

The Soil Monitoring Law (SML): End in Itself or Catalyst for Risk-Based Action?

*DIRECTIVE (EU) 2025/2360 OF THE EUROPEAN PARLIAMENT AND OF
THE COUNCIL of 12 November 2025 on soil monitoring and resilience*

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Soil is no longer the missing environmental compartment

AIR

WATER

SOIL

Established EU frameworks

Established EU frameworks

A common EU framework at last

SML creates a framework and a minimum level of soil governance across all Member States with a view to achieving healthy soils by 2050

From regulatory soil framework to sound soil management

GENERIC QUESTIONS AND STARTING POINTS

Are SML objectives clear enough?

Do SML obligations / measures support achieving those objectives?

What is needed and can be done in SML implementation?

Supportive about the ambition · Critical about the instruments · Reasonable about the implementation



Achieve intended (positive) impacts · Avoid unintended (negative) side effects

SML implementation in Finland

Responsibility divided between two ministries

- Ministry of Agriculture and Forestry
- Ministry of the Environment



Ministry of Agriculture and Forestry of Finland



Supported by expert organisations/research institutes

- National Resources Institute Finland (LUKE)
- Finnish Environment Institute (Syke)
- Geological Survey of Finland (GTK)



National preparatory group for the directive nominated (4-12/26)

Impact assessment regarding SML obligations carried out under the EU Horizon Project ISLANDR

- Focus on monitoring of harmful substances and contaminated sites

Most national decisions yet to be officially done!

The views and opinions expressed in this presentation are mine!



Selected discussion topics and research questions

1 SAMPLING

Will monitoring framework provide representative data for assessing soil health?

2 CRITERIA (TARGET AND TRIGGER VALUES)

Will STVs and OTVs become appropriate tools to identify soil degradation and ensure soil health?

3 CONTAMINATED SITES

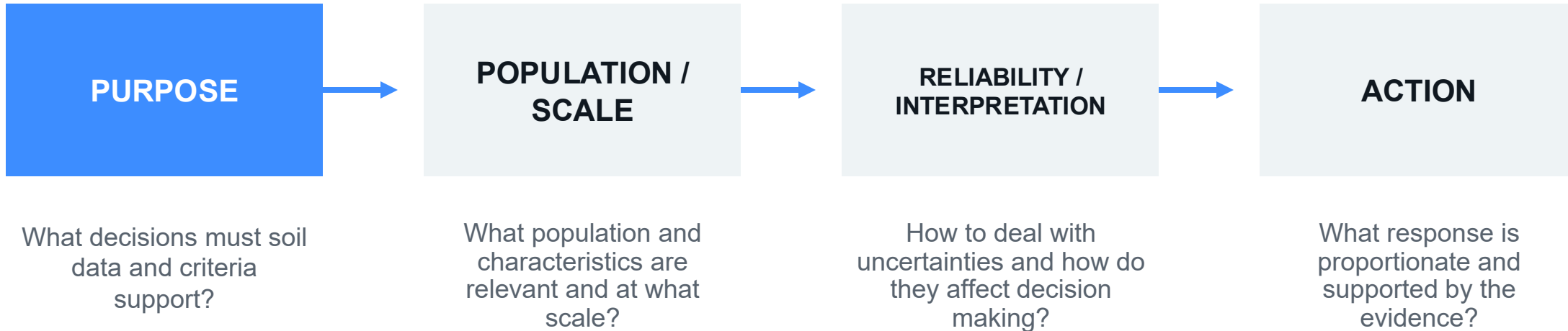
Will the approach allow for genuine case-specific risk-based decisions and sustainable management actions?



MONITORING AND ASSESSMENT OF SOIL HEALTH
Chapter 2

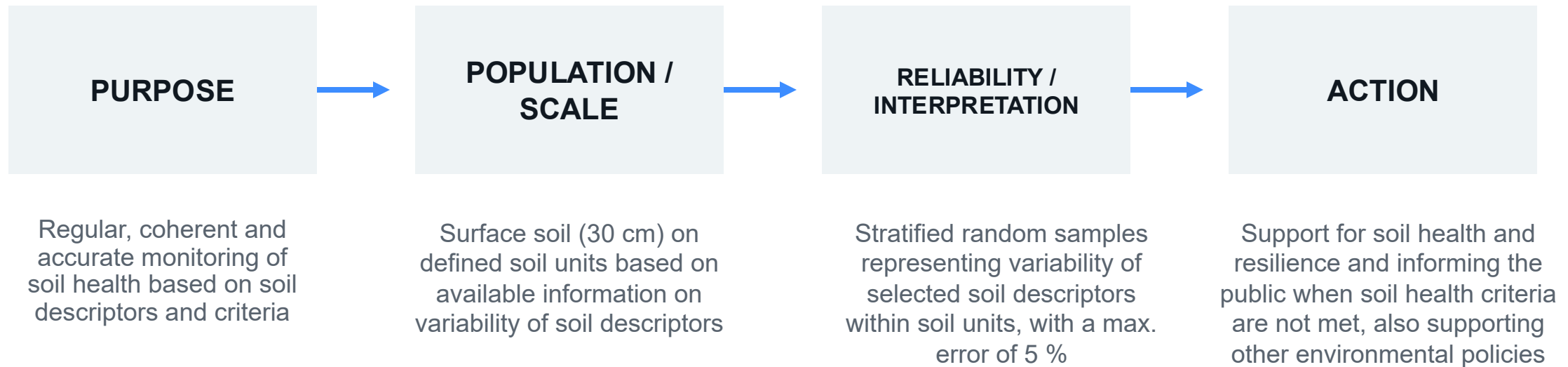
MANAGEMENT OF CONTAMINATED SITES
Chapter 4

Focus on the evidence-to-action chain



Sampling (monitoring)

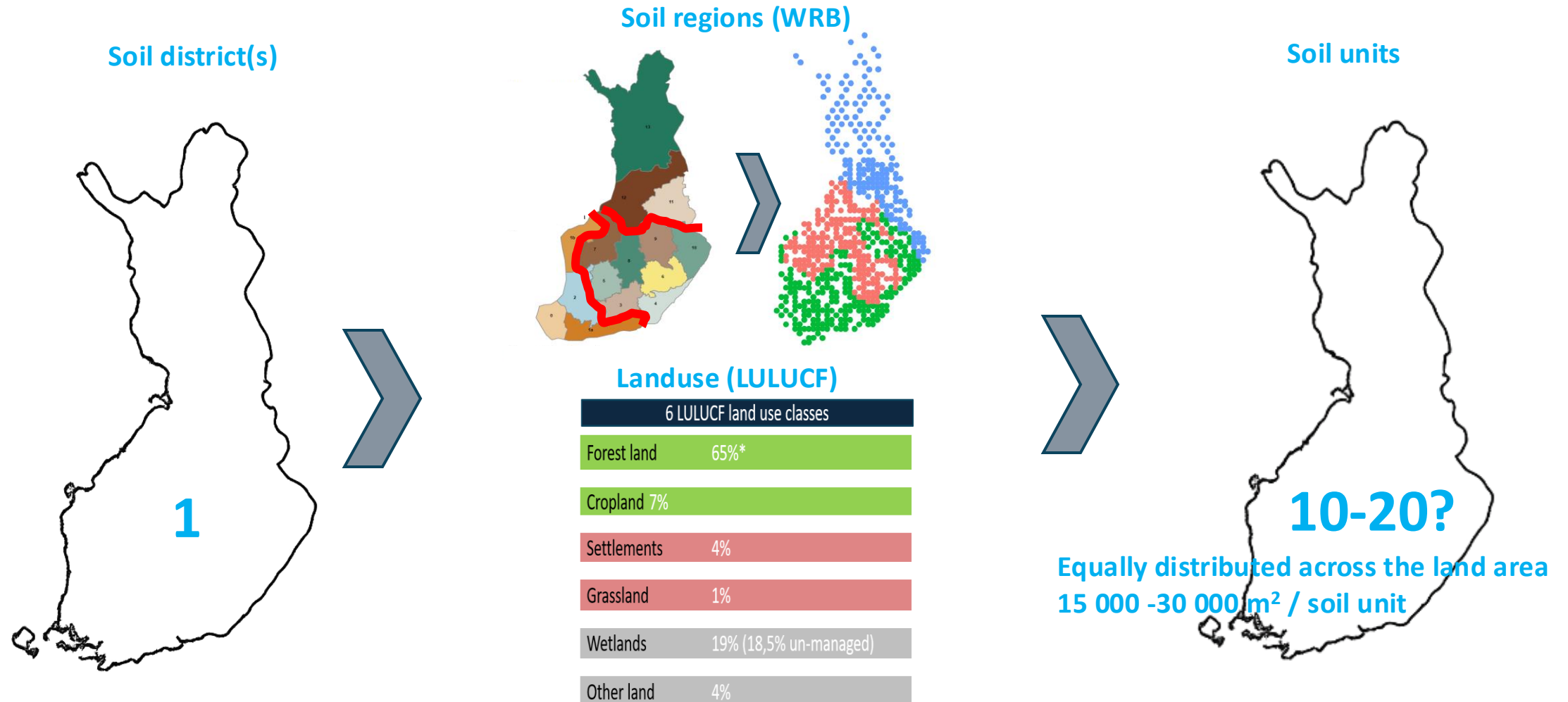
Highlighting the evidence-to-action chain of sampling



What does this mean in practice and what should the data represent?

Representing soil quality on soil units – case Finland

Representative sample = sample in which the characteristic(s) of interest is (are) present with a reliability appropriate for the purposes of the testing programme (CEN 15310-1)



Estimating number of sampling points – case Finland

Soil descriptors

A – target values EU level	B – target values MS level	C – no target values
Electrical conductivity	Extractable phosphorus	Total nitrogen content
SOC concentration	Concentrations of heavy metals	Acidity
Volumetric gravity of the subsoil	Concentrations of organic pollutants	Ratio of SOC to nitrogen
	SOC stock	Concentrations of PFAS substances
	Water retention	Concentrations of pesticides, etc.
	Water conductivity of saturated soil	Volumetric weight of topsoil
	Air capacity	Metabarcoding of DNA in Fungi and Bacteria
	Erosion rate	

Physical

Chemical

Biological

Sampling points



The number and location of sampling points shall represent variation of selected soil descriptors in soil units, with a maximum error (or coefficient of variation) of 5 %

Sampling points FIN (estimate)

Land use type	Current number of sampling points	Number reduced using background data	Number required under the Directive
Agricultural land	620	1500 ¹	2300 ¹
Forest land	615	1495	2320
Urban land	300 ¹	600 ¹	1000 ¹

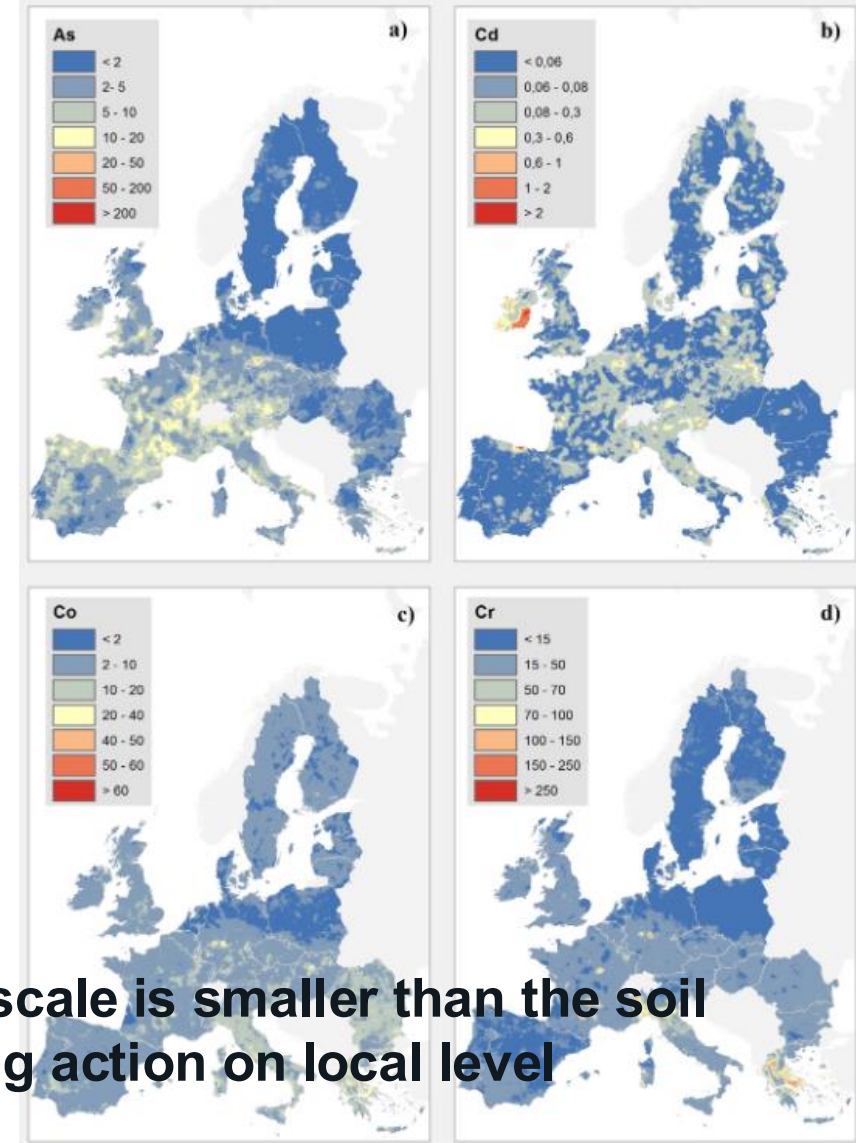
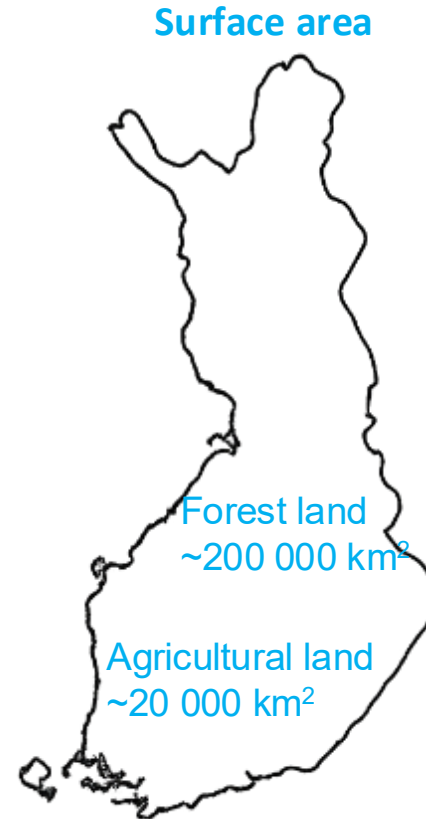
¹ Estimated number

Thousands of samples at minimum -> laborious and expensive task
 Variation of other descriptors (e.g. contaminant conc.) a lot higher -> more sampling points

Interpreting the data – case Finland

Sampling points

Land use type	Number reduced using background data	Number required under the Directive
Agricultural land	1500	2300
Forest land	1495	2320

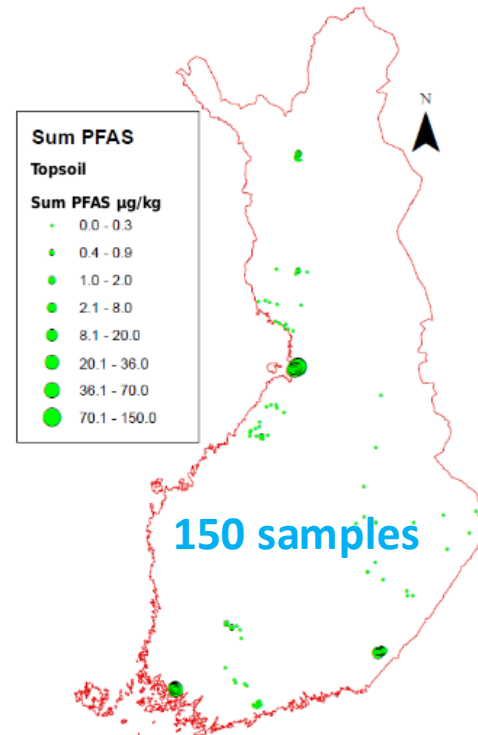


Data is suitable for large-scale statistical monitoring (even if scale is smaller than the soil unit), not for informed decision making and/or governing action on local level

PFAS background concentrations in topsoil (not cropland) - FIN

Natural soils (till/moraine)

- Low concentrations ($< 1 \mu\text{g/kg}$)
- Moderate/low variation
 - spatially
 - in detected substances
- ΣPFAS in humus 10-fold compared to mineral soil
- Main source: atmospheric deposition
- Background conc. for ΣPFAS4 defined



Urban soils

- Partly high concentrations ($150 \mu\text{g/kg}$)
- Significant variation
 - spatially
 - in detected substances
 - in different soil types
- Main source: use of sewage sludge
- Background conc. not defined

Representative sampling on local scale needed for defining urban background, identifying emission point sources or poorly managed crop fields etc. -> SML soil unit level not suitable

Scale matters (even if size does not)

EN 14899: 2005 Characterization of waste - Sampling of waste materials - Framework for the preparation and application of a Sampling Plan

*“As a consequence of the direct relation between scale and heterogeneity, **sampling results are only valid for the scale that is equal to the scale of sampling or higher scales.**”*

Criteria – target and trigger values

Linking soil monitoring to soil assessment and management

SUSTAINABLE TARGET VALUE (STV)

Non-binding long-term objective for ideal healthy soil condition; no obligation to act

OPERATIONAL TRIGGER VALUE (OTV)

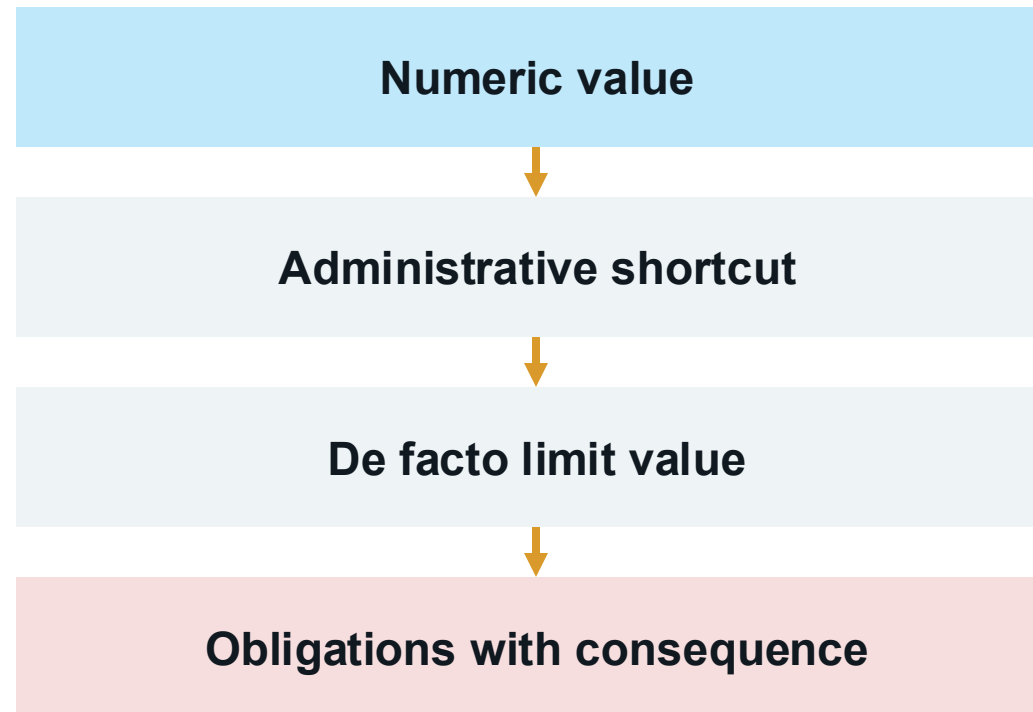
Triggers support for achieving soil health and resilience, considering local conditions & practices

SITE-SPECIFIC CRITERIA BASED ON RISK ASSESSMENT

Defines unacceptable risk to human health and the environment + a need for risk reduction at contaminated sites

Implementation challenge for the criteria: derive and apply them so that they support justified decisions, while acknowledging their different purposes / roles

Generic reality of regulatory thresholds



Simplistic values can hardly ever describe complicated phenomena (e.g. soil degradation processes), yet often the problem is not the number itself, but its migration beyond its intended scale and purpose...

Assessing soil health according to the SML

Article 7 and Annex I

STVs and OTVs derived using **scientific knowledge** on each soil descriptor, defining **good**, **poor** and **moderate** soil condition. Maximum or minimum values not entailing damage to human health and the environment, etc.

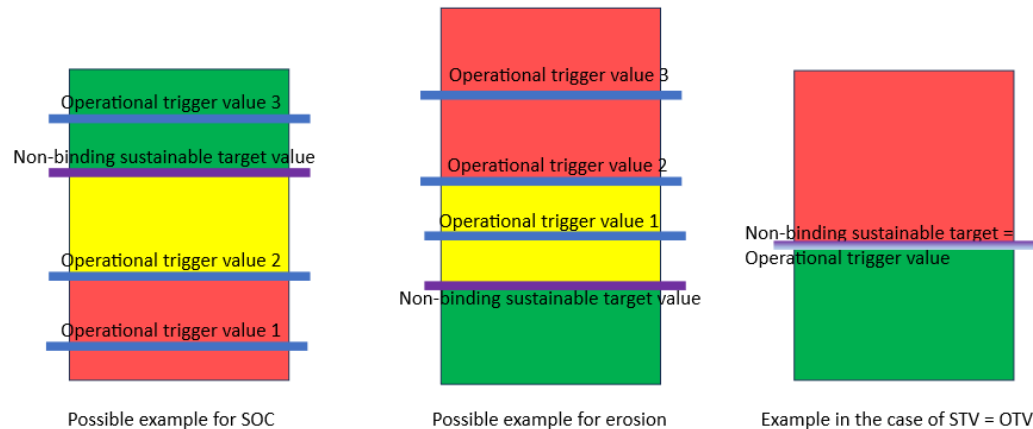


Fig. from "DISCUSSION PAPER For Member States on Possible structure and content of the supporting document SML article 24.1.b"

How to apply such scientific knowledge and make sure STVs/OTVs become tools, not limits?

Article 10

Member States shall:

- Compare monitoring data to STVs and OTVs in **soil units**
-> large spatial scale
- Based on soil health assessment, identify **areas** where individual criteria are not met and support is needed
-> smaller scale than soil unit?
- Communicate soil health data to relevant **landowners** and **land managers** to support developing science-based advice
-> even smaller / local scale?

How clear and justified is the "evidence-to-action" chain here...?

Ideal condition at large scale or unacceptable local risk?

Annex I - Part B: soil descriptors with criteria for healthy soil condition established at Member State level

Aspect of soil degradation	Soil descriptor ⁽¹⁾	Criteria for healthy soil condition – non-binding sustainable target values ⁽²⁾
Soil contamination	— concentration of heavy metals in soil: As, Sb, Cd, Co, Cr (total), Cu, Hg, Pb, Ni, Tl, V, Zn (mg per kg) — concentration of a selection of organic contaminants established by Member States and taking into account existing concentration limits in Union law, e.g. for water quality and air emissions	Reasonable assurance, obtained from soil point sampling, identification and investigation of potentially contaminated sites and any other relevant information, that an unacceptable risk to human health and the environment from soil contamination does not exist Natural and anthropogenic background levels shall be taken into account in the risk assessment If natural background is the only reason leading to unacceptable risks, then the relevant soil shall be deemed to meet the healthy soil criteria provided that it is managed in such a way that an unacceptable risk to human health does not exist Habitats with a naturally high concentration of heavy metals that are included in Annex I to Directive 92/43/EEC shall remain protected

How exactly does the SML deparate diffuse soil contamination from local soil contamination...?

Planning tool today may become permitting limit tomorrow

C-461/13: 2015

Weser Ruling

Transformed EU Water Framework Directive (WFD) objectives – inc. Environmental Quality Standards (EQSs) - from general policy goals into legally binding limits for individual projects

"One-Out, All-Out" Rule: Authorities must refuse a permit if a project risks downgrading even a single water quality element

Finnpulp Case (Finland, 2019): Justified by Weser Ruling, a billion-euro bioproduct mill permit was overturned due to a risk that discharges might undermine the ecological status of a lake

C-535/18: 2020

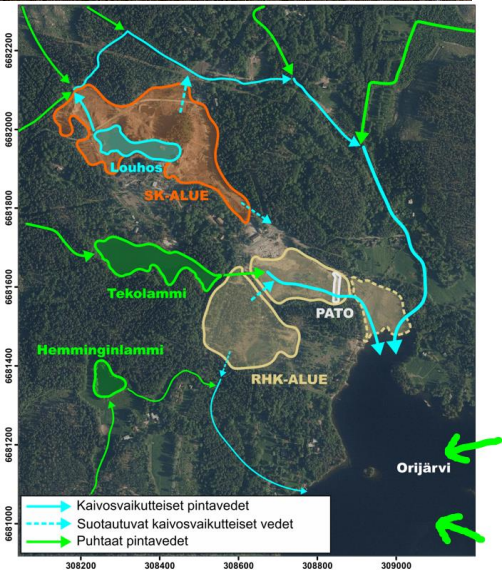
Land Nordrhein-Westfalen

Confirmed that WFD's non-deterioration principle applies equally to groundwater chemical and quantitative status in individual permits

Deterioration occurs if concentration of any pollutant exceeds EQS even at single monitoring point or if concentration increases in a water body where EQS is already exceeded

Derivation and implementation of a regulatory value become crucial and tricky, if its purpose, legal validity and application (scale) may change over time – to be considered for SML, too!

Trust the Science – obey the Law – paint-by-Numbers



SURFACE WATER CASE EXAMPLE FROM FINLAND

Closed metal ore mine with long operating history (1757-1956)

- Mining tailings (> 1 Mt) and waste rocks (> 0,5 Mt)

Impacts of soluble metals in receiving surface water bodies

- Cd, Zn, Cu, (Pb) based on long term monitoring

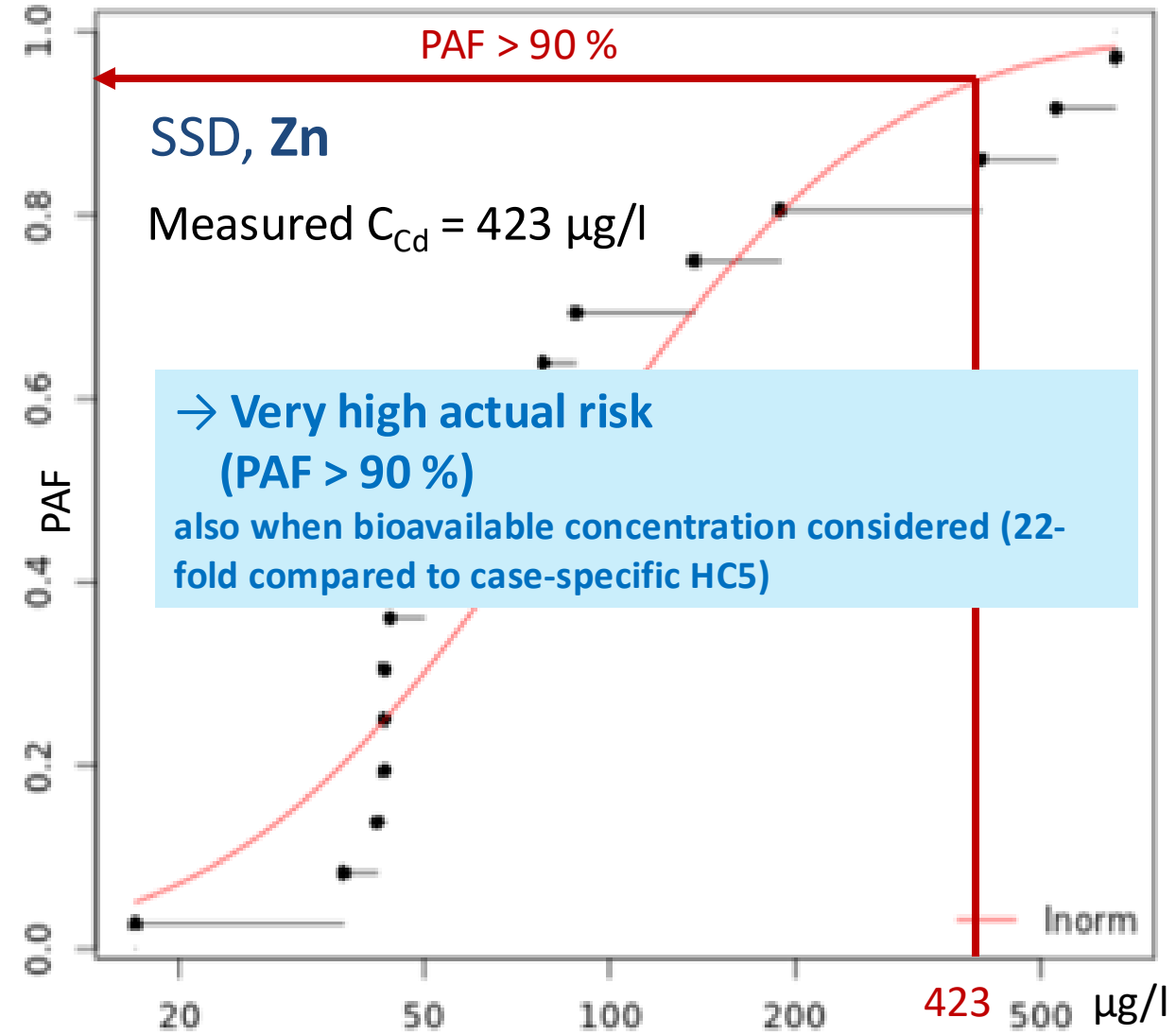
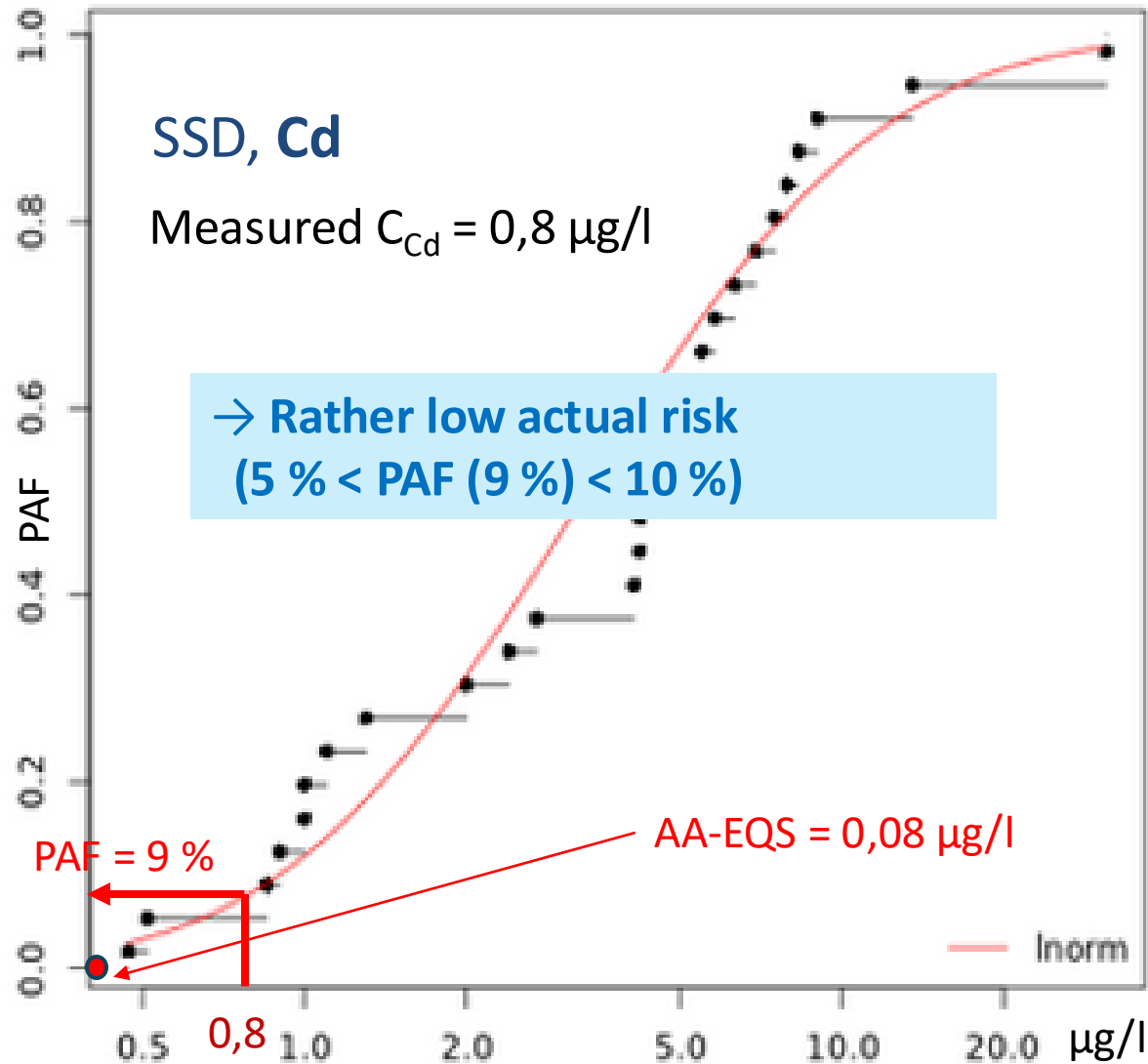
Authorities mostly concerned about Cd due to exceedance of EQS

- EQS (WFD); 0,08 µg/L; no EQSs for Zn and Cu in relevant legislation

Mine talings assumed as primary source based on concentration measurements

→ Site-specific risk assessment carried out

Trust the Science – obey the Law – paint-by-Numbers



Trust the Science – obey the Law – paint-by-Numbers

Despite high concentrations (e.g. PAF > 90% for Zn), WFD **ecological classification** of the nearest receiving lake defined as **excellent** and **differences to reference lakes small**

Moreover, mass-discharge assessments demonstrated that > 90 % of current discharges to surface waters originate from disposed waste rocks, not tailings as previously thought based on concentration data

Biological classification parameters of lake Orijärvi 2012-2017

Parameter	Result	Measured classification
Chlorophyll-a	2 µg/L	Excellent
Total biomass	0,39 mg/L	Excellent
Portion of harmful cyanobacteria	2,39 %	Excellent
Phytoplankton trophic index	-2,03	Excellent

Lake	Years	Samples	Biomass (µg/l)	Density (kpl/ml)	Chlorophyll-a (µg/l)	TPI	Cyanobacteria (%)	Taxons	Species, 60 % of biomass
Orijärvi	2008–2013	6	442	5 520	2,7	-1,75	3,3	29	7
Määrjärvi	2008–2013	6	447	8 663	2,4	-1,55	0,4	36	6
Seljänalanen	2005–2016	9	539	6 625	2,7	-0,9	0,3	38	6
Degersjön	2005–2016	9	651	4 753	4,1	-0,99	1,8	44	5
Reference lakes									
Simijärvi	1986–2017	14	393	3 389	2,2	-2,07	0,1	40	7
Iso-Kisko	2007–2016	13	467	4 839	2,8	-0,91	6,2	52	11

Relying solely on regulatory values (and concentrations) – even if they are risk-based – is simply not enough

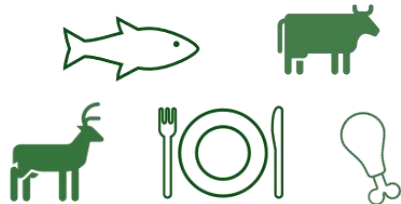
Trust the Science – obey the Law – paint-by-Numbers

Directive (EU) 2020/2184

 Drinking water
DWQS =
100-500 ng/L

Commission Regulation
(EU) 2022/2388

Foodstuffs



MCLs = 0.2- 45 µg/kg

EFSA, 2020

Tolerable intake

Σ PFAS4

4.4 ng/kg_{bw} /week

(PFOS, PFOA, PFNA, PFHxS)



Environment International

Volume 186, April 2024, 108614

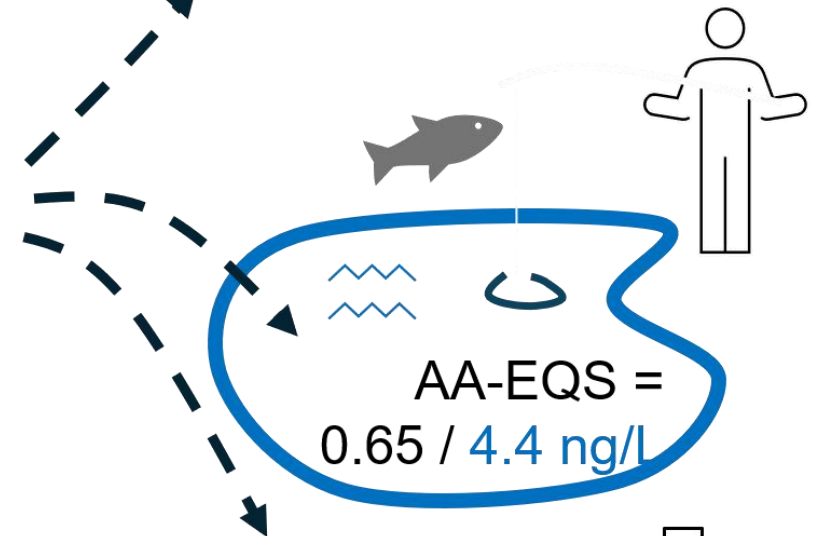
Full length article

Inconsistencies in the EU regulatory risk assessment of PFAS call for readjustment

Jussi Reinikainen ^a, Elodie Bouhoulle ^b, Jaana Sorvari ^a

Priority Substances Directive 2008/105/EC; *new* EU 2026/805

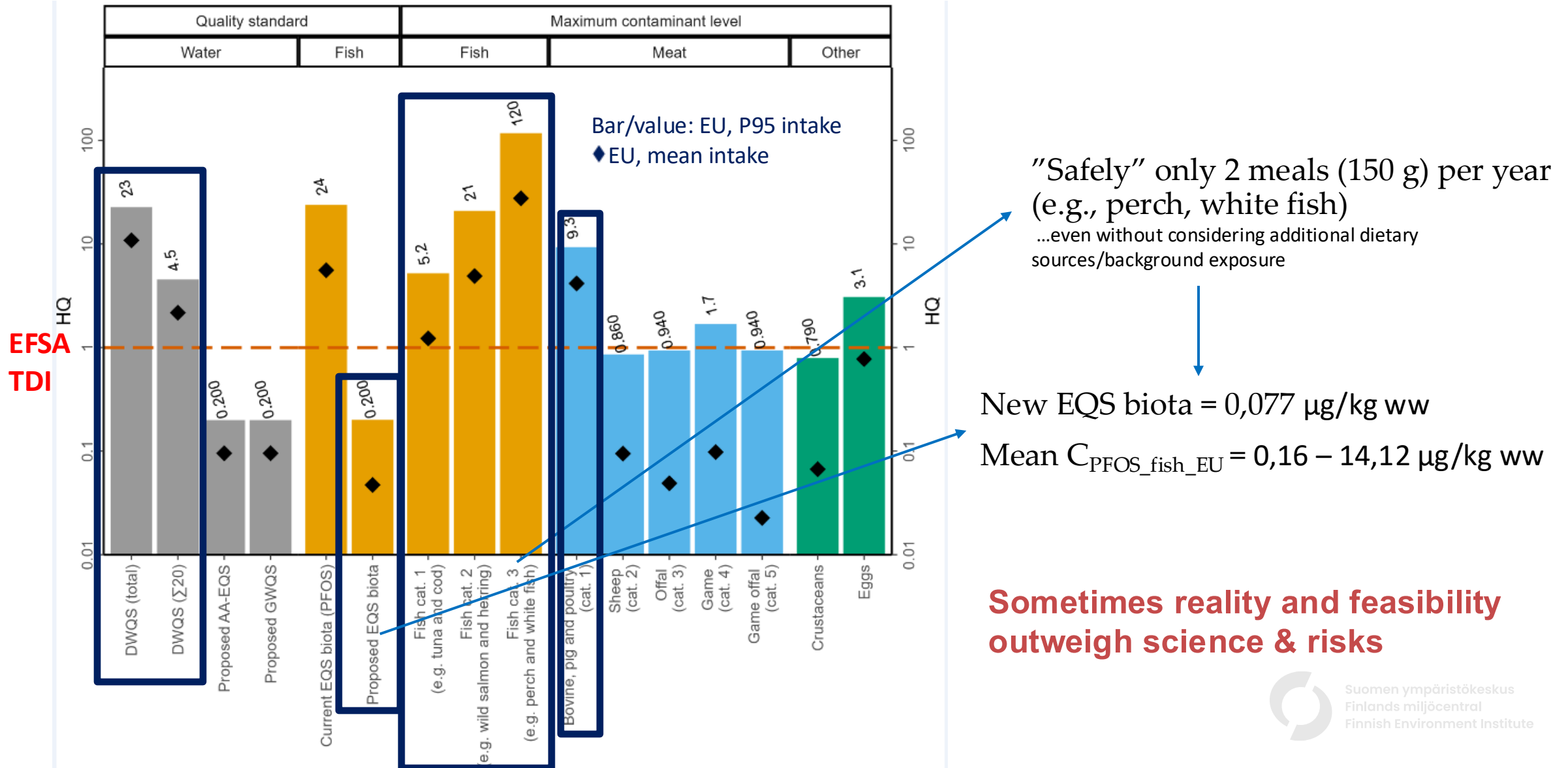
Surface water – fish
EQS_{biota} = 9,1 / 0.077 µg/kg



Groundwater

GWQS
= 4.4 ng/L

Trust the Science – obey the Law – paint-by-Numbers



Trust the Science – obey the Law – paint-by-Numbers

EXAMPLE ON CONTAMINATED LAND MANAGEMENT FROM FINLAND

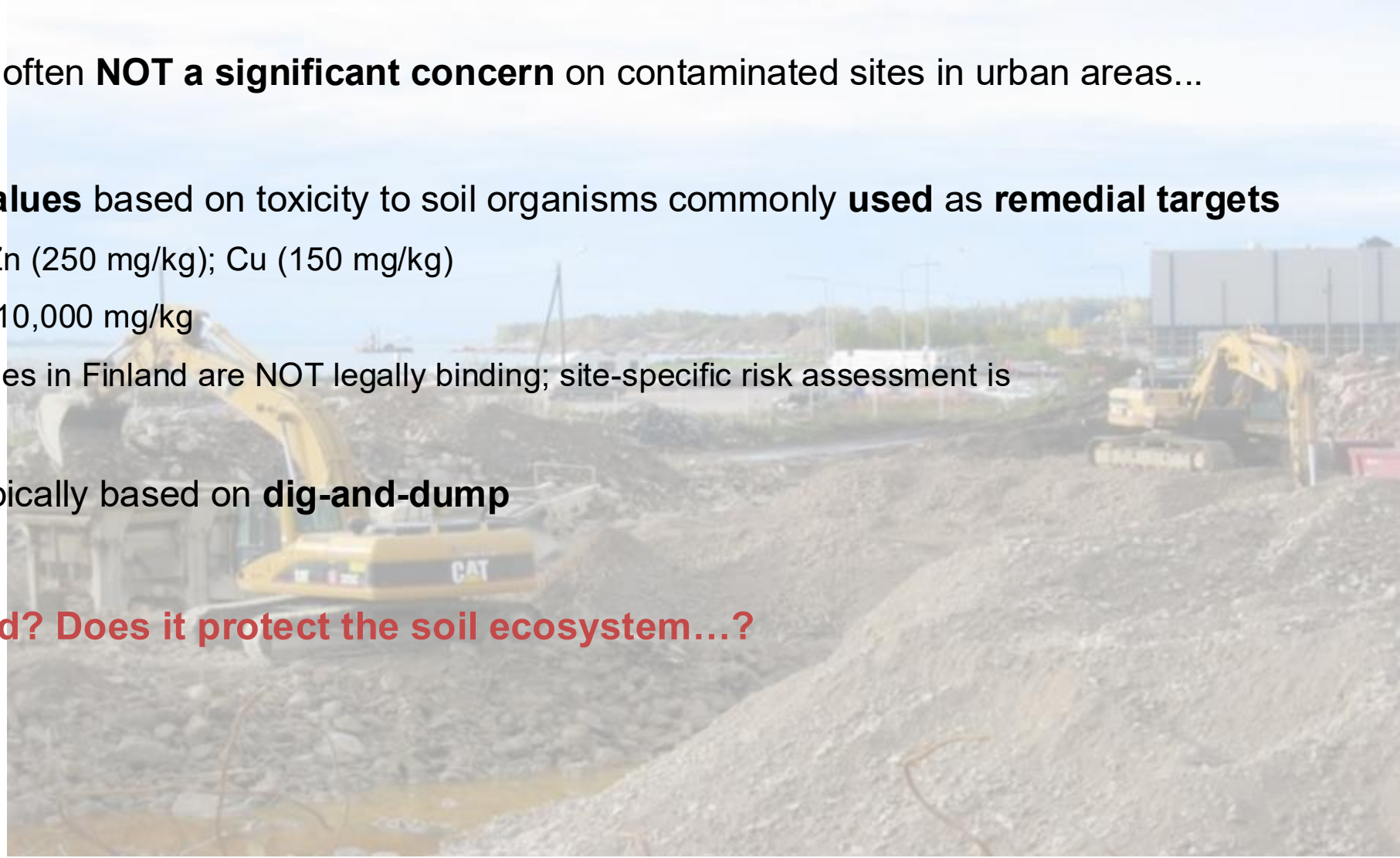
Local terrestrial ecosystem often **NOT a significant concern** on contaminated sites in urban areas...

...yet **ecological guideline values** based on toxicity to soil organisms commonly **used as remedial targets**

- e.g., eco-based values: Zn (250 mg/kg); Cu (150 mg/kg)
- health-based values: >> 10,000 mg/kg
- NOTE: soil guideline values in Finland are NOT legally binding; site-specific risk assessment is

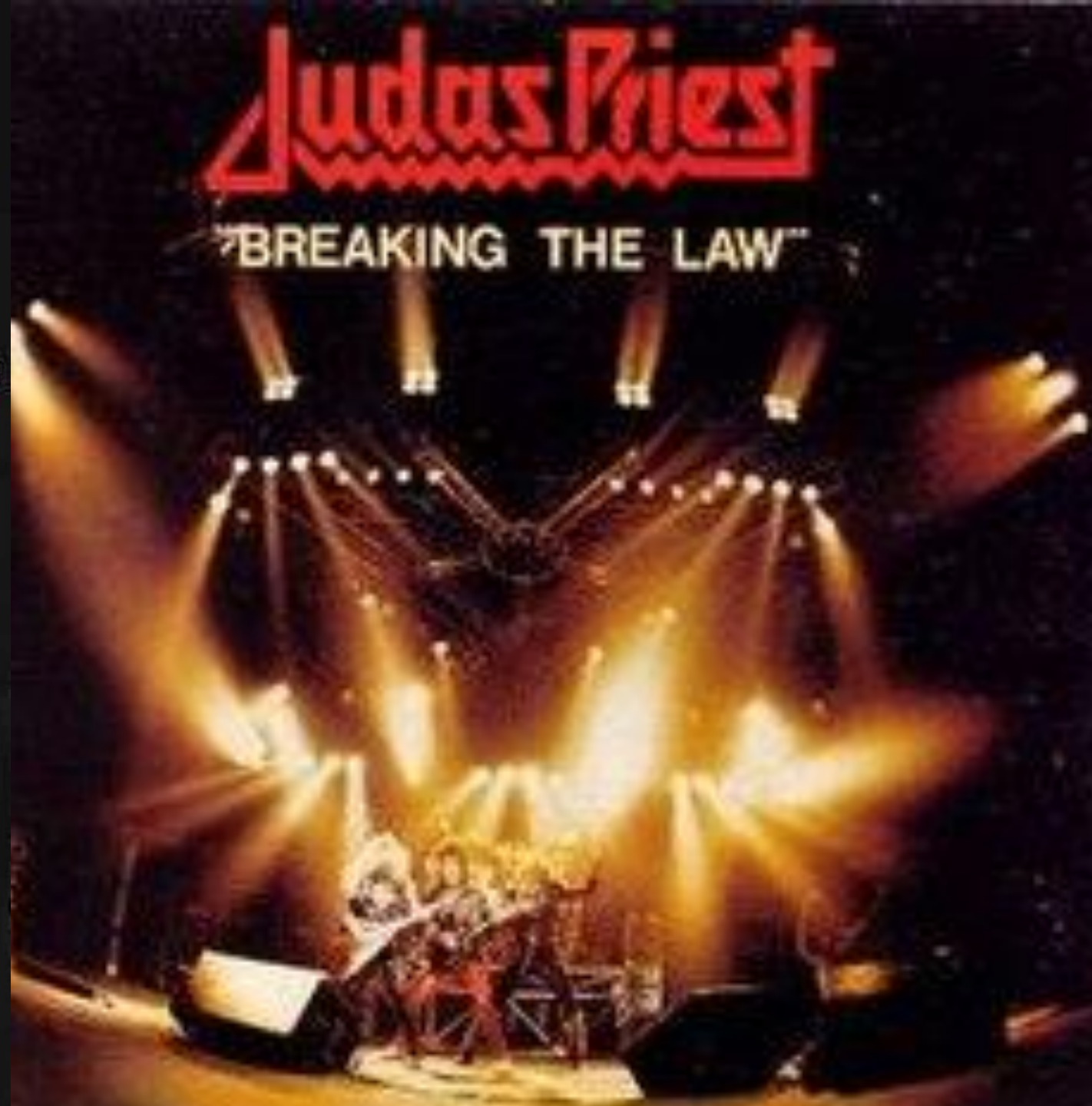
Furthermore, **remediation** typically based on **dig-and-dump**

Sustainable and risk-based? Does it protect the soil ecosystem...?



"Paint by Numbers"... a Harry Styles reference...?

Well, if anything it's the "obey the Law" part that inspires me, though rather than to obey...



Contaminated sites

Implementing articles on contaminated sites

EMERGING SYSTEM

Opportunity

Define institutional control and other capacities, and generate data and knowledge base

Implementation risk

Capacity and funding gaps

DEVELOPED SYSTEM

Opportunity

Move (from limit values) toward more risk-based and sustainable land management

Implementation risk

Lack of expertise and difficulties in changing habits

MATURE SYSTEM

Opportunity

Strengthen more systematic and holistic procedures, prioritisation and data management

Implementation risk

Duplicating or constraining practices that already work

Raising the minimum level, while avoiding compromising already functional systems

Regulatory aspects of implementation in Finland

Article	EU requirement (core content)	Current situation in Finland	Impact / required changes
Art. 13 Risk-based approach	Risk-based, stepwise management; liability; stakeholder participation	Strongly embedded in national law; participation more lenient	Low: increase participation and clarify legacy liabilities (?)
Art. 14 Identification of sites	Systematic identification and list of polluting activities	Databases, procedures and national programs exist; no legal obligation for inventory	Moderate: systematic approach for site identification / inventory into law (?)
Art. 15 Investigation	Rules on timing, prioritisation, and triggers	Risk-based investigations well established case-by-case; no binding national schedule	Significant: introduce prioritisation, timelines, and program-based investigation
Art. 16 Risk assessment and remediation	Risk assessment + sustainable risk reduction measures	Strongly embedded ; case-by-case approach; sustainability currently covered by guidance	Low: strengthen legal basis for sustainability considerations
Art. 17 Register	Public register of sites	Soil database with public data in use	Moderate: strengthen legal status; improve EU compatibility, transparency, and data protection

SML provides flexible approaches that are already mostly in line with the current Finnish system

The devil is in the details (...and the values = details)

ANNEX I Part B: soil descriptors with criteria for healthy soil condition established at Member State level

*Criteria for healthy soil condition – **non-binding sustainable target value: Soil contamination***

*Reasonable assurance, obtained from soil point sampling, identification and investigation of potentially contaminated sites and any other relevant information, that an **unacceptable risk to human health and the environment** from soil contamination does not exist.*

Article 16 Site-specific risk assessment and management of contaminated sites

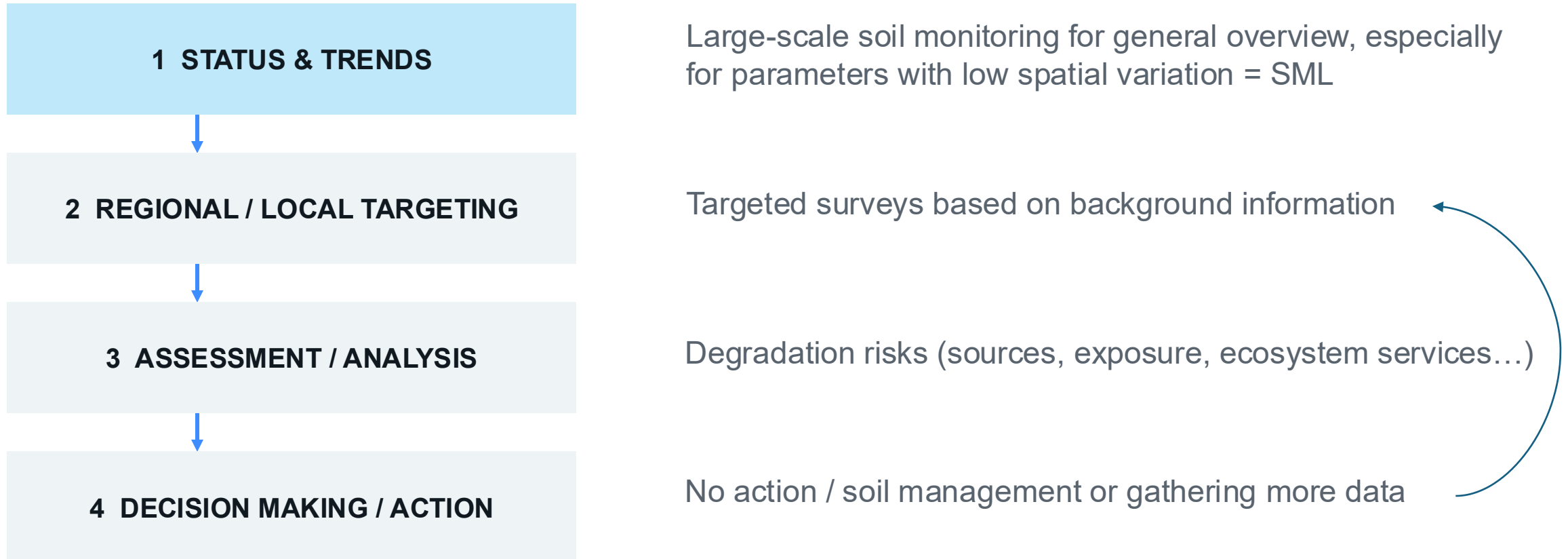
*2. Member States shall determine **what constitutes an unacceptable risk** to human health and the environment resulting from contaminated sites, by **taking into account** existing scientific knowledge, the opinions of health authorities, **the precautionary principle**, local specificities, and current and planned land use.*

*5. When deciding on the appropriate risk reduction measures, Member States shall, **while aiming for soil decontamination**, including the prevention of further contamination, take into consideration the long-term costs, benefits, effectiveness, durability and technical feasibility of available risk reduction measures.*

Crucial to maintain actual site-specific approach and risk-based definition of contamination, and to avoid STVs and OTVs migrating into the framework on contaminated land management

Concluding remarks

Tiered approach for more informed decision making



Stepwise and risk-based approach should be applied in contaminated site management and in soil health assessment alike

Good decisions are built on clear goals and proper data

Question	Evidence needed	Legitimate conclusion
Is the soil healthy on a soil unit?	Representative data on large scale	Overall unit-level soil condition
Where is degradation and why?	Most often spatially delineated data	Priority / risk areas
Is a site contaminated?	Data on source-pathway-receptor linkages	Acceptable / unacceptable risk
What action is justified?	Data on risks / impacts and feasibility	Effective and proportionate measure

Safeguards for functional implementation (...if possible)

- | | |
|---|---|
| 01 Define clear objectives / decision purpose before designing monitoring | 02 Match sampling density and design to the intended inference / decisions |
| 03 Keep STVs / OTVs within their defined role and scale | 04 Separate soil-health assessment from contaminated site management |
| 05 Incorporate tiered and risk-based approach also into soil health assessment | 06 Build on existing systems, data and national competence |

**The SML or soil monitoring are not the destination;
better decisions — and healthier soils — are**

**The SML is not a spot-on catalyst by design, but it
may become one through proper implementation**

THANK YOU! 🙌