



Brussels, 5.7.2023  
COM(2023) 416 final

ANNEXES 1 to 7

## **ANNEXES**

**to the proposal for a Directive of the European Parliament and of the Council**  
**on Soil Monitoring and Resilience (Soil Monitoring Law)**

[...]

{SEC(2023) 416 final} - {SWD(2023) 416 final} - {SWD(2023) 417 final} -  
{SWD(2023) 418 final} - {SWD(2023) 423 final}

## ANNEX I

### SOIL DESCRIPTORS, CRITERIA FOR HEALTHY SOIL CONDITION, AND LAND TAKE AND SOIL SEALING INDICATORS

For the purposes of this Annex, the following definitions shall apply

- (1) 'reverse land take' means the conversion of artificial land into natural or semi-natural land;
- (2) 'net land take' means the result of land take minus reverse land take.

Aspect of soil degradation	Soil descriptor	Criteria for healthy soil condition	Land areas that shall be excluded from achieving the related criterion
<i>Part A: soil descriptors with criteria for healthy soil condition established at Union level</i>			
Salinization	Electrical Conductivity (deci-Siemens per meter)	$< 4 \text{ dS m}^{-1}$ when using saturated soil paste extract (eEC) measurement method, or equivalent criterion if using another measurement method	Naturally saline land areas; Land areas directly affected by sea level rise
Soil erosion	Soil erosion rate (tonnes per hectare per year)	$\leq 2 \text{ t ha}^{-1} \text{ y}^{-1}$	Badlands and other unmanaged natural land areas, except if they represent a significant disaster risk
Loss of soil organic carbon	Soil Organic Carbon (SOC) concentration (g per kg)	- For organic soils: respect targets set for such soils at national level in accordance with Article 4.1, 4.2, 9.4 of Regulation (EU) .../... <sup>+</sup>	No exclusion
		- For mineral soils: SOC/Clay ratio $> 1/13$ ; Member States may apply a corrective factor where specific soil types or climatic conditions justify it, taking into account the actual SOC content in permanent grasslands.	Non- managed soils in natural land areas

<sup>+</sup> OP : please insert in the text the number of Regulation on nature restoration contained in document COM(2022) 304

Subsoil compaction	Bulk density in subsoil (upper part of B or E horizon <sup>1</sup> ); Member States may replace this descriptor with an equivalent parameter (g per cm <sup>3</sup> )	Soil texture <sup>2</sup>	range	Non-managed soils in natural land areas
		sand, loamy sand, sandy loam, loam	<1.80	
		Sandy clay loam, loam, clay loam, silt, silt loam	<1.75	
		silt loam, silty clay loam	<1.65	
		Sandy clay, silty clay, clay loam with 35-45% clay	<1.58	
		Clay	<1.47	
		In case a Member State replaces the soil descriptor “bulk density in subsoil” with an equivalent parameter, it shall adopt a criterion for healthy soil condition for the chosen soil descriptor that is equivalent to the criterion set for “bulk density in subsoil”.		
<b>Part B: soil descriptors with criteria for healthy soil condition established at Member States level</b>				
Excess nutrient content in soil	Extractable phosphorus (mg per kg)	< “maximum value”; The “maximum value” shall be laid down by the Member State within the range 30-50 mg kg <sup>-1</sup>		No exclusion

<sup>1</sup> As defined in the FAO Guidelines for Soil Description, Chapter 5 (<https://www.fao.org/3/a0541e/a0541e.pdf>)

<sup>2</sup> As defined in Arshad, M.A., B. Lowery, and B. Grossman. 1996. Physical tests for monitoring soil quality. p.123- 142. In: J.W. Doran and A.J. Jones (eds.) Methods for assessing soil quality. Soil Sci. Soc. Am. Spec. Publ. 49. SSSA, Madison, WI.

Soil contamination	<ul style="list-style-type: none"> <li>- concentration of heavy metals in soil: As, Sb, Cd, Co, Cr (total), Cr (VI), Cu, Hg, Pb, Ni, Tl, V, Zn (<math>\mu\text{g}</math> per kg)</li> <li>- concentration of a selection of organic contaminants established by Member States and taking into account existing concentration limits e.g. for water quality and air emissions in Union legislation</li> </ul>	<p>Reasonable assurance, obtained from soil point sampling, identification and investigation of contaminated sites and any other relevant information, that no unacceptable risk for human health and the environment from soil contamination exists.</p> <p>Habitats with naturally high concentration of heavy metals that are included in Annex I of Council Directive 92/43/EEC<sup>3</sup> shall remain protected.</p>	No exclusion
Reduction of soil capacity to retain water	Soil water holding capacity of the soil sample (% of volume of water / volume of saturated soil)	<p>The estimated value for the total water holding capacity of a soil district by river basin or subbasin is above the minimal threshold.</p> <p>The minimal threshold shall be set (in tonnes) by the Member State at soil district and river basin or subbasin level at such a value that the impacts of floodings following intense rain events or of periods of low soil moisture due to drought events are mitigated.</p>	No exclusion

<sup>3</sup> Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora (OJ L 206, 22.7.1992, p. 7).

<b>Part C: soil descriptors without criteria</b>	
<b>Aspect of soil degradation</b>	<b>Soil descriptor</b>
Excess nutrient content in soil	Nitrogen in soil (mg g <sup>-1</sup> )
Acidification	Soil acidity (pH)
Topsoil compaction	Bulk density in topsoil (A-horizon <sup>4</sup> ) (g cm <sup>-3</sup> )
Loss of soil biodiversity	<p>Soil basal respiration ((mm<sup>3</sup> O<sub>2</sub> g<sup>-1</sup> hr<sup>-1</sup>) in dry soil</p> <p>Member States may also select other optional soil descriptors for biodiversity such as:</p> <ul style="list-style-type: none"> <li>- metabarcoding of bacteria, fungi, protists and animals;</li> <li>- abundance and diversity of nematodes;</li> <li>- microbial biomass;</li> <li>- abundance and diversity of earthworms (in cropland);</li> <li>- invasive alien species and plant pests</li> </ul>

<b>Part D: land take and soil sealing indicators</b>	
<b>Aspect of soil degradation</b>	<b>Land take and soil sealing indicators</b>
Land take and soil sealing	<p>Total artificial land (km<sup>2</sup> and % of Member State surface)</p> <p>Land take, Reverse land take Net land take (average per year— in km<sup>2</sup> and % of Member State surface)</p> <p>Soil sealing (total km<sup>2</sup> and % of Member State surface)</p> <p>Member States may also measure other related optional indicators such as:</p> <ul style="list-style-type: none"> <li>- land fragmentation</li> <li>- land recycling rate</li> <li>- land taken for commercial activities, logistic hubs, renewable energies, surfaces such as airports, roads, mines</li> <li>- consequences of land take such as quantification of loss of ecosystem services, change in floods intensity</li> </ul>

<sup>4</sup> As defined in the FAO Guidelines for Soil Description, Chapter 5 (<https://www.fao.org/3/a0541e/a0541e.pdf>)

## **ANNEX II**

### **METHODOLOGIES**

#### Part A: Methodology for determining sampling points

<b>Activity</b>	<b>Minimum criteria for methodology</b>
Determination of soil sampling points (sample survey)	<p>The sample survey shall be designed from a complete sample frame containing the best available information on the soil properties distribution, including but not limited to information resulting from previous national measurements and measurements under the LUCAS programme.</p> <p>The sampling scheme shall be a stratified random sampling optimized on the soil health descriptors.</p> <p>The size of the national sample shall meet the requirement of a maximum percent error (or Coefficient of Variation) of 5% for the estimation of the area having healthy soils.</p> <p>The Commission sample for the survey set under Art 6(4) may contribute to a maximum of 20 % of the size of national samples.</p> <p>The allocation and size of the sample shall be determined by applying the Bethel algorithm (Bethel, 1989)<sup>5</sup> accounting for the required maximum estimation error.</p>

#### Part B: Methodology for determining or estimating the values of soil descriptors

When a reference methodology is set, either the reference methodology is used or another methodology, provided that it is available in the scientific literature or publicly available and a validated transfer function is available.

<b>Soil descriptor</b>	<b>Reference methodology</b>	<b>Minimum criteria</b>	<b>methodological</b>	<b>Validated transfer function required (if using a methodology different from the reference methodology<sup>6</sup>)?</b>
Soil texture (clay,	Preferred method: ISO			YES

<sup>5</sup> Bethel, J. 1989. "Sample Allocation in Multivariate Surveys." Survey Methodology 15: 47–57.

<sup>6</sup> The methodologies different from the reference methodology shall either be available in the scientific literature or publicly available.

silt and sand content – needed for the determination of other descriptors and related ranges)	11277:1998 Determination of particle size distribution in mineral soil material – Method by sieving and sedimentation  Alternative method: ISO13320:2009 Particle size analysis – Laser diffraction methods		
Electrical Conductivity	Option 1: saturated soil paste extract (eEC) measurement method (FAO SOP: GLOSOLAN-SOP-08 <sup>7</sup> )  Option 2: ISO 11265:1994 Determination of The Specific Electrical Conductivity;		YES
Soil erosion rate		Soil erosion rate estimation shall take into account all actions taken to mitigate or compensate the erosion risk, including post-fire mitigation measures.  Soil erosion rate estimation shall include all relevant erosion processes such as erosion by water, wind, harvest and tillage.  Soil erosion by water shall be assessed by considering the following factors: <ul style="list-style-type: none"><li>- soil characteristics (e.g. erodibility, soil crusting, soil roughness),</li><li>- climate (e.g. rainfall erosivity – intensity and duration, considering relevant climate change projections for a given area),</li><li>- topography (e.g. slope</li></ul>	N/A

<sup>7</sup>

<https://www.fao.org/3/cb3355en/cb3355en.pdf>

		<p>steepness and length),</p> <ul style="list-style-type: none"> <li>- vegetation cover, crop type, land use and management practices to control or reduce erosion,</li> <li>- management practices (e.g. cover crops, reduced tillage, mulching, etc.),</li> <li>- burned areas.</li> </ul> <p>Soil erosion by wind shall be assessed by considering the following factors:</p> <ul style="list-style-type: none"> <li>- soil characteristics (e.g. erodibility),</li> <li>- climate (e.g. soil moisture, wind speed, evaporation),</li> <li>- vegetation (e.g. crop type),</li> <li>- management practices to control or reduce erosion (e.g. wind breaks).</li> </ul>	
Soil Organic Carbon (SOC)	ISO 10694:1995 Determination of organic and total carbon after dry combustion		YES
Bulk density in subsoil (B horizon <sup>8</sup> ) or equivalent <sup>9</sup> parameter chosen by Member States	<p>ISO 11272:2017 for determination of dry bulk density</p> <p>In case an equivalent parameter is chosen, the methodology shall be either a European or International standard when available; if such standard is not available, the methodology chosen shall either be available in the scientific literature or</p>		YES

<sup>8</sup> As defined in the FAO Guidelines for Soil Description, Chapter 5 (<https://www.fao.org/3/a0541e/a0541e.pdf>)

<sup>9</sup> Equivalent according to the EEA report: [Soil monitoring in Europe – Indicators and thresholds for soil health assessments — European Environment Agency \(europa.eu\)](https://www.eea.europa.eu/en/soil-monitoring-in-europe)



	publicly available.		
Extractable phosphorus	ISO 11263:1994 for spectrometric determination of phosphorus soluble in sodium hydrogen carbonate solution (P-Olsen)		YES
<p>- Concentration of heavy metals in soil: As, Sb, Cd, Co, Cr (total), Cr (VI), Cu, Hg, Pb, Ni, Tl, V, Zn</p> <p>- Concentration of a selection of organic contaminants defined by Member States and taking into account existing EU legislation (e.g. on water quality or pesticides)</p>	Potential environmental available content of heavy metals in soils based on ISO 17586:2016 using dilute nitric acid.	Use European or International standards when available; if such standard is not available, the methodology chosen shall either be available in the scientific literature or publicly available	YES  N/A
Soil water holding capacity	<p>Methodology to determine the value for one sample point:</p> <p>Option 1: LABORATORY: ISO 11274:2019 for determination of the water-retention characteristic.</p> <p>Option 2: ESTIMATION: apply methodology described in the scientific article “New generation of hydraulic pedotransfer functions for Europe”<sup>10</sup> based on texture (or particle size distribution) and soil organic carbon.</p>	<p>Minimum criteria for estimating the total soil water holding capacity of a soil district on a river basin or sub-basin scale:</p> <ul style="list-style-type: none"> <li>- for the area of land not taken estimate the total value of soil water holding capacity</li> <li>- for the area of land taken, consider setting the water holding capacity of impervious areas to zero, attributing proportionately intermediate values to semi-impervious and other artificial areas.</li> </ul>	YES (for point value)

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Nitrogen in soil	ISO 11261:1995 for determination of total soil nitrogen using a modified Kjeldahl method		YES
Soil acidity	ISO 10390:2005 for determination of pH in H <sub>2</sub> O and CaCl <sub>2</sub> extract (pH-H <sub>2</sub> O and pH-CaCl <sub>2</sub> )		YES
Bulk density in “topsoil” (A-horizon <sup>11</sup> )	ISO 11272:2017 for determination of dry bulk density		YES
Soil basal respiration  Member States may also select optional soil biodiversity descriptors such as: -Metabarcoding <sup>12</sup> of bacteria, fungi, protists and animals; - Abundance and diversity of nematodes; - Microbial biomass; - Abundance and diversity of earthworms (in cropland)	Follow indications described in the scientific article “Microbial biomass and activities in soil as affected by frozen and cold storage” <sup>13</sup>	Use European or international standards when available; if such standard is not available, the methodology chosen shall either be available in the scientific literature or publicly available.	YES  For other soil biodiversity descriptors: N/A

### Part C: minimum methodological criteria for determining the values of land take and soil sealing indicators

<sup>11</sup> As defined in the FAO Guidelines for Soil Description, Chapter 5 (<https://www.fao.org/3/a0541e/a0541e.pdf>)

<sup>12</sup> Sequencing of DNA barcodes for measuring taxonomical and functional diversity of archaea, bacteria, fungi and other eukaryotes as was done for LUCAS Soil Biodiversity based on <https://doi.org/10.1111/ejss.13299>

<sup>13</sup> <https://www.sciencedirect.com/science/article/abs/pii/S0038071797001259>

- For land take, reverse land take and net land take, the methodologies used should comply with the definitions set in Article 3 and Annex I.
- Soil sealing shall be expressed as a percentage of sealed area per total area.
- The methodologies chosen shall either be available in the scientific literature or publicly available.

## **ANNEX III**

### **SUSTAINABLE SOIL MANAGEMENT PRINCIPLES**

The following principles shall apply:

- (a) avoid leaving soil bare by establishing and maintaining vegetative soil cover, especially during environmentally sensitive periods;
- (b) minimise physical soil disturbance;
- (c) avoid inputs or release of substances into soil that may harm human health or the environment, or degrade soil health;
- (d) ensure that machinery use is adapted to the strength of the soil, and that the number and frequency of operations on soils are limited so that they do not compromise soil health;
- (e) when fertilization is applied, ensure adaptation to the needs of the plant and trees at the given location and in the given period, and to the condition of soil and prioritize circular solutions that enrich the organic content;
- (f) in case of irrigation, maximise efficiency of irrigation systems and irrigation management and ensure that when recycled wastewater is used, the water quality meets the requirements set out in Annex I of Regulation (EU) 2020/741 of the European Parliament and of the Council<sup>14</sup> and when water from other sources is used, it does not degrade soil health;
- (g) ensure soil protection by the creation and maintenance of adequate landscape features at the landscape level;<sup>15</sup>
- (h) use site-adapted species in the cultivation of crops, plants or trees where this can prevent soil degradation or contribute to improving soil health, also taking into consideration the adaptation to climate change;
- (i) ensure optimised water levels in organic soils so that the structure and composition of such soils are not negatively affected;<sup>16</sup>
- (j) in the case of crop cultivation, ensure crop rotation and crop diversity, taking into consideration different crop families, root systems, water and nutrient needs, and integrated pest management;
- (k) adapt livestock movement and grazing time, taking into consideration animal types and stocking density, so that soil health is not compromised and the soil's capacity to provide forage is not reduced;
- (l) in case of known disproportionate loss of one or several functions that substantially reduce the soils capacity to provide ecosystem services, apply targeted measures to regenerate those soil functions.

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<sup>14</sup> Regulation (EU) 2020/741 of the European Parliament and of the Council of 25 May 2020 on minimum requirements for water reuse (OJ L 177, 5.6.2020, p. 32).

<sup>15</sup> This principle does not apply to forest soils

<sup>16</sup> This principle does not apply to urban soils

## **ANNEX IV**

### **PROGRAMMES, PLANS, TARGETS AND MEASURES REFERRED TO IN ARTICLE 10**

- (1) The national restoration plans prepared in accordance with Regulation .../...<sup>17</sup>+
- (2) The strategic plans to be drawn up by Member States under the Common Agricultural Policy in accordance with Regulation (EU) 2021/2115.
- (3) The Code of Good Agricultural Practice and the action programmes for designated vulnerable zones adopted in accordance with Directive 91/676/EEC.
- (4) The conservation measures and prioritized action framework established for Natura 2000 sites in accordance with Directive 92/43/EEC.
- (5) The measures for achieving good ecological and chemical status of surface water bodies and good chemical and quantitative status of groundwater bodies included in river basin management plans prepared in accordance with Directive 2000/60/EC.
- (6) The flood risk management measures included in the flood risk management plans prepared in accordance with Directive 2007/60/EC.
- (7) The drought management plans referred to in the Union Strategy on Adaptation to Climate Change.
- (8) The national action programmes established in accordance with the United Nations Convention to Combat Desertification.
- (9) The targets set out under Regulation (EU) 2018/841.
- (10) The targets set out under Regulation (EU) 2018/842.
- (11) The national air pollution control programmes prepared under Directive (EU) 2016/2284 and the monitoring data about air pollution impacts on ecosystems reported under that Directive.
- (12) The integrated national energy and climate plan established in accordance with Regulation (EU) 2018/1999.
- (13) The risk assessments and disaster risk management planning in accordance with Decision No 1313/2013/EU.
- (14) The national actions plans adopted in accordance with Article 8 of Regulation .../...<sup>18</sup>+

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<sup>17</sup> + OP : please insert in the text the number of Regulation on nature restoration contained in document COM(2022) 304

<sup>18</sup> + OP : please insert in the text the number of Regulation of the European Parliament and of the Council the sustainable use of plant protection products and amending Regulation (EU) 2021/2115 contained in document COM(2022)305

## **ANNEX V**

### **INDICATIVE LIST OF RISK REDUCTION MEASURES**

- (1) Remediation techniques for in- or ex-situ remediation:
  - (a) Physical remediation techniques:
    - (a) Vapor extraction, air sparging;
    - (b) Heat treatment, steam injection, thermal desorption, vitrification;
    - (c) Soil washing and flushing;
    - (d) Electrokinetic extraction;
    - (e) Liquid layer removal;
    - (f) Dig and dump.
  - (b) Biological remediation techniques:
    - (a) Stimulation of aerobic or anaerobic degradation: bioremediation, biostimulation, bioaugmentation, bioventing, biosparging;
    - (b) Phytoextraction, phytovolatilization, phytodegradation;
    - (c) Composting, soil amendments, landfarming, and bioreactor systems;
    - (d) Biofiltration, biotreatment wetlands, and biobeds;
    - (e) Natural attenuation.
  - (c) Chemical remediation techniques:
    - (a) Chemical oxidation;
    - (b) Chemical reduction and reduction-oxidation (redox) reactions;
    - (c) Pump and treat of groundwater.
  - (d) Remediation techniques for isolation, containment and monitoring:
    - (a) Surface capping, reactive barriers, encapsulation;
    - (b) Chemical stabilization, solidification and immobilization;
    - (c) Geo-hydrological isolation and containment;
    - (d) Phyto-stabilisation;
    - (e) Control and aftercare through monitoring wells.
- (2) Risk reduction measures other than remediation:
  - (a) Restriction on the cultivation and consumption of crops and vegetables;

- (b) Restriction on the consumption of eggs;
  - (c) Restriction on the access of pets or husbandry;
  - (d) Restriction on the extraction or use of groundwater for drinking, personal hygiene or industrial purposes;
  - (e) Restriction on the demolition, de-sealing, or construction on the site;
  - (f) Restriction on the access on or in the neighbourhood of the site (e.g. through fencing);
  - (g) Restriction on land use or land use changes;
  - (h) Restriction on digging, drilling or excavation;
  - (i) Restriction to avoid contact with soil, dust or indoor air and apply precautions to protect human health (e.g. respirators, gloves, wet cleaning, etc.).
- (3) Best available techniques referred to in Directive 2010/75/EU.
  - (4) Measures taken by competent authorities and industrial operators following a major accident, in accordance with Directive 2012/18/EU.

## **ANNEX VI**

### **PHASES AND REQUIREMENTS FOR SITE-SPECIFIC RISK ASSESSMENT**

1. Characterization of the contamination requires identifying the contaminants present at the site and determining their source, concentration, chemical form, and distribution in the soil and groundwater. The presence and concentration of contaminants is determined through soil sampling and investigation.
2. Exposure assessment identifies the path by which soil contaminants may reach receptors. Exposure pathways may include inhalation, ingestion, dermal contact, plant uptake, migration to groundwater or others. This information is combined with the frequency and duration of exposure and receptor characteristics such as age, gender, and health status to estimate the contaminant uptake. The source-pathway-receptor linkages are summarized in a graphic, schematic and simplified representation: the conceptual site model.
3. Toxicity or hazard assessment involves the evaluation of the potential health and environmental effects of the contaminants, based on the dose and duration of exposure. The toxicology or hazard assessment takes into account the inherent toxicity of the contaminants and the susceptibility of different populations, such as animals, micro-organisms, plants, children, pregnant women, elderly, etc. The toxicological information is used to estimate reference doses or concentrations, which are used for the risk characterization.
4. Risk characterization requires integrating the information from the previous steps to estimate the magnitude and probability of adverse effects of the contaminated site for human health and the environment, including from migration of the contamination to other environmental media. The risk characterization helps to prioritize the need for risk reduction and remediation measures. It can also help to define remediation or management objectives for a site, e.g. to achieve maximum acceptable limits or site-specific risk-based screening values.



## **ANNEX VII**

### **CONTENT OF REGISTER OF POTENTIALLY CONTAMINATED SITES AND CONTAMINATED SITES**

The design and presentation of the data in the register shall enable the public to track progress in the management of potentially contaminated sites and contaminated sites. The register shall contain and present the following information at site level for the known potentially contaminated sites, contaminated sites, contaminated sites requiring further action, and contaminated sites where action was taken or is being taken:

- (a) coordinates, address or cadastral parcel(s) of the site in accordance with Directives (EU) 2019/1024 and 2007/2/EC;
- (b) year of inclusion in the register;
- (c) contaminating or potentially contaminating risk activities that have taken or are taking place on the site;
- (d) management status of the site;
- (e) conclusion on the presence or absence, concentration, type and risk of the contamination (or residual contamination after remediation) where information on those elements is already available from the soil investigations and risk assessment referred to in Articles 14 and 15;
- (f) next actions and management steps required and referred to in Articles 14 and 15, including their timeline.

The register may also contain the following information at site level for the known potentially contaminated sites, contaminated sites, contaminated sites requiring further action, and contaminated sites where action was taken or is being taken, where available:

- (a) information on environmental permits issued for the site, including the start and end year of the activity;
- (b) current and planned land use;
- (c) results of soil investigation and remediation reports such as concentrations and contours of the contamination, conceptual site model, risk assessment methodology, techniques used or planned, effectiveness and cost estimates of risk reduction measures.