Herefordshire Council

Image: soil sample taken by Catchment Advisor

Method statement: Soil testing

HEREFORDSHIRE NATURAL FLOOD MANAGEMENT PROJECT

Herefordshire Council

VERSION 1 | JULY 2024

Contents

Version	Date published	Details
Version 1	July 2024	Produced through consultation with Wye and Usk Foundation and Severn Rivers Trust

1 Introduction

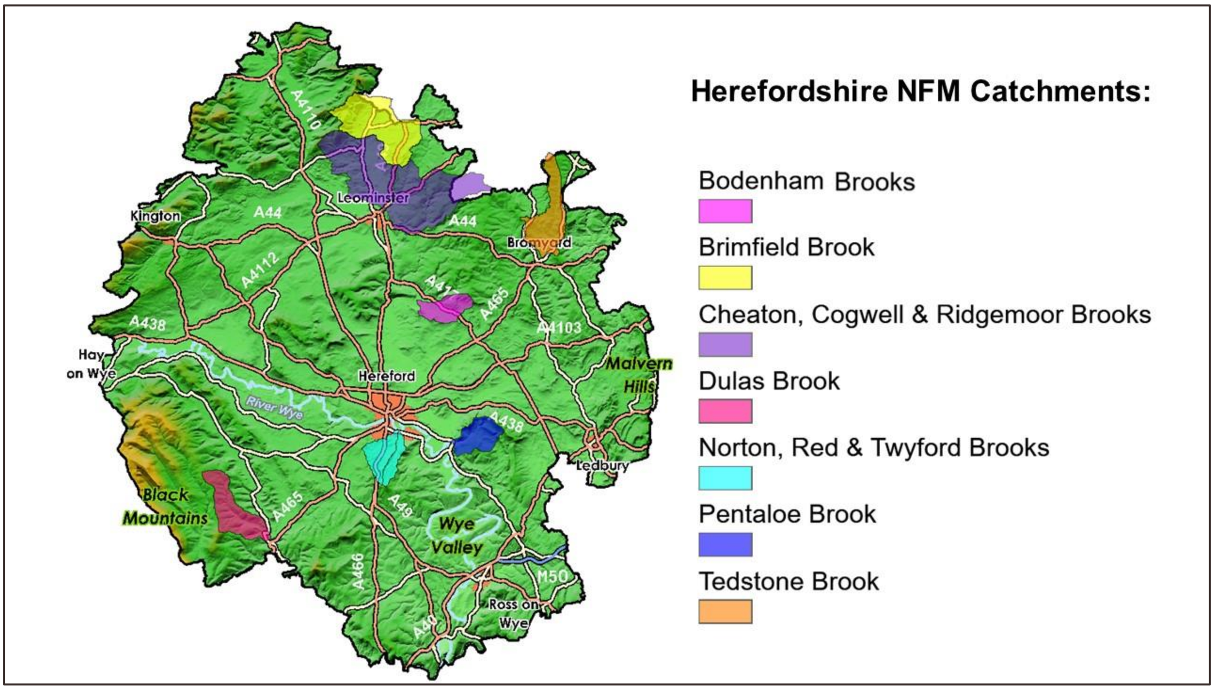
1.1 Herefordshire Natural Flood Management project

The Herefordshire Natural Flood Management (NFM) Project seeks to work collaboratively with landowners and communities within seven priority sub-catchments (Figure 1-1), identifying opportunities to work with natural processes to slow the flow of water within the catchment and reduce the flood risk to downstream communities. Environment Agency funding comprising, Flood Defence Grant in Aid and Local Regional Flood Risk Management Committee monies has been secured until 31 March 2027 to deliver the project. As part of the agreed business case, Herefordshire Council (project lead) must seek to deliver a monitoring programme which aims to enhance the NFM evidence base – one element of which is soil research.

This document outlines how the project will monitor and analyse soils in order to enhance our understanding of NFM and its benefits.

Further information about the project can be found on the [Council's NFM webpage](#).

Figure 1-1 Herefordshire NFM Project catchment areas



1.2 River Wye and Lugg NFM Pilot project – soil analysis

1.2.1 Catchment analysis

Through the Defra funded River Wye and Lugg NFM pilot project (2018 – March 2021), as part of their advisory visits, project funded Catchment Advisors at the Wye and Usk Foundation (WUF) and Severn Rivers Trust (SRT) conducted free soil tests. These tests included an analysis of soil structure, worm count, organic matter content, pH, nutrient content and infiltration rates and were designed to help inform the advisors recommendations as well as provide information on the current state of the catchments soils. Over the course of the pilot project the advisors tested a total of 379 fields, developing a baseline dataset for all of the project catchment areas.

Initial results indicated that arable fields had depleted organic matter content compared to pasture fields. This is significant because organic matter is a good proxy for soil health and is related to its water holding capacity. A study conducted by WUF (2021, Table 1-1) estimated that the total potential reduction in water holding capacity due to depleted organic matter levels on arable fields on engaged farms is 1,788,000,000 litres of water. This potential for additional water storage within the catchment's soils will be a focus of future projects.

Table 1-1 Organic matter content and impact on water holding capacity on arable fields (Table from Wye & Usk Foundation soil analysis report, 2021)

Catchment	Catchment Area (ac)	Area of catchment engaged (ac)	Approx. % of arable	Ave. reduction in % OM on arable soils	Water holding capacity of lost OM % (Li/ac)	Potential reduction in water holding capacity due to depletion of OM levels in arable fields of engaged farms (Li)
Bodenham	4,199	2,731	78	2.30	188,660	**402,000,000**
Cheaton & Ridgemoor	18,278	6,125	54	2.00	164,052	**542,000,000**
Dulas	4,940	1,541	6	2.90	237,875	**22,000,000**
Pentaloe	2,964	2,178	26	3.40	278,888	**158,000,000**
Red/ Norton/ Twyford	3,211	2,324	38	3.60	295,294	**260,000,000**
Tedstone	5,187	4,186	62	1.90	155,849	**404,000,000**

Repeat tests were also conducted in 49 fields to try and develop our understanding of how the NFM measures had benefitted the soils. A study conducted by WUF (2021) analysed the impact of different NFM measures. Whilst most measures appeared to need longer term monitoring to ascertain the true benefits of the NFM, they found that direct drilling on fields (for no more than 3 cropping seasons) had resulted in slight increases in organic matter, suggesting that reduced cultivation techniques may be able to improve organic matter content over a short period of time. A study conducted by SRT (2021) also reported a 42% improvement in soil structure between 2019 and 2021 on fields in the Brimfield brook catchment relating to the implementation of NFM. Out of those fields, 33% saw an improvement relating to under-sowing maize or undertaking cover cropping to enhance soil structure and reinstate organic matter content.

1.2.2 Soil moisture testing

Mirroring the methodology used by the Shropshire Slow the Flow Project, the pilot project undertook a detailed investigation into the relationship between different land management practices and their impact on soil moisture content, both under grassland and arable scenarios (tested soil moisture down to depth of 40 cm). A total of 10 sites (5 variables) were monitored (Table 1-2) with data collected on a weekly/fortnightly basis between January 2020 and August 2021 (number of sample days vary between sites, 9-17 days). The project aimed to identify the land management practices which offer the greatest benefits, both in terms of flood risk reduction but also in terms of ecological benefits, improved soil health and benefits to agricultural business.

In 2023, an MSc student at the Royal Agricultural University, Cirencester used this data to undertake their thesis, titled '*Investigating the role of agricultural soils within a natural flood management system in the United Kingdom*' (W. Betts, 2023). It concluded that the data '*strongly suggests that maintaining soil cover whether grass or cover crops offer the best solution for retaining moisture*' (W.Betts, 2023, pg. 48), noting this is linked to increased soil organic matter content which relates to improved soil structure and subsequent water movement and storage of water within the soil. Whilst little variance was observed between other variables (min-till, no-till, stubble, arable high organic matter), it noted that agricultural practices which promote a high standard of soil health and structure, e.g. min-till, would eventually result in flood risk reduction benefits. The study recommends further research to quantify flood risk reduction benefits (as factors such as soil type will influence results).

Table 1-2 Soil moisture research variables – River Wye and Lugg NFM Pilot project

	Variable 1	Variable 2
Grassland Scenario	Low Organic Matter Levels	Normal/High Organic Matter Levels
	Not aerated	Aerated
Arable Scenario	Low Organic Matter Levels	Normal/High Organic Matter Levels
	Conventionally cultivated	Direct drill
	Cover crops	Bare stubble

2 Approach to soil testing

2.1 Aims

The Herefordshire NFM Project aims to gather soil information/data for the following reasons:

1. To inform the recommendations made by the Catchment Advisors within the NFM advisory reports.
2. To produce a baseline soil dataset for each of the project's NFM catchment areas.

2.2 Where will we sample?

The Herefordshire NFM project will conduct soil testing, following the methodology outlined in Section 2.3 at the following locations:

- On fields identified as being at high risk of surface water runoff, e.g. due to compaction issues or their proximity to a surface water flow pathway (SciMap erosion risk maps).
- On fields where there is a high likelihood that the landowner will implement the recommended NFM measures, relating to the outputs of soil test results.

Note, on arable farms, in order to ascertain the potential soil health and structure that could be achieved on arable fields, it is recommended that a nearby grassland field (ideally on the same farm) should have soil tests undertaken on it.

Whilst soil testing can be a good tool for engaging landowners and may be conducted as part of this initial engagement, wherever possible, soil tests should be focused on fields meeting the above criteria.

As part of the project's monitoring programme, some sites may be re-tested to help develop our understanding as to how NFM measures can improve soil health and structure, relating to reduced flood risk.

2.3 Soil sampling method

Catchment Advisors may conduct soil testing as a way of engaging with the landowner as well as gathering essential information to inform their NFM advisory reports and recommendations.

In order to ensure a consistent approach which builds on the data collected through the NFM pilot project, the following methodology should be used when conducting soil tests. Data collected in the field should be recorded on the Soil Assessment Record Sheet (Appendix C) and then inputted into the 'Hfd_NFM_Soil_data' Excel sheet (on the project's MS Teams SharePoint site).

2.3.1 STEP 1: SAMPLE SITE IDENTIFICATION

As it is not feasible to sample all fields within the holding of an engaged landowner, Catchment Advisors should identify those fields at highest risk of erosion/surface water runoff and then sample four of the highest risk fields. SciMap erosion risk maps can be used to help identify the high risk fields, alongside discussions with the landowner.

Fields sampled should be representative of the land use of the holding, e.g. if the farm is mainly used for pasture, three of the sampled fields should be grassland and one of the sampled fields should be arable.

2.3.2 STEP 2: COLLECT SOIL SAMPLE FOR LABORATORY ANALYSIS

At each identified field sample site, an auger should be used to collect a composite soil sample. For arable fields, samples should be taken at a depth of 20cm (10cm for permanent grassland). The composite sample should consist of 10-20 sub-samples collected at random from the field and combined in a bucket. A 'W' sampling pattern across the field can be used to aid sampling. Note, to ensure the sampling is representative of the whole field, locations such as headlands, field gates, water troughs and feed rings should be avoided. The sub-samples should be thoroughly mixed together before being put into a sample container and sent to the laboratory for further analysis.

Laboratory analysis will test the soil for its; organic matter content, pH, Phosphate index (P index), Potassium (K) and Magnesium (Mg).

For sites related to meadow creation, additional testing for nitrogen may also be conducted.

2.3.3 STEP 3: STRUCTURAL ASSESSMENT OF SOIL

Following methodology outlined in the 'Visual Evaluation of Soil Structure (VESS)' produced by the British Beat Research Organisation (2012), a soil structure assessment should be conducted in each of the identified field sample sites on the holding. This methodology involves, using a spade to extract a soil block which can then be analysed and given a soil structure score (scores from 1, good structure to 5, poor structure, Table A-1). In order to obtain a representative sample, at least three, soil structure assessments should be conducted in each sample field. Samples should be taken from a location within the field which has a uniform crop or soil colour.

Analysis should also be conducted on the presence and composition of worm populations.

2.3.4 STEP 4: WORM ANALYSIS – BURROWS AND MIDDENS

Worm analysis should be conducted using the soil blocks taken in Step 3: Structural assessment of soil. This should be conducted in each of the identified field sample sites on the holding. Soil blocks should be analysed for the presence of worm burrows and middens. The presence of vertical burrows or middens should also be recorded.

2.3.5 STEP 5: WORM ANALYSIS – COMPOSITION

Worm analysis should be conducted at each of the identified field sample sites on the holding using the soil blocks taken in Step 3: Structural assessment of soil. All worms within the soil block should be collected and the total number of worms recorded. The number of worms in each of the following categories should then be recorded:

- Adult
- Juvenile

Note, worm counts vary throughout the year.

2.3.6 STEP 6: SOIL TEXTURE

Following the methodology outlined on page 10 of the Soil health assessment guide by the National Institute of Agricultural Botany (NIAB), the soil texture of each of the identified field sample sites on the holding should be analysed and recorded (topsoil and sub-soil). This involves taking a sample of soil, approximately the size of a dessert spoon and breaking down any aggregates or clumps by working the soil between your fingers and thumb. Any obvious stones or plant debris should be removed from the sample. If the sample is too dry and won't hold together, gradually add a small amount of water to the sample until it is wet enough to hold together and assess whether the sample is sticky. The flow chart shown in Appendix B should then be followed to determine the texture of the soil.

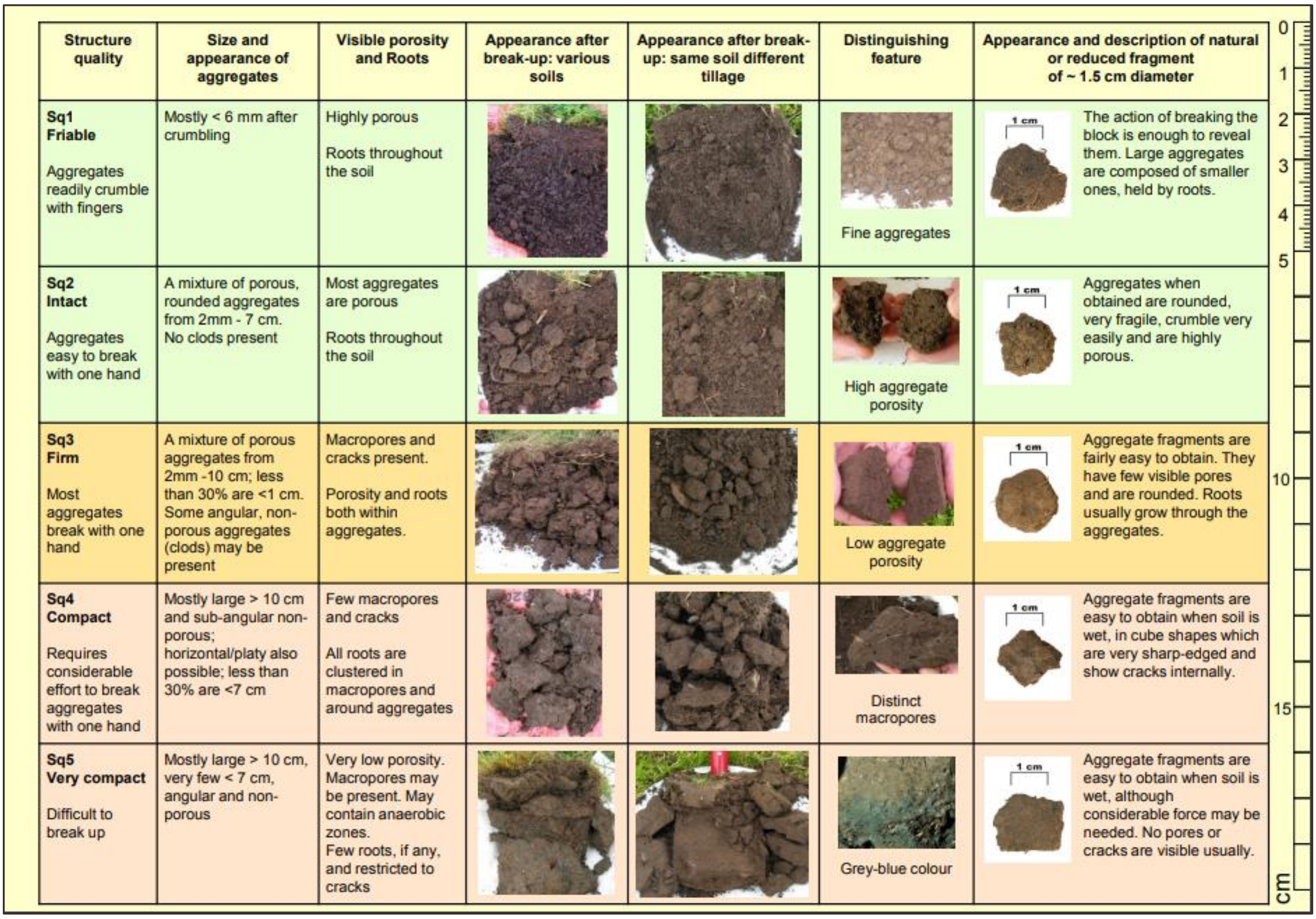
2.4 Soil sampling analysis

In the first instance, soil test results will be analysed by the Catchment Advisors and used to inform the recommendations given within the NFM Advisory reports issued to landowners. For example, fields shown to have compaction would receive a recommendation to undertake works such as sward lifting and grassland aeration to improve the soil structure and subsequent water holding capacity and infiltration rate.

As the project progresses and a baseline dataset is produced, the project will look at opportunities to further develop our understanding of soils and their ability to reduce flood risk.

Appendix A – Soil structure scoring guide

Table A-1 Soil structure scoring guide

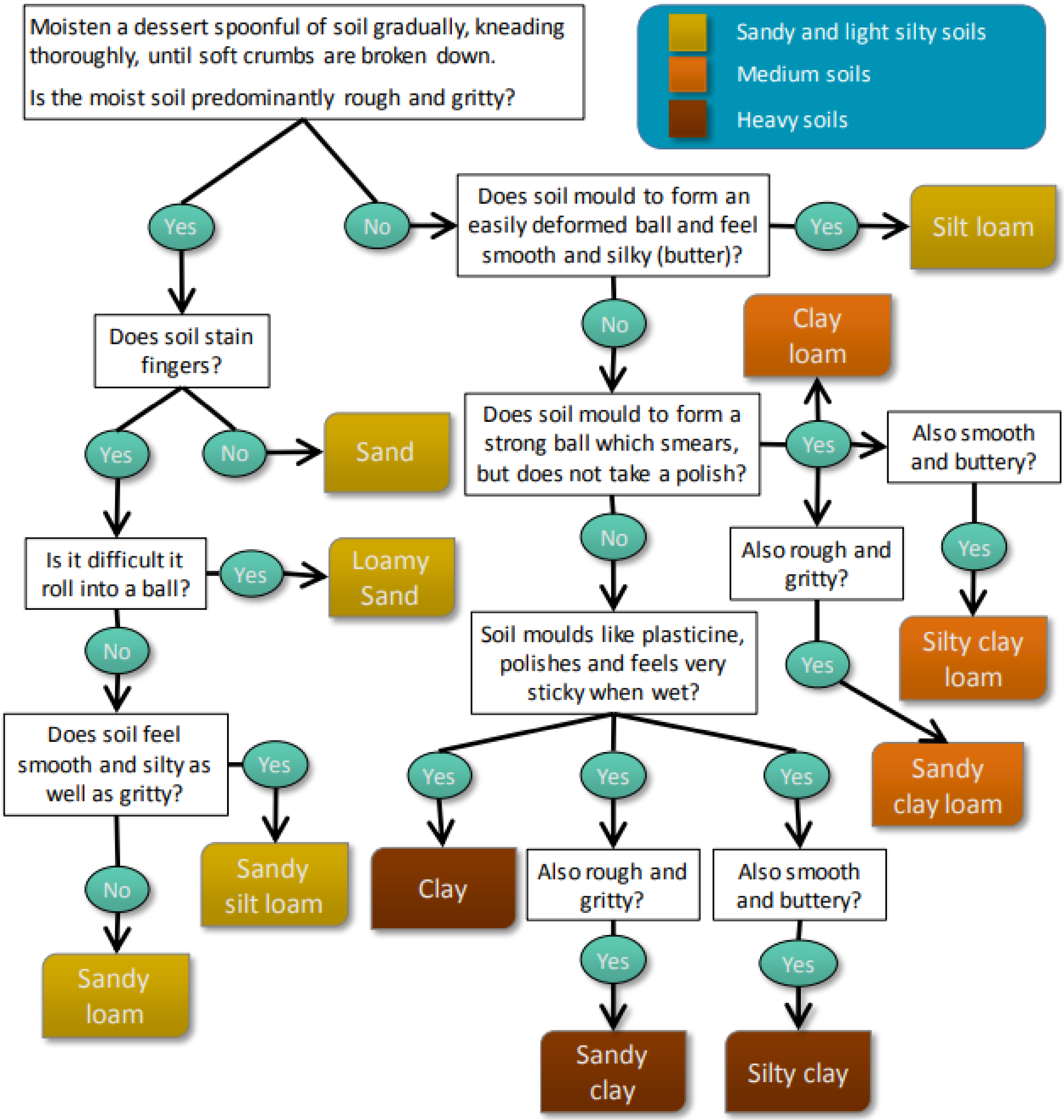


Structure quality	Size and appearance of aggregates	Visible porosity and Roots	Appearance after break-up: various soils	Appearance after break-up: same soil different tillage	Distinguishing feature	Appearance and description of natural or reduced fragment of ~ 1.5 cm diameter
Sq1 Friable Aggregates readily crumble with fingers	Mostly < 6 mm after crumbling	Highly porous. Roots throughout the soil			Fine aggregates	1 cm. The action of breaking the block is enough to reveal them. Large aggregates are composed of smaller ones, held by roots.
Sq2 Intact Aggregates easy to break with one hand	A mixture of porous, rounded aggregates from 2mm - 7 cm. No clods present	Most aggregates are porous. Roots throughout the soil			High aggregate porosity	1 cm. Aggregates when obtained are rounded, very fragile, crumble very easily and are highly porous.
Sq3 Firm Most aggregates break with one hand	A mixture of porous aggregates from 2mm -10 cm; less than 30% are <1 cm. Some angular, non-porous aggregates (clods) may be present	Macropores and cracks present. Porosity and roots both within aggregates.			Low aggregate porosity	1 cm. Aggregate fragments are fairly easy to obtain. They have few visible pores and are rounded. Roots usually grow through the aggregates.
Sq4 Compact Requires considerable effort to break aggregates with one hand	Mostly large > 10 cm and sub-angular non-porous; horizontal/platy also possible; less than 30% are <7 cm	Few macropores and cracks. All roots are clustered in macropores and around aggregates			Distinct macropores	1 cm. Aggregate fragments are easy to obtain when soil is wet, in cube shapes which are very sharp-edged and show cracks internally.
Sq5 Very compact Difficult to break up	Mostly large > 10 cm, very few < 7 cm, angular and non-porous	Very low porosity. Macropores may be present. May contain anaerobic zones. Few roots, if any, and restricted to cracks			Grey-blue colour	1 cm. Aggregate fragments are easy to obtain when soil is wet, although considerable force may be needed. No pores or cracks are visible usually.

Source: British Beet Research Organisation (2012). Available at:
www.bbro.co.uk/media/50172/vess_score_chart-1.pdf

Appendix B - Soil texture analysis flow chart

Figure B-1 Soil texture analysis flow chart



Source: National Institute of Agricultural Botany (NIAB), Pg. 10 (2020) Available here

Appendix C – Soil assessment record sheet

This sheet should be used in the field to record the data gathered trough this analysis. One sheet should be completed per field that's sampled. Data collected should then be inputted into the ''Hfd_NFM_Soil_data' Excel sheet (on the project's MS Teams SharePoint site).

Herefordshire NFM Project: Soil testing data sheet

STEP 3 and STEP 6: Soil structure and texture analysis (at least 3 assessments per sample field)

Site name:
Field name/ number:
Date of sampling:
Sampler:
Area of field (ha):
Grid reference (central field location):
Crop type:
Weather:
Depth of composite sample taken for laboratory analysis: ☐ 20cm ☐10cm (permanent grassland) *Laboratory analysis will be conducted for: organic matter content, pH, Phosphate index (P index), Potassium (K) and Magnesium (Mg)*
Notes:

Sample No.	1	2	3	Average
Grid reference				
Soil structure score - Topsoil *(1 good to 5 poor)*				
Soil structure score - Subsoil *(1 good to 5 poor)*				
Soil texture				

STEP 4: Worm analysis (using soil blocks extracted in Step 3)

Sample No.	1	2	3	Average
Grid reference				
Presence of vertical burrows				
Presence of vertical middens				
Total number of worms present				
Total No. adult worms				
Total No. juvenile worms				