Soil Health Testing

CEMA 216

Definition

Quantitative testing for biological, chemical, and physical characteristics of soil and constraints using approved laboratory methods.

Applicable Land Uses

All Land Uses.

REQUIREMENTS

Qualified Individual Requirements

The Natural Resources Conservation Service (NRCS) strongly encourages Conservation Evaluation and Monitoring Activity (CEMA) participants to know the Qualified Individual (QI) requirements to ensure the person they employ to provide the CEMA is fully qualified to meet the objectives of the activity.

A QI for Soil Health Testing CEMA 216 meets one of the following:

1) Certified Crop Advisor (CCA) or Certified Professional Agronomist (CPAg) through the American Society of Agronomy or a Certified Professional Soil Scientist (CPSS) or Associate Professional Soil Scientist (APSS) through the Soil Science Society of America.
2) Technical Service Providers (TSP) certified for Soil Health Management Plan Conservation Practice Activity (116) or Soil Health Management Design and Implementation Activity (162).
3) An associate degree or higher in an agricultural or soil science field with at least 2 years of experience collecting soil for laboratory analysis.
4) Individuals working under the guidance or management of a QI are allowed to collect soil samples for this CEMA.

General Requirements

1) This CEMA includes the performance of work and documentation of the tasks, results, interpretations, and other activities described herein by a QI.
2) Prior to initiation of the CEMA, the QI must arrange a pre-work conference to ensure all parties understand the participant’s objectives, required deliverables, and characteristics of the CEMA tasks.
   a) The parties in the pre-work conference must include the participant, the QI, and the NRCS field office staff. The parties should agree whether they will join in-person or join via phone, web-meeting, etc.
   b) It is recommended that the Technical Service Provider (TSP) (if one is needed to support

the results of this CEMA) is invited to the pre-work conference for the implementation of a Conservation Planning Activity (CPA) or Design and Implementation Activity (DIA).

3) A QI may use any reference information, resource concerns, conservation practice standards and related documents served in the NRCS Field Office Technical Guide (FOTG) for the state where this CEMA is performed. The FOTG home page hyperlink is: https://efotg.sc.egov.usda.gov/#/

Technical Requirements

This CEMA includes details to collect and analyze soil based on soil health resource concerns and planning objective(s). Soil samples are to be collected in the planning land unit (PLU) and submitted to commercial laboratories for analysis using standardized methods.

All Soil Testing

1) Record the purpose and strategy for testing the soil. Design the soil sampling strategy based on goals, available tools, and other applicable guidance. Analyze the soil type, topography, and management information to determine appropriate sampling locations within a PLU.

2) The soil is an ecosystem. The following five soil processes/characteristics, Soil Aggregation, Soil Carbon Cycling, Microbial Activity, Carbon Food Source, and Nitrogen Food Source must be assessed to measure the status of the soil ecosystem. The participants must choose the preferred or alternate laboratory method for each process/characteristic below:

Table 1. Each soil process should be measured to evaluate overall soil health. Choose a method to measure the soil indicator from each column.

Soil Process and Indicator	**Soil Aggregation – Wet Aggregate Stability**	**Carbon Cycling – Soil Organic C (SOC)**	**Microbial Activity – Soil Respiration**	**Carbon Food Source for Microorganisms – Labile Carbon**	**Food Source for Organisms – Bioavailable Nitrogen**
Reason for Measurement	Measure of the physical soil environment. Related to water infiltration, carbon and nutrient storage, biological activity, and reduced erosion	Related to soil structure, fertility, and provides microbes with food	Measure of how active the microbes are in the soil	Carbon food that is easily taken up by microbes	Related to protein that is readily available to microbes
Preferred Method	Wet sieving (NRCS Soil Survey Staff, 2022)	Dry combustion (NRCS Soil Survey Staff, 2022)	24-hour incubation/burst (Zibilske, 1994)	Permanganate Oxidizable Carbon (POXC) (NRCS Soil Survey Staff, 2022)	Autoclaved citrate extractable (ACE) protein content (Hurriso et al., 2018)

Alternate Method	Cornell Sprinkle infiltrometer (Ogden et al., 1997)	SOC calculated from Soil Organic Matter measured by Loss on Ignition (NRCS Soil Survey Staff, 2022)	96-hour incubation (Zibilske, 1994)	Water extractable organic carbon (WEOC) (Haney et al., 2018)	Water extractable organic nitrogen (WEON) (Haney et al., 2018)

3) Soil pH and texture will be measured to interpret the soil health indicator results. The participants must choose the preferred or alternate laboratory method for each soil pH and texture below:

Table 2. Soil characteristics are used to interpret soil health indicators. Choose a method to measure the soil characteristic from each column.

Soil Characteristic	**Soil Texture**	**Soil pH**
Preferred Method	KSSL Particle Size Distribution Analysis by pipette (NRCS Soil Survey Staff, 2022)	1:1 water (NRCS Soil Survey Staff, 2022)
Alternate Method	Hydrometer Method (Gee and Bauder, 1986)	0.01M $CaCl_2$ (NRCS Soil Survey Staff, 2022)

4) Participants who would like an advanced soil health test with additional microbial diversity/functional diversity information should choose one of the methods below:

Table 3. If additional soil biological information is desired, choose a method to measure microbial/functional diversity.

Soil Indicator	**Microbial Diversity/Functional Diversity**
Preferred Method	Phospholipid Fatty Acid (PLFA) (Buyer and Sasser, 2012)
Alternative Method	Choice of three of the following enzymes: β-Glucosidase (Carbon Cycling) N-acetyl-β-D-glucosaminidase (Carbon and Nitrogen Cycling) Protease (Nitrogen Cycling) Acid and/or Alkaline Phosphatase (Phosphorus Cycling) Arylsulfatase (Sulfur Cycling)

5) Use the following sampling strategies (Figure 1), or combination of strategies, when applicable:

   a) Random – Soil in the PLU is homogeneous and there are few problem areas. Sampling locations are chosen by assigning random numbers to areas on a grid overlay.

   b) Stratified – Soil in the PLU is heterogenous and contains different soil types across different landscape positions. Sampling locations are chosen randomly within delineated subareas (or strata) in proportion to the size of the subarea in relation to the PLU.

c) Problem – Distinct areas with uneven crop performance are strategically sampled.

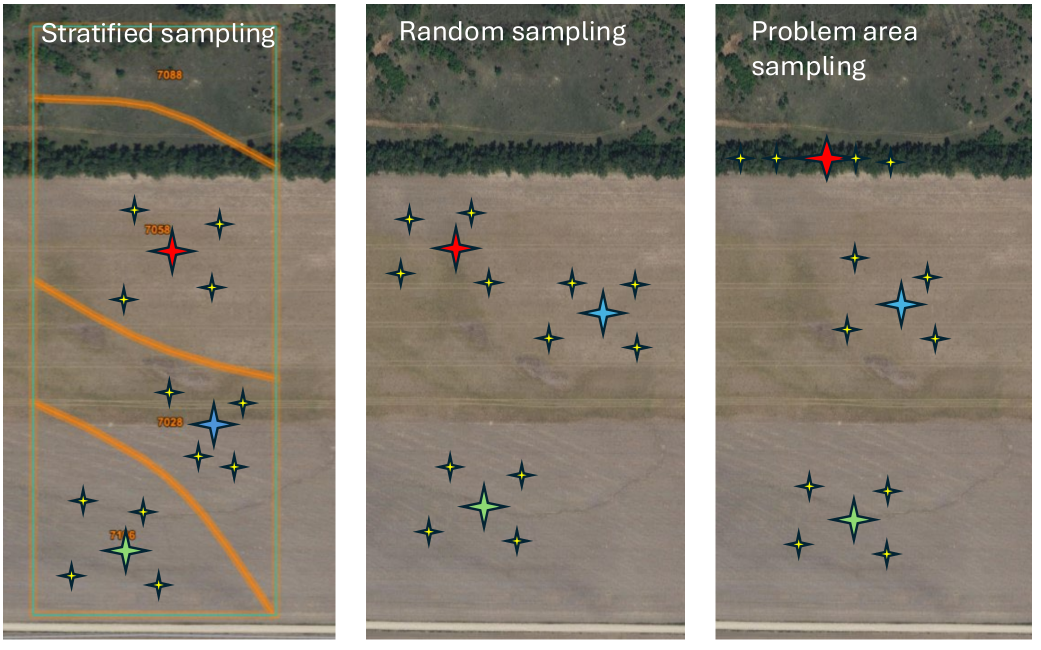

Figure 1. Examples of different sampling strategies in the same field. The stratified example has a field divided into three subunits based on their soil type. The random example has soil collected from three random spots in the field. The problem area sampling has soil collected from a problem area, a well producing area, and a tree/fence line. In all cases, a separate composite sample will be collected to represent each red, blue, and green star location. Each star represents a soil sample, which is collected and mixed for that location. Each composite sample should consist of at least five subsamples (the central location and four samples surrounding it). Each PLU should have three separate samples to send to the laboratory.

6) Ensure all equipment is clean and free from residue prior to collection. Remove vegetation or debris from the soil surface. If sampling for PLFA, sanitize sampling equipment in between collection of composite samples.

7) Collect soil samples during the current crop year and at the same time of year for subsequent samples. Sample when soil moisture and temperature are not extreme and there have not been any recent physical disturbances, additions of soil amendments, or other chemical inputs.

8) Avoid collecting or combining soil samples under the following conditions, unless a sampling strategy is used to specifically address the variability (e.g., stratified sampling):

   a) Wheel tracks or drive lanes, field borders, depressions, or other odd areas within the field.

   b) Areas with historically lower or higher productivity.

   c) Different landscape positions.

   d) Fields with different crops or rotations, or the same crops with a different management Row versus inter-row areas.

e) Eroded versus non-eroded areas.

f) Saturated soil.

9) When using this activity to monitor practice effects over multiple years, it is recommended to remain consistent in the following ways: use the same georeferenced locations, employ the same sampling strategy, collect soil under similar soil conditions, collect soil at the same time of year, utilize the same lab tests and methods, and utilize the same laboratory.

10) Follow all USDA-APHIS regulations for prohibited, regulated, or quarantined soils.

11) Ensure laboratories maintain current certification from one of the following:

a) The Performance Assessment Program (PAP) from The North American Proficiency Testing Program (NAPT) under the auspices of the Soil Science Society of America, or

b) The American National Standards Institute (ANSI) National Accreditation Board (ANAB), or

c) The International Organization for Standardization (ISO/IEC 17043:2010) for ISO 10694:1995, or

d) State-approved certification program that considers laboratory performance and proficiency to assure accuracy of soil test results.

Soil Health Sample Collection

1) Prior to going to the field, contact the soil testing laboratory to obtain recommendations/protocol (soil temperature, soil moisture content, storage, shipping times, etc.) for the indicator(s) being analyzed. Store soil for soil health testing in a cooler or refrigerator if samples are not immediately sent to the laboratory. If sampling for PLFA:

- Coordinate closely with the laboratory to receive instructions.
- Store samples on ice in a cooler in the field.
- Freeze immediately after field collection.
- Ship to the laboratory on ice, as soon as possible, via overnight shipping.

2) Collect soil in the same locations where resource concern assessments, such as an in-field soil health assessment, for the appropriate land use were already completed. Within the PLU, collect soil from at least 3 representative locations (main locations). At each of the 3 main locations, collect soil from the main location plus 4 additional subsamples about 20 to 50 feet from the main location (5 subsamples per location). At each representative location, combine all 5 subsamples to create 1 composite sample. Gently break up any large clods, and remove stones, roots, or debris from the soil. Gently mix the samples and place in sample bags marked with (at a minimum) name of representative location, and date collected (e.g. Fence Row, 05/03/2025).

3) When practical, use a tile spade, sharpshooter, or straight shovel to collect soil. Dig a hole 8 inches deep and remove a 2-inch thick vertical, rectangular slice of soil 6 to 8 inches in depth. Sampling a soil slice in this way preserves the structure and aggregates better than sampling with a probe. If it is impractical to sample a slice of soil, then a soil probe that is 1-inch or more, inside diameter, may be used.

DELIVERABLES

The QI must provide documentation showing that all tasks indicated in the **General Requirements** and **Technical Requirements** sections are complete, and the following sections:

Cover Page

Cover page reporting the technical services provided by the QI. Cover page(s) must include the following:

1) CEMA name and number.
2) Participant information: Name, farm bill program name, contract number (QI obtains contract number from participant), land identification (e.g., state, county, farm, and tract number).
3) QI name, address, phone number, and email.
4) A statement by the QI explaining how they currently meet the Qualified Individual Requirements for this CEMA. Attaching or enclosing a copy of documentation on how the QI requirements are met is encouraged. Examples include:
    - Certification Name and Number,
    - License Name and Number,
    - Agricultural Retailer Business Name, or
    - Other brief written statement indicating how the requirements of a QI for this CEMA are met.
5) A statement by the QI that services provided meet NRCS requirements, such as:

    I certify the work completed and delivered for this CEMA:

    - *Complies with all applicable Federal, State, Tribal, and local laws and regulations.*
    - *Meets the general requirements, technical requirements, and deliverables for this CEMA.*
    - *Is consistent with and meets the conservation objectives for which the program contract was entered into by the participant.*
    - *Addresses the participant's conservation objectives for this CEMA.*

    QI Signature: ___________________________________ *Date:* ______________
6) A Participant's acceptance statement, such as:

    I accept the completed CEMA deliverables as thorough and satisfying my

    objectives. Participant Signature: ___________________ *Date:* ______________
7) A space for an NRCS reviewer to certify the agency's acceptance of the completed CEMA such as:

    NRCS administrative review completion by:

    Signature: ____________________ *Title:* _______________ *Date:* ______________

Notes and Correspondence

1) Include documentation of each site visit, its participants, the activity completed in the field, and results of each site visit.

2) Copies of correspondence between the QI and the participant relating to goals for soil health sampling, decision-making, and completion of this CEMA.
3) Copies of observations, data, or test results prepared during completion of this CEMA.

Maps, Diagrams, Plan Views

1) Maps to include, but not limited to:
   a) General location map to locate the sampling area, such as geographic coordinates, public land survey coordinates, roads to access the site, etc.
   b) Soil Sampling map showing the PLU polygon data and GPS point data (WGS84 latitude, longitude) for sampling locations.
   c) Other maps as needed, with appropriate interpretations.
2) All maps developed for the CEMA will include:
   a) Map title.
   b) Client's name (individual or business).
   c) Assisted By [QI name].
   d) Date prepared.
   e) Map scale.
   f) North arrow.
   g) Appropriate map unit symbols and a map symbol legend on the map or as an attachment.

Evaluation or Monitoring Results

At a minimum, prepare a report (including the following):

1) Report describing the sampling strategy used for the test type.
2) Sample identification code(s).
3) Laboratory test results.
4) Test result interpretations/observations, to include outputs from Soil Health models or tools used if applicable.
5) Schedule of additional testing or monitoring at recommended frequency, as determined by the conservation plan.

Deliver Completed Work

1) The QI must prepare and provide the participant with two sets of all the items listed in the **General Requirements**, the **Technical Requirements,** and the **Deliverables** sections of this document.
2) One set is for the participant to keep.
3) The other set is for the local NRCS Office.
4) The QI may transmit a set of the completed work to the local NRCS Office, if their participant has authorized it.

It is recommended to provide the NRCS field office an opportunity to review the CEMA deliverables, prior to asking for their acceptance.

Post Testing Analysis

After laboratory results are supplied, participants may submit laboratory test results and sampling location(s) coordinates to SoilHealthTest@usda.gov.

Laboratory test results will be used to improve and strengthen the Soil Health Assessment Protocol and Evaluation process, procedures, and results (Nunes et al., 2024). No identifying information or results will be publicly available.

Appropriate waivers to release participant information may be used to grant permission for the QI, or NRCS field office to submit the test results.

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