LAND EAST OF HAWKSWORTH AND NORTH OF THOROTON,
NOTTINGHAMSHIRE
APP/P3040/W/23/3330045

REBUTTAL EVIDENCE TO THE RULE 6
PARTY'S AGRICULTURAL EVIDENCE

By Tony Kernon

31st May 2024

1 Introduction

1.1 This short Rebuttal addresses a number of mostly technical matters raised in the evidence of Mr Franklin on behalf of the Rule 6 Party (R6P).

1.2 The response addresses the comments made by reference to Mr Franklin's Proof of Evidence referenced, eg, [**SF 1.10**] for para 1.10.

1.3 Reference to the Agricultural Evidence by Tony Kernon is referenced [**TK 1.1**]

2 Matters Raised and Responded To

2.1 The matters raised to which a response is made cover:

- technical/construction assumptions or corrections;
- soil damage and land loss comments or assumptions;
- the use of poorer quality land;
- food security and land use issues, and I reference the Written Ministerial Statement which post-dates Mr Franklin's Proof.

2.2 I therefore comment on points raised generally following the sequence of his evidence, but start with the technical corrections.

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3 Technical Corrections

3.1 The following factual statements need correcting.

3.2 [**SF 7.4**]. Concern is raised that grass cutting or panel cleaning will result in excessive trafficking when wet. **Response.** There is no reason why any mechanical management of grassland, which is generally a summer and early autumn task, would have to be carried out when ground conditions are poor. Panel cleaning is also carried out early summer to maximise cleanliness prior to the peak generating period, so similarly will be done when conditions are suitable.

3.3 [**SF 7.8 & 7.9**]. Concern is raised about the effect of soil inversion. **Response.** As set out in [**TK 5.27 and 5.28**] soil inversion is not proposed, so the downgrading referred to will not occur. It is accepted that it was stated otherwise in the application.

3.4 [**SF 7.16**]. This sets out that the panels will have a maximum ground clearance of 14cm off the ground at the lower end. **Response.** No plan references are provided, but I am advised that these changes have not been proposed. The minimum clearance will be 80cm, which is not restrictive to sheep grazing.

4 Soil Damage and Land Loss

4.1 Mr Franklin makes a number of statements about land loss and the effects of installing panels, including:

- (i) [**SF 5.6**]. After 40 years the land may not be capable of being returned to arable use and the land quality may have been affected;
- (ii) [**SF 5.6**]. There is little evidence that the land "**will ever return to arable farming**";
- (iii) [**SF 5.7**]. Other agricultural land management techniques can improve soil health;
- (iv) [**SF 7.6**]. During construction water run-off from bare soils could result in erosion;
- (v) [**SF 7.19**]. Research by the Welsh Government shows "**the process of constructing solar developments caused significant damage to agricultural land, such that it may never be capable of restoration. Typically, agricultural land quality was reduced**".

4.2 These statements are, at best, an exaggeration. The only periods when soils are subject to larger vehicular passage, beyond maintenance operations (discussed earlier) is at the construction and decommissioning phases. This I describe in my Agricultural Evidence [**TK 5.3 to 5.19**]. The photographs show construction and, where there were problems, restoration including cultivation between the rows of panels. Furthermore the vehicles involved are not large.

4.3 Addressing the points above in order:

(i) & (ii) the removal of the panels will be controlled through condition. Once removed there is no constraint to arable use, and the land and soils will be perfectly capable of such use. A 40 year period under grassland does not prevent arable use, nor does it downgrade land. There is no basis for such a claim;

(iii) whilst other farming techniques can result in improvements to soils, the British Society for Soil Science states that "**significant land use change, (eg conversion of arable land to grassland or woodland) has by far the biggest impact on soil organic carbon**" (see first paragraph of page 5, **Attachment A**);

(iv) run-off from bare soils is a risk of arable farming. There is a similar risk during the site construction period too, it is accepted. Currently that risk exists every winter where crops are not growing, so the risk is greatly reduced over the lifetime of the Proposed Development when grass cover is maintained, not increased as inferred;

(v) the Welsh Government report does not conclude that solar panel installation causes significant damage to soils. Para 5.4 concludes that "**soil compaction……can have a residual impact on soil and land**", but not if handled when the conditions are suitable. Paragraph 8.3 concludes that key to managing risks is an adequate soils a resource and management plan. There is no conclusion that "significant damage" is caused.

4.4 I attach a few key pages from the document (**Attachment B**). The report does not conclude as the R6P's witness describes. This report is the source of the timeline photographs in Mr Franklin's Appendix 7.

4.5 That site, clearly constructed over the winter in wet conditions, shows soil disturbance (not necessarily causing compaction) on the haul route but you will note that the mid-construction photo (which I reproduce below) shows undisturbed and obviously uncompacted grass underneath the panel frames.

Insert: Photo From Mr Franklin's Appendix 7

Mid construction

5 Whether Poorer Quality Land is Available

5.1 The comments made in [**SF 6.5 to 6.7**] are covered in my Agricultural Evidence, and in the Agricultural Evidence to address the Council's late-raised concerns.

5.2 In reviewing Mr Franklin's comments, it is important to note that undifferentiated Grade 3 land (including most of the site) is "**good to moderate quality agricultural land**" (see [**TK Appendix KCC4 footnoted page 56**], not just moderate quality as Mr Franklin infers.

6 Food Security and Land Use

6.1 In his section 8, Mr Franklin references a number of concerns about food production. The text is generally a statement, and does not go so far as to state that this is a matter for concern or against policy.

6.2 In response I draw attention to:

(i) Government's press release food security [**TK 5.48 and Appendix KCC7**];

(ii) whilst the MP for Central Suffolk and North Ipswich made comments about using land for producing green energy [**SF 6.8**], Government wishes to see this increase, including through biomass [**TK 5.52**];

(iii) the amount of land needed for solar is only a small proportion of farmland [**TK 5.52**] and significantly less than, for example, is funded for non-producing biodiversity uses [**TK 5.49**];

(iv) the figures involved – circa 30 tonnes of wheat from a production of 22 million tonnes [**TK 5.42 – 5.44**] - is negligible;

(v) the reason for installing solar energy is to help tackle climate change. As Mr Franklin notes in [**SF 8.4 and 8.7**], climate change is the biggest threat to food production in the UK. Tackling climate change must, therefore, weigh heavily in favour of the proposals.

6.3 The Written Ministerial Statement (WMS) of 15th May 2024 does not increase the protection of BMV land. It does not alter the balance.

6.4 It is noted in the WMS that "**even in the most ambitious scenarios**" (solar) "**would still occupy less than 1% of the UKs agricultural land**". As statistically 42% of agricultural land is likely to be BMV (**Appendix KCC2**), even on that basis solar could involve a small proportion of BMV land (less than 0.5% of agricultural land).

6.5 An estimated 3.7 million ha is BMV land. 1% of that is 37,000 ha. By comparison, the area of uncropped arable land in 2023 was 311,303 ha.

6.6 There are about 900,000 horses in the UK. The split between England and the other countries is not known exactly, but in terms of sports horses about two thirds are in England. If that applied to the total, then some 590,000 horses are in England, which if each requires 0.4 ha of land for grassland (grazing and hay) means about 240,000 ha of land is used for horses grazing and feeding. If 42% of that is BMV, some 100,000 ha of BMV is used for grazing or feeding horses. This I include only to illustrate the land use choices we make and the land potentially available.

6.7 The use of land and BMV land for solar must be seen in that context.

Attachment A

British Society for Soil Science Note

SCIENCE NOTE: SOIL CARBON

BRITISH SOCIETY OF SOIL SCIENCE

Highlights

- **There is an urgent need to reduce atmospheric carbon dioxide (CO_2) concentrations.**
- **Supporting natural and agricultural systems to sequester carbon (C) can help achieve this.**
- **Many soils have the capacity to sequester C from the atmosphere, however the process is slow, easily-reversible and time-limited.**
- **The greatest and most rapid soil C gains can be achieved through land use change (e.g. conversion from arable land to grassland or woodland), but this can have implications for food production and the displacement or exporting of emissions.**
- **Increasing soil organic C contents through sustainable soil management (SSM) practices can improve soil health, the efficiency of food production and the delivery of multiple public goods and services.**
- **Where financial incentives are developed to encourage SSM practices and sequester C it is essential that funders provide ongoing support to these schemes.**
- **Given the uncertainties around the amount of additional C that can be sequestered in future, and the ease with which C gains can be lost, it is essential that the carbon stores in existing permanent grasslands, moorlands, peatlands, wetlands and woodlands are protected.**

Introduction

Recent reports from the Intergovernmental Panel on Climate Change (IPCC) highlight how human activity is changing the climate in unprecedented and sometimes irreversible ways.

The reports make it clear that action to tackle climate change is an urgent priority. The 26th United Nations Climate Change conference (COP26) is due to take place in Glasgow in November 2021 and is seen as critical for establishing a robust path to future zero or negative emissions of greenhouse gases (GHG's) at a global scale. There is an urgent need to reduce fossil fuel emissions to near zero, while supporting natural systems to sequester and store carbon (C). Soils contain more C than in the atmosphere and vegetation combined and are therefore an essential *carbon store*. Under certain conditions with careful management they can act as an important *carbon sink*.

Increasing the amount of C stored in soil is beneficial from a climate change mitigation perspective, but how much C can be stored in this way?

This science note aims to:

- Set out the importance of C in soils, how it behaves, and the role it plays in supporting soil functions, delivering vital public goods and services, and helping societies adapt to and reduce the rate of climate change.
- Raise awareness of the main issues surrounding soil C and the actions that governments, communities and individuals can take.

Carbon sequestration

A net transfer of carbon (C) from the atmosphere to land (either into soil or vegetation).

Carbon store

A medium that stores C. Over a given period of time, the amount of C in the store may be increasing, decreasing or static.

Carbon sink

Any reservoir or medium that over a given period of time accumulates and stores more C than it loses.

Carbon source

Any reservoir or medium that over a given period of time loses more C than it accumulates.

Figure 1

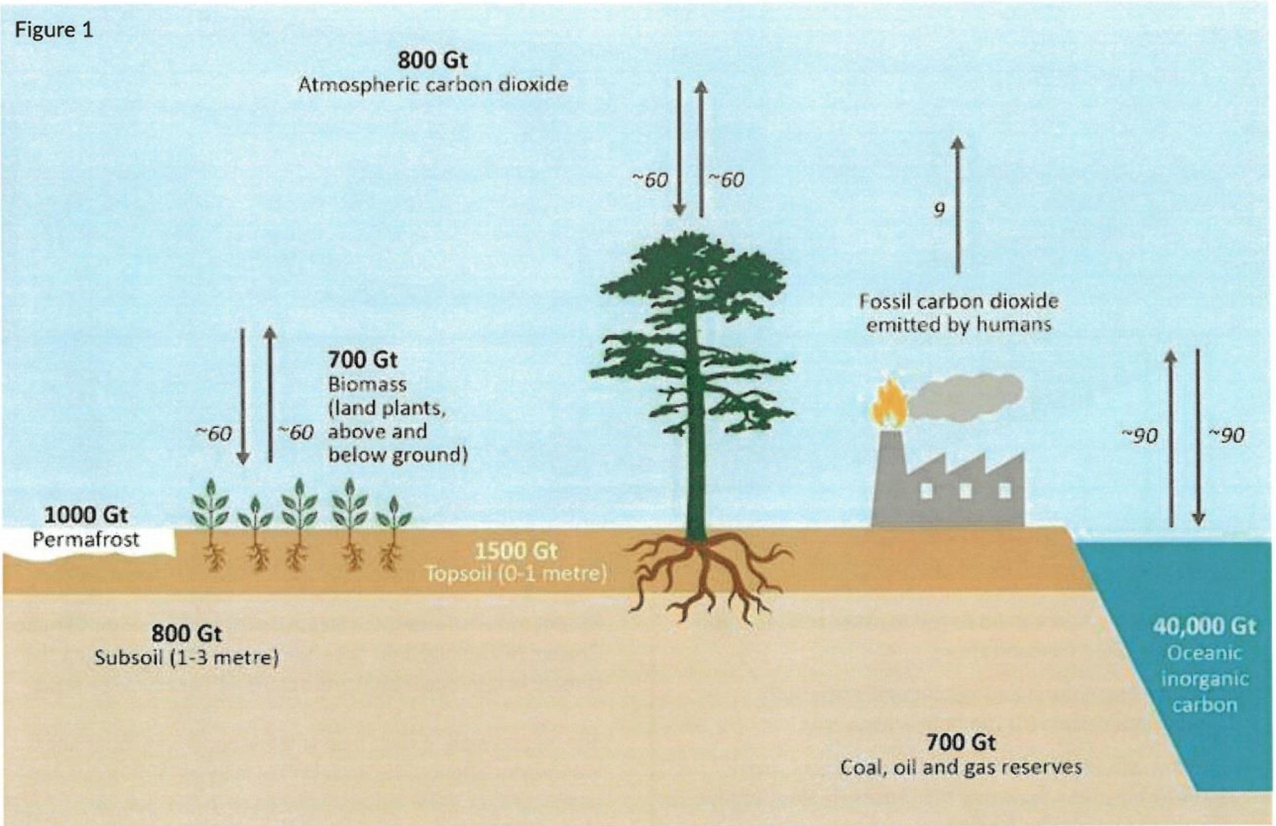

Figure 1: Carbon stocks and flows on land and in the oceans (adapted from Jenkinson, 2010 [1]). The numbers in bold are stocks in Gigatonnes (Gt) C: those in italics are flows in Gt C per year. Topsoil and subsoil stocks exclude peatlands.

What is soil carbon?

C is the fourth most abundant element in the universe by mass after hydrogen, helium and oxygen, and is the primary basis of life on Earth.

The ability of C to form many bonds allows it to form large complex molecules that attach to other elements that are essential to life, such as nitrogen (N), phosphorus (P) and sulphur (S). These bonds also trap energy as a source of fuel for microorganisms.

The soil C stock is around three times that of the atmosphere, at around 2,300 Gt (2.3 trillion tonnes) to three metres depth and 1,500 Gt in the top metre

When plants, animals and microorganisms die and decompose, their remains form organic matter of which about half is C, and on land this combines with weathered minerals from rock (inorganic material) to form soil.

After the world's oceans, soil is the world's largest active C store, holding 80% of terrestrial C, which is almost three times the amount held in the world's atmosphere [2] [Figure 1].

Carbon concentrations are usually smaller in sandy (light) soils and larger in clay (heavy) soils.

Soil organic carbon (SOC) content varies enormously from less than 1% in desert soils to over 50% in peats but is typically less than 5% in most agricultural soils [3].

Deforestation and cultivation can reduce SOC by exposing it to the process of oxidation and conversion to CO_2 which is emitted into the atmosphere. Within soil ecosystems there is a constant exchange of C between SOC and the atmosphere, and these interactions and transformations are part of the global C cycle (Figure 2, page 3).

C is found in soils in two forms:

- **Soil organic carbon (SOC)** – the living and dead components of organisms, including fine plant roots, root exudates, fungi, microbes and decomposing organic matter from plant litter or animal products such as manure.

- **Soil inorganic carbon (SIC)** – chemical compounds such as calcite or chalk (calcium carbonate: $CaCO_3$) [4]. SIC is generally more stable than SOC and accounts for approximately 38% of the total soil C pool. It is much more abundant in the low rainfall regions than in moist, temperate regions of the globe. SIC can also be added to soils in the form of amendments such as rock dust and could be a means of storing more SIC in soils. However, the full cycle and cost-benefit analysis of this emerging technique needs further consideration.

SIC is predominantly controlled by the weathering of C-based rock minerals (mostly underlying chalk and limestone in the UK) and it can essentially be considered to be a fixed constant for most temperate zone soils, notwithstanding the application of lime and other carbonate-containing mineral amendments in agriculture. For this reason, it is SOC that is the more dynamic fraction, being more responsive to management, and it is SOC that is the focus of this scientific note.

Soil organic carbon (SOC) levels can be increased (or decreased) through changes in management, although it normally takes years to decades to bring about measurable change. Where SOC stocks are currently large e.g. under old grassland or forest, it is important to keep them and not lose them through changing land use. Long-term historical loss of SOC, (particularly in arable soils) offers a potential route for future C storage increases.

Soil carbon stocks and flows

Carbon dioxide (CO_2) in the air is absorbed by plants through photosynthesis, creating biomass that is eventually deposited on or in soil as wood, leaf litter, root exudates and root material [Figure 1, page 2]. In well-aerated soils, most of the C in this plant debris is converted back to CO_2 by the activities of soil organisms (fungi, bacteria, etc.) through soil respiration, but a fraction is retained in soil and becomes stabilised to varying degrees. In temperate climates about one third of plant C entering soil is still present after one year. Integrated with the cycling of C is the cycling of important plant nutrients, which enhances soil fertility. As organic matter enters the soil, the soil organisms process it to mineralise the key nutrients into forms that are available to plants [5].

Soil conditions vary and in more extreme environments (such as very acidic, dry or wet) soil C turnover is reduced. For example, in waterlogged soils, with very low oxygen levels, decomposition is slow to non-existent and peat forms along with other 'saturated soil' (anaerobic) decomposition products, including methane (CH_4), an important GHG [2]. Where these conditions are maintained for centuries, such as on upland bogs and lowland fens, peat accumulates over time. However, if these peats are drained, allowing air to enter, microbial respiration is reactivated and the peat C is emitted as CO_2 at rates in excess of 30 t CO_2/ha/yr [6], although it will take many decades to lose all this stored C.

Plants also respire all the time (Figure 2) and use the sugar produced through photosynthesis to drive their metabolism in

Figure 2

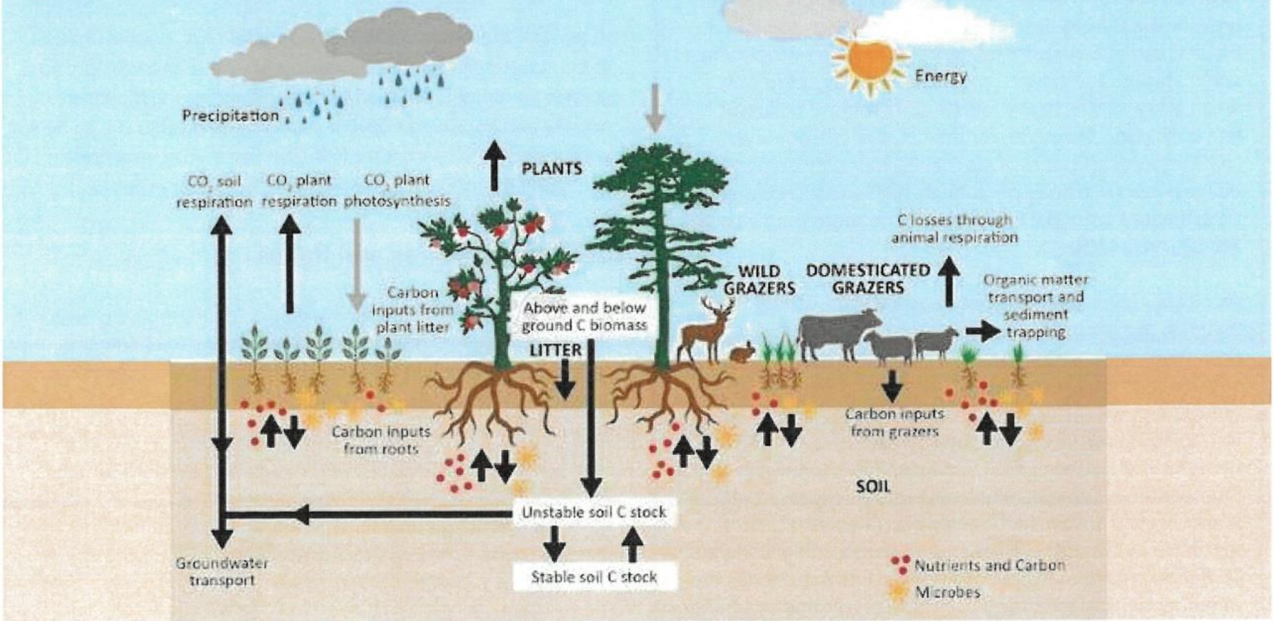

Figure 2: A simplified representation of the carbon cycle in terrestrial ecosystems (adapted from Garnett *et al.*, 2017 [7]).

a process known as plant respiration. In stable ecosystems, and in many agricultural systems, which have not changed for decades, photosynthesis and plant/microbial respiration are in balance, with the overall effect on atmospheric CO_2 being zero.

However within these systems, in addition to respiration, C is removed through harvested crops and livestock products, and also through animal respiration and fermentation from ruminating cattle, sheep, goats and domesticated deer; and in addition to photosynthesis, C is returned to the land as crop residues, livestock manure (Figure 1), human sewage and food waste. Organic C can also be added to soils as biochar, a stable form of C that is a category of charcoal (See Biochar box). If the rate of C input is greater than the rate of decomposition, then the amount of C in the soil increases. The opposite is true where the rate of decomposition exceeds C input [5].

Humans have therefore had an important influence on the C cycle through the burning of fossil fuels (Figure 1), breeding of domesticated livestock on a large scale and replacing natural ecosystems with agricultural and urban land. All these activities have altered the balance of the *natural* C cycle to such an extent that in many agricultural systems the amount of plant and microbial respiration (due to a combination of bare soils and cultivation) exceeds the amount of photosynthesis, resulting in a gradual depletion of SOC. However, this depletion can be reversed through land use change and sustainable soil management (SSM) practices [8].

Biochar

Biochar is the organic and inorganic C remains of organic material that has been heated in the absence of air (oxygen) to produce a form of charcoal. This heating or *pyrolysis* can prevent the C from degrading and returning to the air [9]. Biochar can also support soil fertility through nutrient and water storage and release, particularly in degraded soils. It can also stabilise heavy metals and promote pollutant immobilization. However, for the UK, the efficacy and GHG removal potential of biochar is limited by domestic biomass resource and prohibitively high costs, resulting in an estimated potential for biochar of no more than 6 to 41 Mt CO_2/year [10].

As biochar composition varies depending on source material, processing, local climate and soil type, the timeframe over which biochar-C remains sequestered in the soil is uncertain. There is also a lack of long-term data, e.g. biochar crop yield response field experiments provide only four to five years of data, and glasshouse experiments are necessarily short-term [11]. Therefore, it is suggested that biochar should meet quality standards, be closely monitored and only used in specific targeted circumstances that maximise its benefits [9]. Although the use of biochar should be tightly regulated, where it is applied with care it has the potential to increase long-term soil C, at a greater rate than any other treatment or management technique [12].

Soil carbon functions [13]

There are many reasons why we should be concerned about protecting or increasing the stock of C within soils [14, 15]. SOC has a profound influence on soil properties and functions that affect the production of food and fibre. It also impacts on the functions that soils perform for the wider environment such as regulating the flow and quality of water, providing clean air, filtering pollutants and contaminants, and supporting biodiversity. All functions which are often termed 'soil ecosystem services' (SES) are reliant on the turnover of SOC and are closely related to 'soil health' [15,16,17].

Soil organic C is an essential component of soil structure, function and soil life

SOC is the energy supply that enables soil organisms to carry out their functions in a healthy soil. Together with soil microorganisms, SOC is a key factor in the formation and stabilisation of soil structure – the system of aggregates (units of sand, silt and clay particles bound together) and the surrounding pore network (containing air and water) [18]. SOC can interact with soil particles (notably clay) to form small aggregates through various chemical and biological processes. The processing by soil microorganisms of organic matter that enters the soil from leaf litter or from roots produces substances which act as a glue (glomalin) to combine smaller aggregates into larger aggregates, making the aggregates more stable and resistant to external forces such as raindrop impact and cultivation [19]. The greater resilience of soil aggregates also stabilises the soil pore network, allowing the soil to carry out its functions of retaining water for plants, transmitting water down to the groundwater and, in the topsoil, allowing plant roots to grow without restriction and to access nutrients.

In general therefore, a soil with a greater SOC content has a more stable structure, is less prone to runoff and erosion, has greater water infiltration and retention, increased biological activity and improved nutrient supply compared to the same soil with a smaller SOC content [20, 21]. Even small increases in SOC can markedly influence and improve these properties [22].

Soil carbon stores and fluxes

SOC is a key component of the global C budget and changes in stocks have implications for the mitigation or intensification of climate change. The largest stocks of soil C are found in non-agricultural soils with a peaty surface horizon (e.g. semi-natural grasslands, moorlands and wetlands), woodlands, peatlands, and uncultivated long-term agricultural permanent pasture, where it is important to protect the existing C stores [23, 24, 25]. Soil C sequestration represents an important mitigation route for climate change and is achieved largely by stabilisation rather than turnover of SOC.

Although soils used for arable agriculture (annually cultivated) typically have smaller SOC contents than grassland or woodland soils, they are potentially more amenable to alteration through direct management interventions. Soil C stocks can be increased by either increasing inputs (e.g. crop residues, cover crops, use of organic materials, inclusion of grass leys in arable rotations) or decreasing losses (i.e. reducing oxidative losses to CO_2, or particulate and dissolved organic content), via improved management such as reduced intensity tillage [26]. Significant long-term land use change (e.g. conversion of arable land to grassland or woodland) has by far the biggest impact on SOC, but is unrealistic on a large scale because of the continued need to meet food security challenges.

More practical approaches could be the inclusion of grass leys into arable rotations (i.e. arable soils being under grass for several years in a crop rotation). This may result in a more sustainable system with healthier soil, although the cycling of C will result in some GHG emissions, and the whole rotation crop productivity is decreased since there is no human-edible crop during ley years. Integrating livestock may displace some human edible crop production, emit more CH_4 (if ruminant livestock numbers are not reduced elsewhere), and the change in soil C stocks is small compared with that of land use change.

Since changes to soil C occur over periods of many years, the financial benefits of soil C sequestration are normally based on modelled future soil C levels. Such models need to be relevant to individual soil types, land use and climate, and need to be accurately baselined through field measurements.

Nevertheless, relatively small changes in C stock per unit area in arable agricultural soils may translate into substantial stock increases at the national or regional scale [27, 28]. There has been much discussion of the possibility of mitigating climate change through soil C sequestration [27]. However, changes in SOC are generally slow to occur and, because of the large background C in soils and the inherent variation, it is difficult to measure accurately.

Moreover, the process of soil C sequestration is often misunderstood, and can lead to an overestimation of the climate change mitigation achievable by using this route [28]. This is primarily because the quantity of C that can be stored in any soil is finite. After a positive change in management practice, soil C levels increase (or decrease) towards an equilibrium value (after 20-100 years or more) that is characteristic of the 'new' land use, management system and climate [21]. The relatively large annual rate of soil C accumulation in the early years after a major change in land use or management (such as a change from a conventional cultivated arable rotation to a reduced tillage system incorporating grass leys and cover cropping) cannot be maintained indefinitely and the annual rate of increase will decline (eventually to zero) as the soil approaches its new equilibrium. The use of organic amendments in arable agriculture, such as composts and manures, is a practice that can increase SOC, but the supply is finite and there are costs incurred with such practices. It is therefore unlikely that the initial rate of increase in soil C following a change in land use /management practice will be sustained over the longer term (>20 years), as the new equilibrium level is reached.

When increased over time through altered management, soil C concentrations will reach an equilibrium state beyond which, no further increases are (naturally) possible.

Beneficial soil management approaches need to be continued beyond the equilibrium point to prevent returns to prior low C status.

In addition, C sequestration is reversible. Maintaining a soil at an increased soil C level, due to a change in management practice, is dependent on continuing that practice indefinitely. Indeed, soil C is lost more rapidly than it accumulates [29]. Also, to increase soil C levels, inputs of other elements such as nitrogen (N) and phosphorus (P) are needed. [30] The soil C, N and P cycles are intimately linked, and increasing soil C may affect the release of diffuse water pollutants (nitrate-NO_3 & phosphate-P) and GHGs considerably more potent than CO_2 (e.g. nitrous oxide (N_2O) & CH_4).

In other words, there is a risk of 'pollution swapping' where the reduction of one form of pollution increases another. Land use changes such as reafforestation and wetland creation may also result in deforestation and cultivation elsewhere to grow the food that is not produced in the C sequestration project (i.e. displacement) [31].

Despite these risks and limitations, there is scope for soil C sequestration to contribute to climate change mitigation, particularly on low C, degraded landscapes. It is equally important that this C sequestration is allied with retention of existing SOC stocks in non-agricultural and long-term permanent pasture soils. Maintaining or enhancing SOC levels can deliver a range of benefits not only for climate change mitigation, but also for soil quality and functioning which can make soils more resilient to the impacts of climate change (e.g. ability to cope with extreme events such as droughts and floods) and other global change factors [32].

Measurement, Monitoring, Reporting, Verification (MRV) and Valuing

Sequestering additional C in agricultural soils is attracting interest from governments and industry as a way to meet climate change objectives and is leading to the development of schemes to pay farmers to adopt SSM practices. Such soil-focussed schemes do not yet exist in the UK, but equivalents have been running in Australia and Canada for a number of years [33] and the European Commission's Carbon Farming Initiative is due in 2021. The Australian Emission Reductions Fund (ERF) and Carbon Farming Initiative encourage the adoption of a number of land management strategies that result in either the reduction of GHG emissions or the sequestration of atmospheric CO_2, while the Conservation Cropping Protocol in Canada provides payment for no-till cropping [34].

Any financial mechanism based on soil C status needs to include mechanisms to accommodate situations where soil C:

- has declined over an agreed sequestration period
- has increased (relative to other soils of a similar type) prior to an agreed sequestration period.

Setting up robust monitoring, reporting and verification (MRV) platforms for soil C is very challenging, due not just to variations in how changes in soil C are influenced by climate, land use and management in different agro-climatic regions, but also because it can be difficult to determine the baseline soil C content against which to judge (and pay for) the success of any sequestration initiatives [35]. The potential for future land management changes to cause captured C to be re-released from soils also means that monitoring has to be robust for the lifetime of any payment scheme.

Existing MRV protocols for soil C credits take different approaches to quantifying soil C and net removals of GHGs from the atmosphere. Some rely on soil sampling, some combine sampling with process-based modelling, while others rely on combinations of modelling and remote sensing [35]. Differences in the way protocols and C markets estimate sequestration make it difficult to be confident that climate benefits have actually been achieved – but the costs associated with direct measurement of soil C make it impractical as a long-term monitoring option [2], meaning that models and remote sensing become essential once a ground-truthed soil C baseline has been established. Ground truthing needs to take account of the high degree of variability between soil C contents even where soils are apparently similar across a field. An alternative is to simply link specific management practices to mean C sequestration potential within a set of given contexts.

Soil C sequestration provides a useful tool in global efforts to tackle GHG emissions, but the slow rate of change, the relatively small amounts that can be sequestered (e.g., in 2010 it was calculated that even the most extreme land use change scenarios in Great Britain would account for only c. 2% of national GHG emissions [36]), and the ease of reversibility in soil C gains present significant challenges with respect to measurement, monitoring and verification [5]. Stakeholders must be aware that a focus on soil C can have unintended consequences and should not be perceived as a 'quick fix'.

Conclusions and recommendations

Climate Change is arguably the greatest challenge facing humanity and efforts are underway globally to reduce GHG emissions and to capture those that continue to be emitted.

The counterbalancing need, on the one hand, to remove C from the atmosphere and, on the other, to add C to soils, presents an obvious confluence. Soils are a significant reservoir of C, but land use changes over centuries have resulted in a proportion of that C being lost from many soils. Although present in both organic and inorganic forms, it is SOC and (more specifically) soil organic matter that is critical to the functioning and resilience of soils in countries such as the UK. This is why addressing historic C losses provides clear potential for improving soil quality and for future C sequestration in soils, which is leading to the development of monetised soil C sequestration schemes that can be built into governmental or corporate strategies to offset residual GHG emissions.

Increasing the SOC of degraded soils can significantly improve productivity and resilience, and SSM techniques such as reduced intensity tillage, residue management to maintain ground cover, the use of cover crops, and the application of bulky organic manures (e.g. compost) are commonly used to achieve this. Changing SOC concentrations with such techniques can however take decades, and gains can be rapidly reversed in the event of further land management changes. Further, increases in soil C will not continue indefinitely; rather C concentrations will reach new equilibria, which can themselves only be maintained by continuation of the favourable management practices. Equilibrium concentrations of C will vary depending on soil type, land use and climatic conditions. It is possible that in some circumstances the natural SOC store can be augmented to some extent through use of basalt minerals or biochar, which offer potential for longer term inorganic or organic C storage - but the whole life cycle C costs of such techniques need to be considered with care before genuine sequestration benefit can be claimed. The source and chemical characteristics of biochars and rock dusts can also be problematic from both regulatory and environmental perspectives.

In the UK context, it is essential that historic SOC declines are addressed if soils are to function effectively, improving their resilience to increased temperatures, increased intensity of rainfall events and other inevitable effects of climate change. However, this essential requirement creates significant potential for abuse at a time when governments, corporations and individuals are increasingly keen to offset their C emissions through sequestration initiatives.

Although this Science Note is based on a UK perspective, we recognise that the same issues apply internationally and there is a need for action on a global scale.

Based on the available scientific evidence, we recommend that:

- The C stores in existing permanent grasslands, moorlands, peatlands, wetlands and woodlands are protected.
- SSM practices are more widely adopted to increase SOC, to help mitigate existing GHG emissions, to improve soil health and resilience, and to protect and enhance the multiple public goods and services provided by soil.
- Where financial incentives are developed to encourage SSM practices it is essential that funders provide ongoing support to these schemes. This recommendation applies equally to any scheme claiming C sequestration in soils.
- Soil C concentrations should be periodically monitored. While modelling can be used to estimate future C stocks in specific soils, it is essential that these estimates are validated through soil testing at a network of representative field sites.
- Sequestering C in soils and vegetation, although important, must not distract from the urgent need to reduce CO2 emissions from the burning of fossil fuels. Failure to address the latter will render the former irrelevant.
- Attempts to overcome natural soil C equilibria through application of materials such as rock dust or biochar must consider the whole life C costs of such practices as well as ensuring that they do not impact negatively on soil quality through pH change, chemical contamination or other undesirable characteristics.

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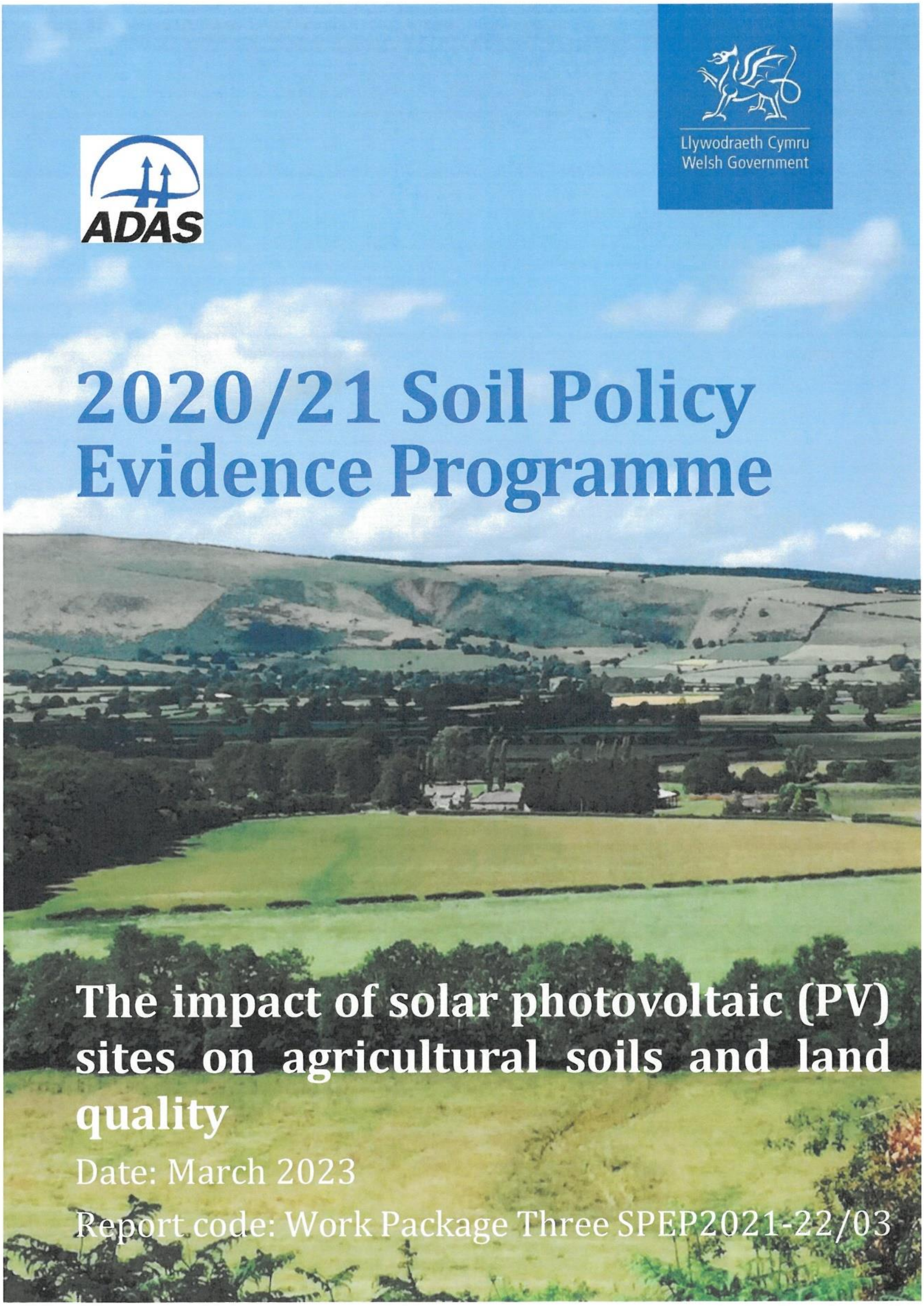
Attachment B

Extracts from Welsh Government Report



Llywodraeth Cymru
Welsh Government

ADAS

2020/21 Soil Policy Evidence Programme

The impact of solar photovoltaic (PV) sites on agricultural soils and land quality

Date: March 2023

Report code: Work Package Three SPEP2021-22/03

Welsh Government

The impact of solar photovoltaic (PV) sites on agricultural soils and land

Work Package Three: Review of Impacts

March 2023

ADAS

EXECUTIVE SUMMARY

This report is part of an evidence-based assessment of the impact of solar photovoltaic (PV) sites on agricultural land and soil. The work, under the Welsh Government's Soil Policy Evidence Programme SPEP 2021-22/03, is to inform Welsh Government and Natural England specialists when dealing with solar photovoltaic (PV) planning applications.

The impacts on Best and Most Versatile[1&2] (BMV) agricultural land from the construction, operational and decommissioning phases are reviewed, based on the findings of the earlier literature review (WP1), best practice and extensive experience of land restoration. The main impact of the three phases of development is deep soil compaction resulting in the loss of versatility of Best and Most Versatile agricultural land and in wetter parts of England and Wales the loss of Best and Most Versatile agricultural land. An assessment is made of the reversibility of the impacts. Soil compaction results mainly from trafficking and alleviation is reported to depths of 45cm. It can take many years for soils to recover from compaction and compaction may be permanent. Runoff from panels can result in rivulets, which can lead to soil loss by erosion.

The benefits of topsoil carbon capture and soil structural improvements are reported for grassland. Research on the impact of solar PV panels on microclimate beneath panels highlights the changes in temperature on vegetation growth.

The decommissioning phase involves the removal of the solar PV site infrastructure. The issues of 'pile pull out' are considered, including corrosion and fracture of the piles.

Good soil handling conditions may mitigate the threats to soil and land. Appropriate planning with a quality soil resource and management plan is essential at the planning application stage to ensure that conditions, as part of the planning process, are relevant and focussed on the restoration of the land to agriculture.

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[1] Planning Policy Wales Paragraphs 3.58-3.59 Edition 11 February 2021 and National Planning Policy Framework

[2] Land classified as Grade 1, 2 and 3a. MAFF Agricultural Land Classification Guidelines. 1988

CONTENTS

5 ARE SOLAR PV SITES REVERSIBLE TO AGRICULTURE WITHOUT RESIDUAL (NEGATIVE) IMPACT?

5.1 Introduction

A brief review and summary of the hypothesis: '*that solar PV sites are physically reversible to agriculture without residual (negative impact) in the BMV and Non-BMV context*' is presented. The evidence base to support this hypothesis and the main issues influencing reversion to agriculture are identified.

5.2 Evidence Base

The key residual impact on the land is soil compaction. Defra (2016) reported that careful management of machinery use in terms of when and how many times soils are trafficked was a key influence on the level of soil compaction on grassland.

Current techniques on alleviating soil compaction are effective in the topsoil and upper subsoil, generally above a depth of 45cm (Batey, 2009). The depth of the uppermost compacted layer (e.g. after remediation) may be the determining factor in the realisation of potential agricultural use. Keller et al (2021) provide evidence that the recovery of soil from compaction was longer than 2 years. Compaction may be very persistent in the subsoil and possibly permanent (Hakansson et al 1988). Where there is 'industrial' compaction the depth of compaction can extend to depths of 1 m (Spoor, 2006) and may persist for up to 30 years (Batey, 2009). A review by Nawaz et al. (2021) refers to time scales of 5 to 18 years for soils to recover from compaction with the aid of agricultural machinery and for soil to recover from compaction naturally (without aid) 100 to 150 years.

At the point of decommissioning there is likely to be a residual impact of soil compaction across solar PV sites. The impact may affect the agricultural use of the land and decisions about cropping and yields.

Soil mixing has been reported by Choi (2020) where there was a greater fraction of coarse particles in the study solar PV site soil than the reference soil. It was considered that the difference arose during the construction phase, when the topsoil was disturbed and fine soil particles were lost by water erosion. Soil mixing has potential to occur at other stages in the life of a solar PV site, such as pile extraction.

5.3 The main issues influencing reversion to agriculture

At decommissioning all materials are expected to be removed including the removal of piles from the soil. Most standard steel products corrode, particularly in the upper part of the pile and this may adversely affect the ability to extract the piles after 40 years. (Non-corrosive materials could be used but have cost implications). It may be that piles fracture and are difficult to extract without additional digging. An engineering solution, where extraction is adversely impacted, would be to partially cut down the piles and provide a capping layer of soil (per comm. P Woodfield, Technik GS). Any residual piles are likely to have a negative impact on whether the land is physically reversible to agriculture unless buried sufficiently deep to enable cultivations and drainage. Where residual piles could not be buried to a depth to allow cultivations the grading of the land would take into account the severity of the limitation. Land with severe or very severe limitations, which restrict the range of crops, is placed into either Grade 4 or Grade 5 in the MAFF Agricultural Land Classification system. To bury the piles to a sufficient depth would mean excavating to a depth of at least 1.0-1.2 metres. This would result in significant soil disturbance if many of the piles were affected in this way.

Where galvanised beams are used zinc is present in the galvanised coating. There are two methods of galvanising used- 'continuous galvanising' and 'batch hot dip galvanising' (per. comm. A Whalley, Milestone Communications). Continuous galvanising (DIN EN 10327) gives a thinner coating, so the expected life is lower. If the beams are batch hot dip galvanised then standard ISO14713-1 applies, which includes reference to exposure to soil. Corrosion in soil is dependent on the soil's mineral content, the nature of the minerals and organic components and the water and oxygen contents. The impact of any interaction between the piles and the soils and potential loss of zinc coating over 40 years and whether there is any residual impact may need to be considered (per. comm J Williams, ADAS). Guidance from Defra (2018) on the use of sewage sludge on land states that the maximum quantity of zinc that can be applied per ha is 150kg over 10 years. Potentially any loss of zinc from piles could be well within this limit, but there is no supporting evidence. There is also evidence that high zinc levels in soils affects the soil biological activity (Moffett et al, 2003).

Handling soil in suitable conditions has an influence on the reversion of land to agriculture. Different soil textural classes have more resilience to structural damage and are more responsive to remediation during soil handling. Light textured soils e.g. sand, loamy sand, sandy loam and sandy silt loam have a higher resilience to structural damage than medium texture soils e.g. soil with 18-27% clay content. Silt loam soils and heavy soils with >27% clay content have a low resilience to damage. Soil should only be handled or trafficked when as dry and as friable as is practicable. If handled or trafficked in adverse conditions damage to the soil structure can easily occur.

The period available for soil handling and trafficking on a solar PV site can influence the impact on the soil, the resultant structural damage and reversion to agriculture. The Institute of Quarrying (2021) has prepared a map of England and Wales showing climatic zones when vegetated mineral soils may be in a sufficiently dry condition according to their geographic location, depth of soil and clay content. When the clay content is between 10% and 27% in the topsoil in Wales, the South West and North of England the indicative on-average period when soils may be in a sufficiently dry condition for handling is generally late May to early October. For similar soils in central parts of England it is generally late April/early May to early November, while in the East of England it is generally late April to early December. The location of the proposed solar PV site and susceptibility of a soil type to structural damage should be considered at the design stage to ensure timeliness of soil handling and trafficking. A soil in West Wales with a medium clay loam texture and clay content of 24% will have a shorter window for soil handling and trafficking than the same soil in East Anglia. The impact of climate and climatic zones should be built into the design statement at the pre-planning stage of a site.

A research study into end of life decision making for solar farms (Windemer,2021) reported that there may be changes in ownership of the solar PV site with a change in the priorities for the site. The study considered finance for decommissioning, reporting that bonds are not always used in the solar sector as it is 'felt that decommissioning will not present a challenge'. The study found that some developers considered that decommissioning may be self- funding through the resale value of equipment and materials from the site. A sample decommissioning plan (Solar Energy UK, 2022) refers to the provision of a decommissioning fund either through a surety bond, an irrevocable standby letter of credit or other financial security.

Developers may consider that the scrap value of the panels etc on site will cover the costs of decommissioning. There are few contingency plans in place and should operators encounter financial instability and the economics of solar PV change during the project life and trigger early decommissioning then this may influence the reversion of the site to agriculture and other changes of land use may be sought.

Finances available for decommissioning are part of the responsibility of the operator or landowner or both and can influence the reversion to agriculture. It is the responsibility of the planning authority to ensure that the developer or landowner has secure finances or a bond in place to fund decommissioning.

5.4 Summary

There is evidence that soil compaction from machinery can have a residual impact on soil and land. Soil mixing may occur during construction and in the voids left after piles are extracted. Soil compaction and mixing may result in issues for land management. Removal of physical infrastructure on site and re-instatement of soil/land is necessary if the land is to be capable of reversion to a BMV agricultural land quality as well as a non BMV agricultural land quality.

The finance available for the required decommissioning and the timings of these operations may be an influencing factor on the reversion to agriculture. There may be financial constraints, time penalties and contractual performance issues that affect the decommissioning programme and the quality of remediation works.