stunted, and the previous oilseed rape stubble having a bleached or dead appearance. Significant weed infestation (mostly dead) was also evident in parts of the area, as were wheelings caused by implement tyres.
- 4.5 These irregularities are also evident on the May aerial photography where retarded growth is identifiable by slight tonal and textural differences in the crop (see Annex 3).
- 4.6 The highest reading, (16 on the 100% LEL scale) was recorded at 40cm depth immediately adjacent to the chain link fence. On the May aerial photography a patch of bare ground was evident in this area, although this had subsequently become colonised by a few (mostly dead) 'invader' weed species which were evident at the time of survey. One topsoil - also located in very close proximity to the chain lime fence - was distinctly warm to the touch, when sampled.
- 4.7 It should be noted that gas readings taken during the reconnaissance survey in January within this area indicate significantly higher gas concentrations. At this earlier date the majority of readings were being made on the 100% LEL scale with values of 40 and 46 being recorded. Occasionally very high gas concentrations of up to 20% on the 100% gas scale, occurred. These higher gas readings may result from local climatic conditions being more favourable for gas production and release in January, than in the more recent August survey (see paragraphs 3.6 and 3.7 above).
- 4.8 Very low or trace readings (0.1 to 0.3 on the 10% LEL scale) were recorded at variable depths within the soil profile at a further 18 soil inspections in the August survey. It should be noted that these very low readings should be treated with extreme caution since they are beyond the accuracy limits of the equipment and are not necessarily indicative of absolute concentrations of methane present. It is interesting to note however, that the majority of these very low readings (72%) occurred in areas immediately adjacent to areas higher gas concentrations. The remaining (28%) low or trace readings occurred

within the Control area, usually towards the base of the soil profile (90cm +). Little or no evidence of retarded crop growth was noted in these areas, either during ground survey or from aerial photography.

4.9 Soil Pit Observations

Four soil pits were excavated on site. Pits 1 and 2 were located in areas of higher gas readings close to the landfill site, while soil pits 3 and 4 were located at points with zero readings within the control area. Soil pit investigations revealed that root growth from the previous oilseed rape crop was significantly impeded in areas of higher gas concentrations compared with non affected Control areas.

- 4.10 At soil pit 1 which was excavated in the clayey soil variant, root growth ceased below 65/70cm depth. At 75/80cm significant gas induced anaerobism was evident with grey (Munsell colour 10YR5/2 and 10YR5/3) colours present on ped faces and a distinct foul odour. Gas readings in the auger hole at this location recorded very low concentrations of .2 from 30cm, increasing to .4 at 100cm and .5 at 110cm (all readings on the 10% LEL scale). The soil was noticeably moist throughout and wheelings from implements were obvious in the immediate vicinity.
- 4.11 At pit 2 which was excavated in the sandy soil variant higher concentrations of methane had been recorded in the auger hole, with readings of .4 from 40cm, increasing to .5 at 60cm and .6 at 90cm. Surprisingly visible signs of gas induced anaerobism were absent in the soil pit as was the foul odour noted at soil pit 1, although a "musty" smell was evident in the soil below 80cm depth. Root growth was slightly stunted in the upper subsoil, and became rare below 85/90cm. The oilseed rape stubble in the immediate vicinity of the pit was thin, as were the establishing volunteer oilseed rape plants. Some weed infestation had occurred in areas of bare ground.
- 4.12 Soil pits 3 and 4 were excavated in the Control area in clayey soil variants with zero concentrations of gas. Both pits showed strong brown colours (Munsell colours 7.5YR4/6 and 7.5YR5/6) predominating to depth with no signs of anaerobism and no trace of "mustiness" or foul

odour. Rooting was rigorous with common roots observed travelling along ped faces to well in excess of one metre.

- 4.13 The lack of visible evidence of gas induced anaerobism at pit 2 may be due to its location within lighter, sandy soil material. Because these soil textures are highly porous the gas is able to diffuse evenly through the soil matrix. In clay profiles, in contrast, it is confined to relatively small numbers of cracks and fissures when increased concentrations consequently occur, causing anaerobic conditions to develop.

5.0 DISCUSSION

- 5.1 In most areas of very low gas values (in the range 0.1-0.3) few or no visible crop effects were evident, suggesting that higher values at depth (ie in excess of .5) may have a more significant effect on crop performance than very low values near the surface. Soil pit investigations, however, indicated that significant readings of .5 on the 10% LEL scale at 110cm can give rise to zones of gas induced anaerobism above this depth. These visible signs of anaerobism do not necessarily coincide with particularly high reading on the gascoseeker. This could be due to the fact that at this depth the gas is concentrated in relatively few cracks and fissures where it is not easily detected by the gas probe. Alternatively, since landfill gas is capable of migration, these anaerobic zones could be relict features indicative of high gas concentrations at a previous date.
- 5.2 In some areas of high gas concentrations the soil was moist to depth with wheelings from trafficking with implements clearly evident at the surface. These high moisture levels could be due to a localised drainage problem. It is also possible however, that they are a result of reduced transpiration rates associated with absent or retarded crop cover due to restricted rooting. No obvious signs of contamination by landfill leachate were observed during the survey.
- 5.3 The very low gas readings recorded towards the base of some control profiles may reflect the proximity of the underlying sand and gravel deposit which, being porous, will readily act as a conductor for migrating gases.

6.0 CONCLUSION AND AGRICULTURAL LAND CLASSIFICATION

6.1 The presence of gas in small areas close to the eastern site boundary is having a detrimental effect on agricultural land quality. The adverse effects of gas are currently very localised and concentrated in a narrow ribbon, close to the eastern site boundary, in the central section of the site (see Annex 4). This area extends to a little over one hectare and has resulted in downgrading land of higher quality to grades 3b and 4.

A breakdown of the agricultural land classification grades in hectares and percentage terms is provided below. The Accompanying Agricultural Land Classification Map is located in Annex 3.

ALC	Ha	%
2	12.1	61.5
3a	6.0	30.3
3b	1.3	6.5
4	0.3	1.7
TOTAL	<u>19.7</u>	<u>100.0</u>

6.2 Grade 2

This occurs over the majority of the site where soils typically comprise medium loamy textures overlying clay at 50-60cm (see paragraph 4.2). In many of the profiles within this area very low levels of gas (0.1-0.3 on the 10% LEL scale) were recorded below depths of 70cm . Soil pit investigations indicated that these very low gas levels do not impede root development, furthermore no visible signs of retarded or stunted growth were evident at the surface in these areas. For these reasons the very low gas readings recorded are not considered to be an overriding constraint to ALC grade. The chief limitations to agricultural land quality within this area are consequently minor winter wetness and summer droughtiness constraints.

6.3 Grade 3a

This is mapped to the north and north east of the site where fine loamy textures overlie poorly structured clay at shallower depth. Small areas of slightly stony light textured, sandy soils are also included within this mapping unit. These soils hold smaller reserves of plant available water than land graded 2, and are consequently limited by droughtiness constraints. In common with land graded 2, very low gas readings were recorded at isolated locations within this mapping unit but are not believed to constitute a significant limitation to agricultural land quality.

6.4 Grade 3b

This occurs in a small area flanking grade 4 to the east of the site. Soils occurring in this area are variable comprising of both clayey and sandy soils variants. The chief limitation to land quality within the area is droughtiness. In the south this derives wholly from the inherently light textures within the subsoil which hold inadequate reserves of plant available water. In the north droughtiness constraints arise from restricted rooting which is caused by gas induced anaerobism within the profile.

6.5 Trace gases which are harmful to plants (phytotoxic) may also be present within this area, and could constitute an additional limitation to land quality. This has not been investigated as part of the current survey.

6.6 Grade 4

This occurs in a narrow ribbon of variable soils immediately flanking the eastern site boundary. High gas levels were recorded in this area imposing a very significant constraint on crop growth. Heat effects and possible phytotoxic effects associated with unmeasured trace gases are likely to constitute further limitation to crop performance within this area.



GMI OXYGAS GASCOSEEKER

This instrument has three ranges of operation:

- (1) 0-100% Volume Methane in air
- (2) 0-100% Lower Explosive Limit (LEL)
(0-5% Volume Methane in air)
- (3) 0-10% Lower Explosive Limit (LEL)
(0-0.5% Volume Methane in air)

The % volume gas range indicates the total volume of methane with respect to air.

The % LEL ranges indicate the explosibility of the flammable gas (methane/air) in the atmosphere. A reading of 1.0 on these scales represents concentrations of 0.05% Methane in air.

All gas monitoring undertaken in August was with the % LEL ranges, with the majority of readings being made on the highly sensitive 10% LEL range. It should be noted that these gas readings may not represent absolute concentrations of methane gas, (due to the modifying effect of other trace gases present) but can be used as a guide to the relative magnitude of the landfill gas problem. Furthermore, large daily fluctuations in rates of landfill gas emissions may occur in response to changes in prevailing weather conditions.



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