Environment in practice

MANUAL

Sampling and sample pretreatment for soil pollutant monitoring

Swiss Agency for the Environment, Forests and Landscape
SAEFL

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Sampling and sample pretreatment for soil pollutant monitoring

Soil sampling manual OIS

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Editor

Swiss Agency for the Environment, Forests and Landscape (SAEFL)

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Report

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ABSTRACTS

This manual is concerned with sampling techniques and the physical pretreatment of samples for use in the analysis of soil pollutants. It begins with a discussion of the basic problems connected with sampling, and considers certain aspects of quality assurance. Following a presentation of the principles underlying the sampling plan, choice of location and long-term and reference studies, detailed instructions on the performance of monitoring and sample pretreatment are given. Finally, practical monitoring forms are presented and discussed.

Key words: sampling, sample pretreatment, soils, pollutants

Das Handbuch befasst sich mit der Probenahme und physikalischen Probenvorbereitung für Schadstoffuntersuchungen in Böden. Vorangestellt sind Grundprobleme der Probenahme und Aspekte der Qualitätssicherung. Nach der Darstellung allgemeiner Grundlagen zu Probenahmeplan, räumlicher Abgrenzung sowie Langzeit- und Referenzuntersuchungen folgt eine konkrete Anleitung zur Durchführung der Probennahme und Probenvorbereitung. Für die Praxis hilfreich sind die erläuterten Protokollformulare.

Stichwörter: Probenahme, Probenvorbereitung, Böden, Schadstoffe

Ce manuel traite du prélèvement et de la préparation d'échantillons de sols en vue de l'analyse de substances polluantes dans les sols. Dans un premier temps sont abordés les problèmes de base de l'échantillonnage et certains aspects de la garantie de qualité. La présentation des principes du plan d'échantillonnage, de la délimitation spatiale ainsi que des études à long terme et de référence est suivie par des instructions concrètes concernant l'exécution des prélèvements et la préparation des échantillons. Le manuel est complété par des fiches commentées utiles pour la pratique.

Mots-clefs: prélèvement d'échantillons, préparation des échantillons, sols, substances polluantes

Il presente manuale illustra il procedimento per il prelievo ed il pretrattamento di campioni di terreno ai fini dell'analisi delle sostanze nocive presenti nei suoli. Vengono innanzitutto spiegati i problemi di fondo legati al prelievo e gli aspetti relativi alla garanzia della qualità. La presentazione dei principi generali per il piano di campionamento, la delimitazione spaziale e le analisi a lungo termine e di riferimento è seguita da istruzioni concrete sull'esecuzione del prelievo e sulla preparazione dei campioni. Utili dal punto di vista pratico sono infine gli schemi per la redazione dei verbali di campionamento, completi delle necessarie spiegazioni.

Parole chiave: prelievo di campioni, pretrattamento dei campioni, suoli, inquinanti

FOREWORD

A knowledge of the pollutant content of the soil is an essential requirement for effective soil protection as laid down in the *Law Relating to the Protection of the Environment*. This calls for measures which, whilst not going beyond what is essential, are nevertheless effective. Since it is known that monitoring data can trigger restrictive and expensive measures to maintain soil fertility and protect humans, animals and plants, the compiling of such data is a crucial task. To enable changes to be identified, the data must be consistent over time, and must cover the whole of Switzerland. A robust methodology must be applied to keep the sources of error to an absolute minimum.

This manual concerns two fundamental aspects of soil surveying, namely those of soil sampling and sample pretreatment. The procedures for the extraction and analysis of pollutants are partly included in the *Ordinance Relating to Impacts on the Soil* (*OIS*), and partly in scientific publications.

This enforcement aid is a further element in the mosaic of Swiss soil protection provisions and unquestionably represents a major step towards the purposive and consistent implementation of the law.

We should like to thank not only those who have contributed to the successful completion of this manual, but also all those who will use it in the interests of soil conservation.

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1 Introduction

1.1 General

The present manual is concerned solely with soil sampling and the physical pretreatment of samples for the purpose of analysing their pollutant content. It replaces the relevant parts of the *"Guideline to Soil Sampling and the Analysis of Pollutants in the Soil" (SAEFL, FAC 1987)* and the related supplementary memoranda *(SAEFL, FAC 1989, Desaules 1995).*

The chemical methods for extraction and analysis have recently been presented in other publications *(Tab. 1).* The revision of the guideline became necessary due to the revision of the *Law Relating to the Protection of the Environment (LPE 1983)* of December 1995, in which the *Ordinance Relating to Soil Pollutants (OSP 1986)* was replaced by the *Ordinance Relating to Impacts on the Soil (OIS 1998).*

Tab. 1: Publications on methods of soil extraction and analysis.

Pollutant	Method
Inorganic pollutants according to OIS	- Annex 1 OIS (1998) - Reference methods of the agricultural research institutes *(FAL et al. 1995; continuously updated)* - Methodenbuch für Boden-, Pflanzen- und Lysimeterwasser-Untersuchungen *(FAL 1998)*
Organic pollutants according to OIS	- Annex 2 OIS (1998) - Recommended methods for PAH, PCB and PCDD/F *(SAEFL 2000a, 2001c–d, 2003)*
Other pollutants	- Appropriate recommended methods

1.2 Objectives

Whilst this manual is addressed primarily to the enforcement authorities, it is also intended for use by engineering and environmental consultants. In it, the basic methods for sampling and sample pretreatment are set out. The planning and performance of monitoring must be based on well-founded guides to procedure and aids to decision making. The intention of the manual is:

- to explain all aspects of sampling and sample pretreatment to those performing the monitoring
- to assist in achieving uniform monitoring procedures
- to assure the quality of the monitoring.

1.3 Scope

The manual is concerned with sampling and sample pretreatment for the investigation of chemical soil pollution according to Art. 7 Para. 4^{bis} LPE. The term soil is confined to the topmost permeable layer in which plants can grow *(Fig. 1).* According to the *Ordinance Relating* *to Impacts on the Soil (OIS),* the following situations can arise in connection with the monitoring:

- Monitoring and observation of soil pollution (Art. 3 and 4 OIS). This also includes investigations carried out within the national soil monitoring and cantonal soil observation networks (NABO, KABO).
- Investigation and evaluation in cases where the guide, trigger or clean-up values (Art. 5, 8, 9 and 10 OIS) are exceeded. The related pollution is hazardous to soil fertility in the sense defined in Art. 2 OIS, that is to say when it endangers soil organisms, wild and cultivated plants, grazing animals, playing children and consumers of crops.
- Assessment of soil excavated for further use (Art. 7 OIS; cf. *Guideline for the Reuse of Excavated Soils (SAEFL 2001a).*

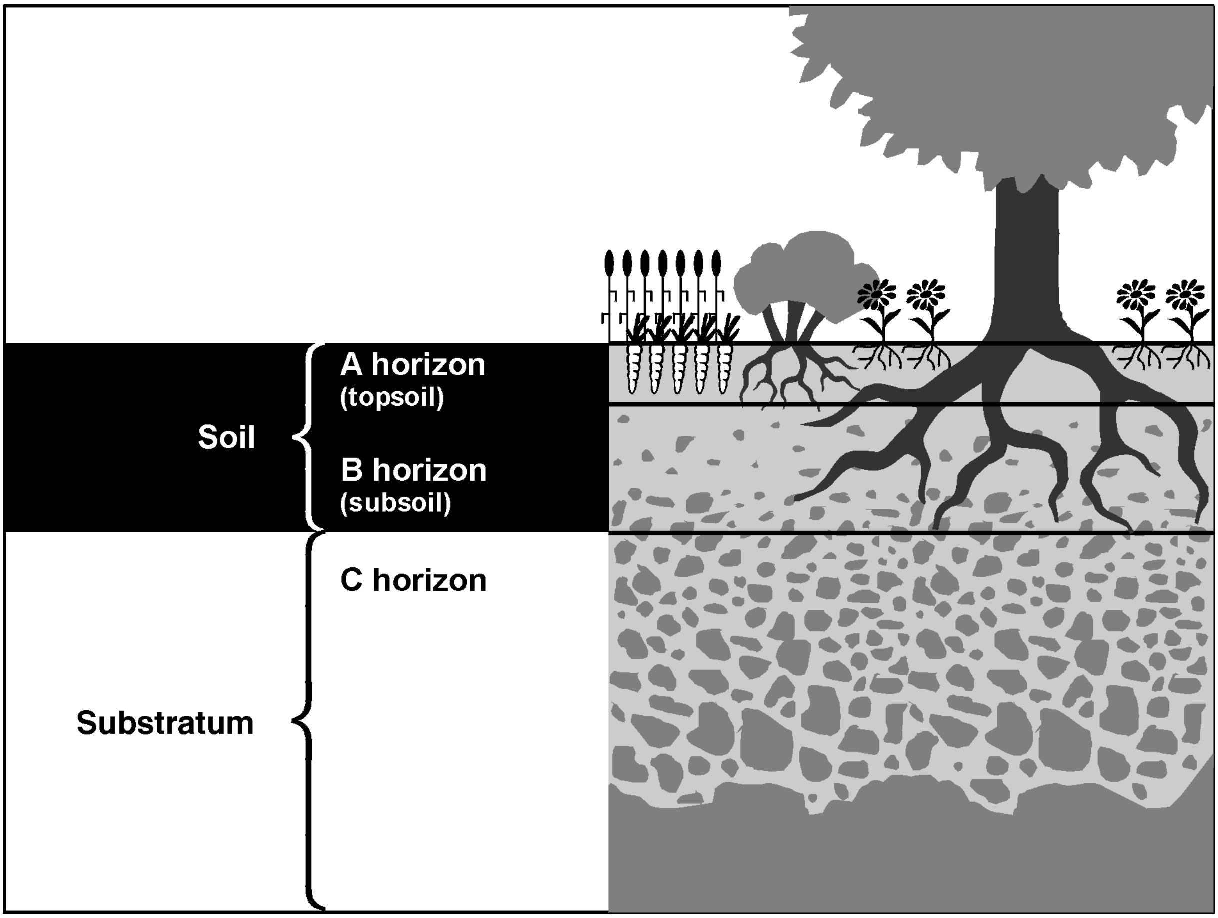

Fig. 1: Subject of this manual ***(shown in black).***

Where contaminated sites as defined in the *Ordinance on Contaminated Sites (OCS)* are concerned, this manual applies only in cases when:

- contaminated sites impact on soils, etc.
- soils on contaminated sites affect humans, animals and plants.

The manual does not apply to other impacts arising from polluted sites defined in the OCS (e.g. impacts on ground or surface waters, or on indoor or outdoor air). In these cases, sampling is based on the SAEFL *"Guideline for Sampling of Solids at Contaminated Sites".* The

1.4 Contents

In preparing the present report, the previous sampling guideline *(SAEFL, FAC 1987)* was revised to accord with amendments in soil protection legislation. In doing so, tried and tested parts were retained, and these supplemented by the experience gained from the national (NABO) soil monitoring and cantonal (KABO) soil observation networks. In addition, the relevant ISO standards *(ISO 1995a–b; 1996a–b; 2002a–c),* international guidelines and scientific literature were consulted. Special attention was paid to quality assurance in sampling and sample pretreatment. The manual is divided into the following sections:

- ***Chapter 2*** explains the basic purpose and organisation of sampling, together with the methods for quality assurance.
- ***Chapter 3*** explains how sampling is planned.
- ***Chapters 4*** and ***5.*** In these, planning and sampling in typical practical situations are considered in detail for long-term and reference monitoring (cf. *Chap. 4,* particularly in connection with continuous monitoring, e.g. NABO, and continuous observation, e.g. KABO), and for setting the boundaries of polluted soils (cf. *Chap. 5,* particularly in connection with excavated soils and hazard assessment).
- ***Chapter 6*** deals with practical aspects of sampling in the field, and ***Chapter 7*** with sample pretreatment and archiving.
- ***Annex 5*** contains the monitoring forms for sampling and sample pretreatment described in ***Chapter 8.***

The flow diagram shown in *Fig. 2* shows the arrangement of the manual. Each of the procedure stages shown are covered in separate chapters. The relevant procedures and the methods for interpreting the results are laid down at the planning stage.

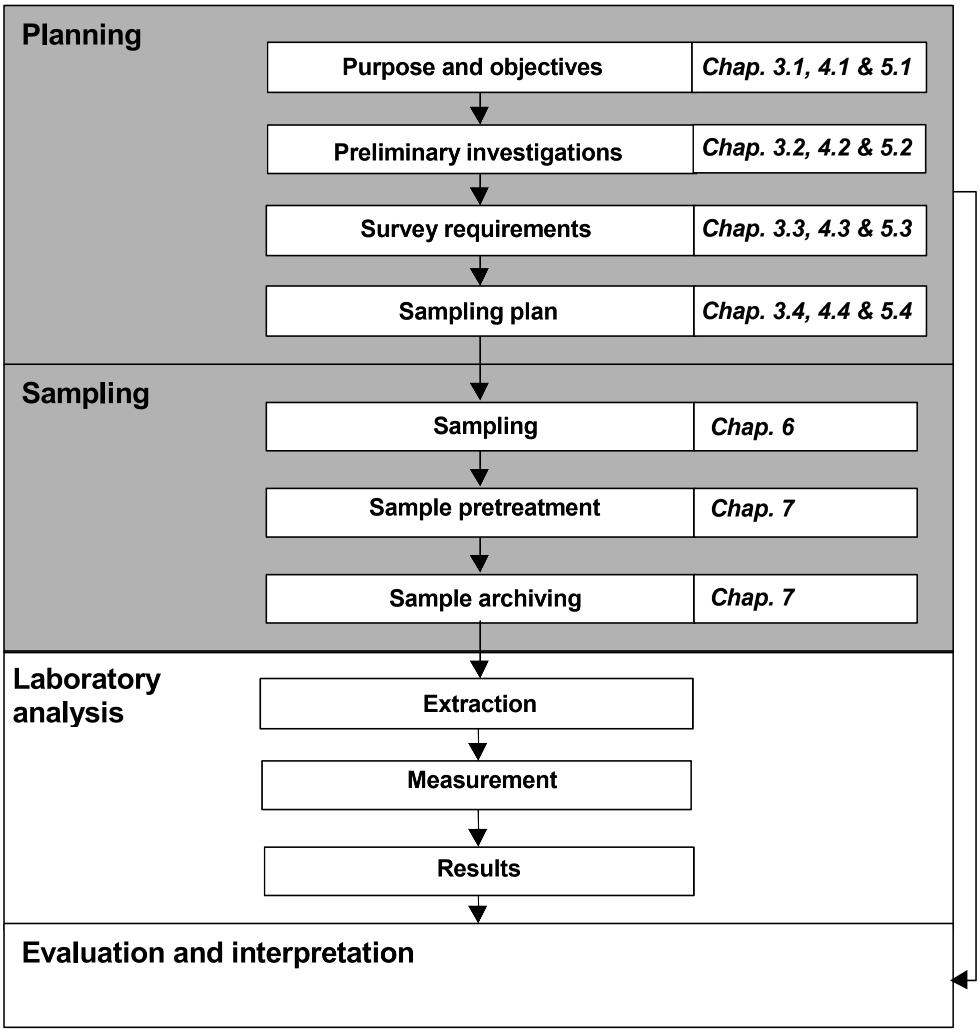

Fig. 2: Procedure for sampling and sample pretreatment.
(This manual concerns the area shown in grey.)

2 Purpose and quality assurance

2.1 Heterogeneity – the fundamental problem

The objective in sampling is to record and simulate pollutant distribution in the form of statistical values (e.g. mean values, standard deviation) as reliably as possible in accordance with the purpose and objectives of the monitoring. In doing so, the point-to-point variability, and thus the heterogeneity, of the values recorded in the area investigated, plays a central role. This must be regarded from the point of view of individual samples, sampling areas or the entire monitoring area, depending on the purpose and objectives of the monitoring.

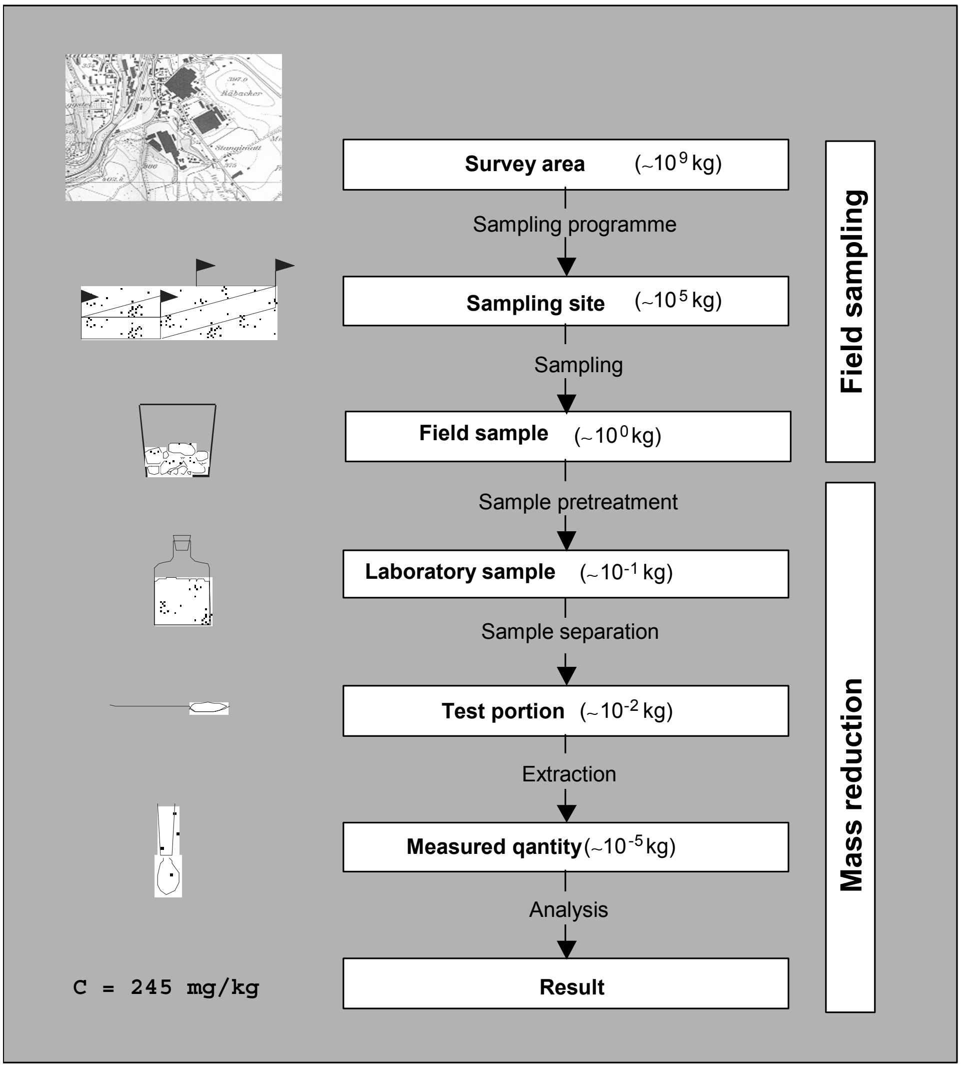

Fig. 3: Sampling and mass reduction procedure.

To obtain a realistic picture of the pollutant content of the soil, a sampling and mass reduction procedure is applied, the steps of which are shown in *Fig. 3*. Where the sampling procedure is concerned, the emphasis is on the valid representation of heterogeneity in the area under study: in connection with the mass reduction procedure, interest centres on the samples and sub-samples derived from these. Each of the steps shown in *Fig. 3* leads to unavoidable errors and related uncertainties. The result of the analysis (i.e. the measured value) is therefore composed of the following:

Result of analysis = **True value** + **Sum of the errors of the sampling and mass reduction procedures** + **Measurement error**

The errors in the sampling and mass reduction procedures can only be quantified approximately, since the sources of error are many and varied. For one, it is not possible to obtain absolutely representative samples. Secondly, it lies in the nature of errors that they cannot be reduced below the elementary error. It is thus only possible to obtain an approximation to the true value. The best approximation to the true value is obtained when each step in the sampling and mass reduction procedure is performed in such a way that each successive subsample is as representative as possible of the preceding sample, ensuring that the incurred error remains small. The sampling and mass reduction procedure is subject to two groups of errors *(Gy 1991)* as follows:

- primary sampling error, i.e. the difference between the unknown true value in the monitoring area and that of the field samples
- sub-sample error, i.e. the difference between the unknown true value of the field sample and that of all subsequent sub-samples.

The errors arise from the fact that the sampling and mass reduction procedures do not take adequate account of the heterogeneity of the values under study. The reason for the primary sampling error lies in the heterogeneity of the characteristic values in the area under study (field heterogeneity). The cause of the sub-sample error lies in the heterogeneity of the samples.

In laboratory analytics, increasingly sophisticated quality control and monitoring strategies are applied. In sampling, this is only possible to a limited extent, since the field heterogeneity cannot be calibrated against a certified quasi-homogeneous field area, as is the case in laboratory analytics using certified reference material. In sampling, the error reduction scheme endeavours to reduce the likelihood of error through careful planning *(☞ Chap. 3),* sample pretreatment *(☞ Chap. 7)* and professional execution *(☞ Chap. 6).* Notwithstanding this, the measures taken to reduce errors should be designed to have a reasonable relationship between benefits and costs.

The literature endeavouring to quantify the errors and uncertainties over the entire measurement process from sampling through sample pretreatment to laboratory analysis is meagre and contains gaps (e.g. *Desaules* and *Dahinden 1994, Huesemann 1994, Thompson* and *Ramsey 1995, Ramsey 1997, Squire et al. 2000, Wagner et al. 2001).* Experience to-date shows that the uncertainties may vary greatly between pollutants, with their concentration and with the area under study. Meaningful quantitative generalisations cannot therefore be made based on the present state of knowledge. The method of "uncertainty budgets" *(EURACHEM/CITAC Guide 2000)* permits a quantitative estimate of the sources of error to be made, thereby contributing to their relative reduction.

Further literature

EURACHEM/CITAC Guide, 2000, Quantifying Uncertainty in Analytical Measurement, Laboratory of the Government Chemist, London. 120 p., second edition.

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Thompson M., Ramsey M.H., 1995, Quality Concepts an Practices Applied to Sampling – An Exploratory Study, Analyst, 120, 261–270.

2.2 Sampling quality

2.2.1 Quality criteria

The purpose of this manual is to facilitate correct planning and performance of sampling and sample pretreatment operations. For this, the following criteria (which in some cases conflict with one another) are applied:

Conclusiveness

- compatibility of the sampling plan with the actual circumstances
- spatial resolution and number of samples taken
- relevance of the chosen characteristic values to the purpose and objectives of the investigation.

Reliability

- reliability through characterisation and quantification of errors
- validity of the sampling plan in fulfilling the purpose of the monitoring.

Cost effectiveness

- careful adjustment of the relationship between benefits and costs to facilitate effective fulfilment of the purpose of the monitoring.

The assessment of the individual criteria and their priorities must be made based on expert judgement, specific experience and the constraints imposed by the purpose and objectives of the monitoring.

2.2.2 Quality assurance

As opposed to laboratory procedure, no standardised procedure for the planning and performance of sampling can be given, since both the circumstances and the problems encountered are manyfold. The ISO *(ISO 2002c)* recommends that quality assurance be performed according to the principles of the ISO 9000 standard *(SNV 1999)*. An adequate standard of quality demands the application of quality assurance methods. Quality assurance involves strategies for the reduction of errors in sampling and sample pretreatment from the planning to the operational stage, by making the procedural steps readily comprehensible and retraceable (ISO 9000). On this basis, a later check can be made whether the methods adopted accorded with the requirements and specifications of this manual, and therefore fulfilled the quality requirements. Quality assurance also obliges those performing the monitoring to uphold the necessary standards during their task.

The principal method applied in quality assurance is to document the procedure performed from the planning through to the evaluation stage, as shown in *Fig. 2.* The sampling plan plays a central part in this *(☞ Chap. 3.4).* To document the procedures, monitoring forms are provided *(☞ Annex 5).* All other stages in the procedure are documented in text form. Further essential requirements in quality assurance are:

- qualified personnel
- documentation of work plan and procedures
- use of suitable material, equipment and buildings
- laboratory accreditation and participation in ring analysis.

The *Quality* check list *(☞ Annex 1)* is also part of the quality assurance procedure. Each step in the procedure is accompanied by questions enabling an autonomous assessment to be made.

Further literature

Nothbaum N. et al., 1994, Probenplanung und Datenanalyse bei kontaminierten Böden, 164 p., Erich Schmidt Verlag, Berlin.

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VEGAS, 1999b, Probenahme von Böden bei Altlasten (Lehrgang IV für Probennehmer), Analytische Qualitätssicherung Baden-Württemberg, VEGAS Versuchseinrichtung zur Grundwasser- und Altlastensanierung, Landesanstalt für Umweltschutz, Stuttgart and Karlsruhe.

3 Sampling fundamentals

3.1 Problem and objectives

The problem and objectives must be expressly and clearly laid down and documented from the outset. This step is essential for the purposive, efficient and competent planning and execution of monitoring and observation. Moreover, the documentation permits an assessment to be made whether the results of a monitoring may also be used in other studies. Examples of specific problems and objectives are given in *Chaps. 4.1* and *5.1.*

3.2 Preliminary investigations

3.2.1 Objectives and methods

Preliminary investigations are required to obtain the information for identifying the problem and determining the objectives. In the preliminary procedure, information is obtained on the choice of monitoring area and its contamination history and use (cf. *Annex 2),* on the site characteristics (local and site factors) and on safety precautions required in performing sampling. The task includes literature research, and general orientation and interviews in the field. Detailed instructions on preliminary investigation are given in *Chaps. 4.2* and *5.2* under typical monitoring conditions.

3.2.2 Contamination hypotheses and hazards

Using the criteria in *Tab. 2*, one or more contamination hypotheses may be formulated based on the contamination history and past uses of the site. The hypotheses are essential in preparing the sampling plan. Depending on the outcome, the problem and objectives may have to be reviewed and revised (iterative procedure).

Tab. 2: Formulation of contamination hypotheses.

Areas concerned	Questions arising
Pollutant contamination paths	- is there a geogenic background contamination that affects the site? - what anthropogenic pollutants were released to the soil? - how were these pollutants released to the soil? - how many, and which, polluters are involved?
Horizontal and vertical extent	- what is the horizontal extent of the exposed area? - how far down does the contamination reach?
Horizontal and vertical differentiation	- depending on the type of pollutant input, does the contamination have well-defined horizontal or vertical boundaries, or is the transition gradual?
Contamination pattern	- where were pollutants released to the soil? - what parts of the area, or what strata, are more (or less) polluted? - is the contamination pattern homogeneous or rather heterogeneous?

Based on the contamination hypothesis, an assessment can be made as to which hazards could be significant.

These are mainly:
- hazards to soil fertility
- hazards to humans, animals or plants.

3.3 Monitoring requirements

As soon as the preliminary investigations have been performed and the necessary information obtained, the monitoring required to meet the objectives may be determined (*Tab. 3*).

Tab. 3: Criteria for determining monitoring requirements.

Area of investigation	Monitoring requirements
Sampling	- required resolution (number of sampling sites) - appropriate size of sub-areas to determine pollutant content (optimisation of the extent of the monitoring and any disposal needed, e.g. for composite samples) - required accuracy of the results (number of dual samples) - required positional accuracy of the site to ensure reproducibility of the samples
Accompanying investigations	- Soil profile description: type and number, characteristics - borings: type and number - soil characteristics: number and type of samples (sampling depths) - observation of land use
Analytical programme	- pollutants involved and specification of analysis methods - characteristic soil values and specification of analysis methods
Methods of evaluation and interpretation	- standards of assessment (e.g. OIS regulatory values) - values of interest (mean, maximum and minimum values) - interpretation bases (characteristic soil values, site data) - evaluation procedures (e.g. qualitative assessment, geostatics, test of hypothesis)
Stepwise procedure	- stepwise procedure for extensive observation

3.4 Sampling plan

3.4.1 Introductory remarks

The procedures necessary to meet the monitoring requirements are recorded in the sampling plan *(Fig. 4)*. The chief objective is to set out the procedures in advance, thereby ensuring that the practical procedures *(☞ Chap. 6)* accord as far as possible with the theoretical requirements *(☞ Chap. 2)*. The sampling plan is the kingpin of quality assurance: it must therefore be committed to paper.

3.4.2 Sampling pattern

The sampling pattern shows the *distribution* of one or more sampling sites in the designated monitoring area. It must take account of the purpose and objectives, contamination hypothesis(es) and the required resolution.

An appropriate sampling pattern is one in which the sampling sites adequately represent the monitoring area, and the number of samples is as small as possible. **Non-representative sampling patterns present one of the most serious sources of error in soil pollution observation.** Not only do they produce erroneous results, but may also lead to false interpretation.

To ensure sampling proceeds according to plan, the sampling sites must be entered in advance in a map of suitable scale. If it is not possible to take samples at a designated site (e.g. owing to obstacles in the terrain), an alternative site must be used. The procedure for designating alternative sites must be specified in advance. This avoids arbitrary selection and associated sources of error. The procedure for choosing an alternative site is based on the purpose and objectives, the contamination hypothesis and the original sampling pattern. In the case of extensive observation, a decision tree is recommended in designating alternative sites. *Tab. 4* shows the sampling patterns commonly used in soil sampling.

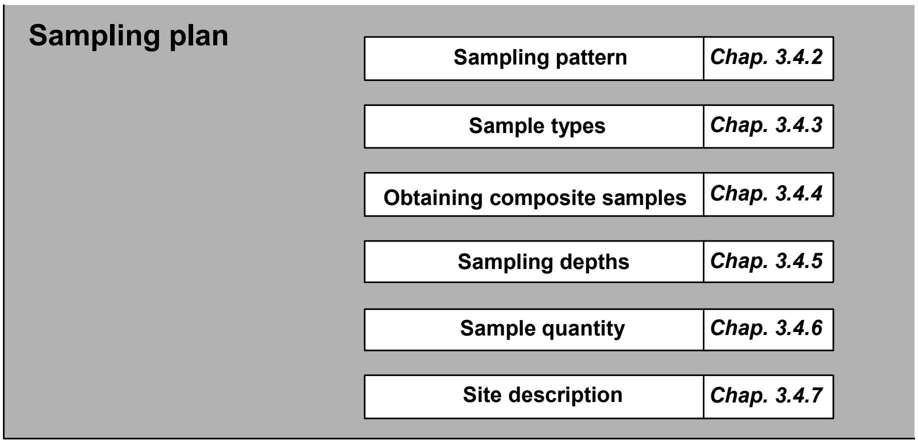


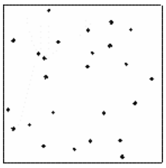
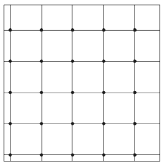
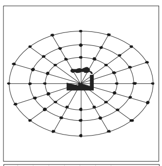
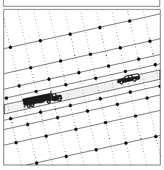
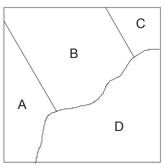
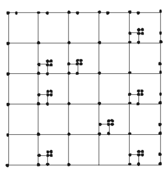
Fig. 4: Sampling plan elements.

Basic sampling patterns *(Tab. 4):*

- *Random distribution*

Although random distribution is the only objective procedure, it calls for a very large number of samples. It ensures that every point in the terrain is sampled with the same probability, enabling systematic errors to be almost entirely eliminated. However, even random sampling (i.e. without a plan) does not produce a pure random distribution, since to do so, all external influences (e.g. the application of professional knowledge) have to be excluded. Also, factors such as the relief, the vegetation and other obstacles must not be allowed to influence the distribution, a condition not always achievable in practice. Where such effects cannot be avoided, recourse must be had to alternative sites. In practice, the random procedure is very time consuming (owing to positioning requirements, poor accessibility and inadequate reproducibility). An additional disadvantage is that the samples are not evenly distributed over the area.

Tab. 4: Sampling patterns for soil pollutant observation.

Distribution	Procedure	Advantages	Disadvantages
Random 	Distribution of the sampling sites using random numbers and with complete exclusion of professional knowledge	- the only objective procedure - every point is sampled at the same probability - small systematic error	- large number of samples necessary - time consuming procedure - number of samples not proportional to area
Systematic 	Distribution of the sampling sites on a geometrical grid: - square grid - rectangular grid - triangular grid	- small time expenditure - small number of samples - good coverage with triangular grid - even distribution of sampling sites - number proportional to area	- inappropriate grid size can cause systematic errors - triangular grid is time consuming
Judgmental  	Distribution of the sampling sites based on expert judgement and considerations of plausibility (contamination hypothesis): - point sources: polar distribution - line sources: line distribution - other sources: in accordance with contamination hypothesis - greater sampling density in vicinity of source	- smallest number of samples - in accordance with contamination hypothesis	- greatest susceptibility to systematic errors where contamination hypothesis is inappropriate - time consuming preliminary investigations
Stratified pattern 	Appropriate distribution in more homogeneous sub-areas. Number of sampling sites proportional to the area. Distribution within the area: random, systematic or directed	- in accordance with contamination hypothesis	- susceptibility to systematic errors where contamination hypothesis is inappropriate - demands prior knowledge
Nested pattern 	Systematic distribution of the sampling sites and higher local sampling density as predefined in a diagram (random or systematic)	- heterogeneity recorded at different geographical scales - suitable for geostatic evaluation (with large number of samples)	- large number of samples necessary - time consuming procedure

Sources: *Borgman* and *Quimby (1988), Dalton et al. (1975), Harvey (1973), ISO (1995a), Keith (1990), Lepretre* and *Martin (1994), Nothbaum et al. (1994), Rubio* and *Vidal (1995), Woede (1999).*

- *Systematic distribution*

Systematic distribution is based on a geometrical grid. A square grid is commonly used. Using a triangular grid, and assuming the same number of grid points, the non-sampled sub-areas are smaller, but their positioning is more time consuming. Since the choice of grid is based on expert assessment, systematic errors cannot be excluded. Assuming the same resolution, the number of samples required for systematic distribution is less than for random distribution. An advantage of systematic distribution is its proportionality to area.

- *Judgmental distribution*

In judgmental distribution, the sampling pattern is derived from the contamination hypothesis. The distribution of the sampling sites is based on expert assessment and on considerations of plausibility. Judgmental sampling has the highest susceptibility to systematic errors among the distribution procedures, since unknown causes of contamination may be present. Judgmental distribution requires the smallest number of samples. The likelihood of error due to an inappropriate or incomplete contamination hypothesis is very high. Careful and well-considered preliminary investigations are therefore essential *(☞ Chap. 3.2)*.

A general relationship exists between the required number of samples and the probability of error for the three distribution types: *random, systematic* and *judgmental*. Random distribution requires the largest number of samples and gives the lowest error. Directed distribution requires comparatively few samples, but the probability of error due to an inappropriate contamination hypothesis is largest. Systematic distribution lies between the two *(Keith 1990)*.

Use of sampling patterns in sub-areas *(Tab. 4)*

- *Stratified sampling pattern*

The monitoring area is divided (or "stratified") into appropriate homogeneous sub-areas ("strata"), in which the number of samples is proportional to the area. A random, systematic or directed sampling pattern is then chosen in each sub-area.

- *Nested sampling pattern*

In this method, the sampling areas are nested within one another, i.e. the grid extends over the entire monitoring area, with some parts having a higher sampling density. This enables an assessment of the heterogeneity to be made at different scales *(☞ Chap. 2.2)*. Nested distribution is the most suitable form for estimating the values at non-sampled points by interpolating the measured values using geostatic methods *(SAEFL 1994)*.

Further literature

SAEFL, 1994, Regional soil contamination surveying – A: technical note, B: case study, Environmental Documentation no. 25 – Soil, 70 p., Berne.

Dalton R. et al., 1975, Sampling techniques in geography, 95 p., George Philip and Son Ltd, London.

Isaaks E.H., Srivastava R.M., 1989, An introduction to applied geostatistics, 561 p., Oxford University Press.

ISO, 1995a, Soil quality – Sampling, Part 1: Guidance on the design of sampling plans (ISO/DIS 10381-1), 44 p., German Institute for Standardization (DIN), Berlin.

Keith L.H., 1990, Environmental sampling: a summary, Envir.Sci.Tech. 24, 610–617.

Webster R., Oliver M., 2001, Geostatistics for Environmental Scientists, 271 p., John Wiley & Sons, New York.

Woede G., 1999, Probenahmeraster für Bodenuntersuchungen, Bodenschutz, 4, 147–151.

3.4.3 Sample types

Single samples

Single samples are obtained from a single increment. A distinction is made between disturbed and undisturbed samples. With undisturbed samples, the natural soil structure is largely preserved. They are used for the determination of physical soil characteristics such as bulk density, hydraulic conductivity and pore volume.

With disturbed samples, the soil structure is destroyed. Disturbed samples are used in the analysis of chemical properties such as pH, and nutrient and pollutant content. Owing to the heterogeneity of the soil, single samples are not usually representative of an area, but only of the point of increment *(☞ Chap. 2.2)*.

Composite samples

To obtain a representative sample of a given volume, several single samples are combined to a (disturbed) composite sample. It is assumed that the pollutant content of the composite sample approximates to the average pollutant content of the given soil volume. By this means, the heterogeneity is largely smoothed out at the sampling stage *(Aichberger et al. 1985, Federer et al. 1989)*. The decisive factors are the magnitude and heterogeneity of the parameters within the soil volume, and the number and distribution of the single samples *(☞ Chap. 3.4.3)*.

A distinction is made in practice between the sampling of topsoil and subsoil. For the purposes of this manual, topsoil is defined as the uppermost humic layer (usually 0–20 cm, referred to in soil science as the A horizon). Subsoil is defined as the area below the topsoil in which plants take root (referred to in soil science as the B horizon).

For the purposes of this manual, the following types of sample are defined:

- **Area and line samples**

  Area samples are composite samples of topsoil obtained from a particular distribution of single samples over the sampling area *(☞ Chap. 3.4.2)*. Line samples are composite samples of topsoil obtained along a sampling line.

- **Bore samples and soil pit samples**

  Bore samples are composite samples of subsoil using borings (single samples). They can be taken either over a sampling area or along a sampling line in accordance with the contamination hypothesis. Soil pit samples are composite samples of subsoil obtained from the walls of a soil pit.

- **Volume samples**

  Volume samples are single or composite samples of given volume. They are used to determine the bulk density. They may be disturbed or undisturbed depending on the device *(☞ Chaps. 6.7* and *6.8)*.

  Volume samples are required when the soil contains more than 15 % humus, since in this case the OIS specifies guide, trigger and clean-up values in volumetric units (mg/dm^3, cf. Annexes 1 and 2 OIS). Volume samples are usually taken in addition to area, bore and section samples, and serve to convert the results from weight to volumetric units *(☞ Chap. 7.1)*. To obtain a representative result, at least three volume samples are required.

3.4.4 Taking of composite samples

The size of the area required for composite samples is defined when specifying the monitoring requirements *(☞ Chap. 3.3)*. To obtain a composite sample, the number and distribution of single samples within the area must be specified. The decisive factor is the heterogeneity of the required value in relation to the size of the area. In general:

- the larger the number of samples, the more reliable the results, i.e. the better the reproducibility.
- the greater the heterogeneity of the required value, the greater must be the proportionality between the number of samples and the area.
- the heterogeneity of a soil value can only be taken into account up to a certain point by increasing the number of single samples *(Aichberger et al. 1985)*. Therefore the required soil value should be distributed as homogeneously as possible within the volume from which the composite sample is taken.

It would be impracticable to specify the procedure for obtaining composite samples in each individual case. Instead, plausibility considerations based on the contamination hypothesis *(☞ Chap. 3.2.2)* must be used.

Area samples

Area samples are taken at points where no appreciable pollutant content gradient is expected from the contamination hypothesis (e.g. agricultural areas). *Tab. 5* shows three typical distributions used to obtain area samples. For a sampling area of 100 m^2, 16–25 single samples have proved sufficient to obtain a composite sample *(Federer et al. 1989)*. Where large areas are to be monitored, and where the contamination may vary, a stratified procedure is to be preferred *(☞ Chap. 3.4.2)*.

Line samples

Line samples are taken where an appreciable pollutant gradient is expected (e.g. normal to a roadside) from the contamination hypothesis *(☞ Chap. 3.2.2)*. A sampling line is drawn normal to the gradient. The single samples are distributed at systematic intervals along the sampling line. The length and form of the line are based on the contamination hypothesis.

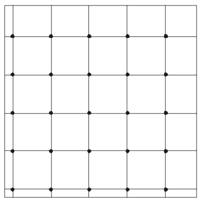
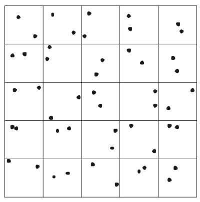
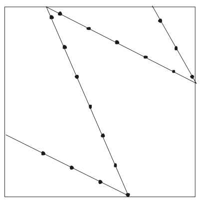
Soil pit samples

Soil pit samples are obtained from several single samples distributed over the width of the soil pit and over the depth range of interest. The soil pit should, if possible, be chosen to be 1 m wide to ensure that any heterogeneity in the required value is at least partly compensated for.

Bore samples

Composite samples are obtained by cutting out the cores of single samples at the required depth and combining them. The borings are distributed over an area or along a line using the same criteria as in obtaining area and line samples. Borings may be made manually or using devices (e.g. penetration core borer).

Tab. 5: Distribution of single samples in area sampling.

Distribution		Procedure	Advantages	Disadvantages
Systematic		Systematic distribution of a fixed number of single samples over the sampling area (usually square grid)	- uniform sampling of the area	- relatively large time expenditure - single samples not always obtainable at the grid nodes
Stratified ad hoc		Stratification of the sampling area (usually 10 m x 10 m) into sub-areas (usually 16–25 areas), with ad hoc distribution of a given number of single samples (usually 1or 2) in each sub-area	- uniform sampling of the entire area - small time expenditure	- subjective choice of ad hoc sampling points can lead to systematic errors
Diagonal		Systematic distribution of the sampling points along one or more carefully chosen diagonals in the sampling area (I, X or W pattern)	- measurement of striated contamination pattern - very low time expenditure	- non-uniform sampling of the area - can cause systematic errors with very heterogeneous contamination - I and X patterns are sensitive to direction

When using borings, there is a substantial risk of compaction, making it more difficult to establish the correct sampling depths. It is also possible that the sample may become contaminated by other soil strata during the motion of the borer *(Schulz et al. 1996).* The subsoil may, however, be sampled over a larger area than using vertical sections, enabling the variability to be better compensated in accordance with the contamination hypothesis, thus reducing the need for, and effort involved in, intervention.

Further literature

Garner F.C. et al 1988, Composite sampling for environmental monitoring, *in:* Keith L.H. (ed.), Principles of Environmental Sampling, 25, American Chem. Society, 363–374.

Rohlf F.J. et al., 1996, Optimizing composite sampling monitoring forms, Envir.Sci.Techn., 30, 2899–2905.

3.4.5 Sampling depth

Definition of sampling depth

The choice of sampling depth depends on the given problem. Observation according to the OIS is contamination-related and serve to assess the hazard. For these, the fiducial point (zero level) for depth measurement is chosen at the surface of the terrain, i.e. at the surface of the humus layer. Where the focus is on soil science, however, the surface of the topsoil should be chosen as the fiducial.

Sampling of topsoil

For pollutant observation according to the OIS, the sampling depths are specified in the ordinance *(Tab. 12)*. Deviations from these are, however, permitted in justified cases. This is the case if no meaningful result can be obtained using the standard depths *(☞ Chap. 5.4.4)*.

The inclusion of the humus layer in the samples can influence the results of the analysis, since – particularly with forest soils – the pollutant gradient in the transition area between the humus layer and the mineral substratum is very high *(Angehrn-Bettinazzi 1989)*. However, it is often not possible to distinguish the humus layer reproducibly from the topsoil *(Federer 1982)*. For this reason, routine sampling under OIS is performed without separating the humus layer from the topsoil. Coarse organic material is lost when sampling with a half corer auger and in sample pretreatment (cf. sieving, *☞ Chap. 7.1)*. Experience shows that the results of the analysis are well reproducible in a given laboratory *(SAEFL 1993, Desaules* and *Dahinden 1994),* and that the values obtained are suited for long-term and reference monitoring *(☞ Chap. 4)*.

For soil observation in which the pollutant content of the humus layer is of primary interest (particularly at forest sites), the humus layer can be sampled (without litter) either in its entirety, or separately in organic horizons, from the soil pit. Although the results of the latter are not as reproducible, this procedure is justified from the standpoint of soil science.

The sample type must be recorded (to ensure traceability).

Sampling of the subsoil

The subsoil is sampled from soil pits or using bore samples either at soil horizons or at fixed depth levels. Care must be taken to ensure that the depth of the soil layer sampled is not less than 5 cm (to ensure reproducibility) and not greater than 40 cm (to ensure representativeness). The decision whether to use horizons or depth levels, and the specification of maximum sampling depth, are made separately in each case based on the purpose and objectives *(☞ Chap. 3.1)* and on the contamination hypothesis *(☞ Chap. 3.2.2)*.

Where the focus is on soil science (e.g. migration of pollutants between layers), sampling of soil horizons is usually preferable. In determining the depth at which a regulatory value is exceeded, the choice of fixed depth levels (e.g. with direct input) or horizons (e.g. with geochemical migration) should be made in accordance with the contamination hypothesis. Where the fixed depth levels are not too thin, a combined procedure in horizons and fixed depth levels may be adopted.

3.4.6 Sample quantities

As part of the preparation procedure, the required quantity is specified in advance for each sample *(☞ Chap. 6)*. The sample quantity must be large enough to permit representative conclusions to be drawn on the pollutant content over an area. It also depends on the net quantity required for laboratory analysis, and on the intended number of replicate, reserve and archive samples. It should also be noted that part of the sample is lost during pretreatment *(☞ Chap. 7.1)*. More specifically, the coarse material (>2 mm) is sieved out in preparing the sample. The theory relating to minimum sample quantities is given in the *"Guideline for Sampling of Solids at Contaminated Sites"* (SAEFL).

Reserve samples

Reserve samples are samples saved for short periods (days, months) that may be needed to repeat tests depending on the results of the plausibility analysis. The reserve samples are stored until the analysis has been finalised.

Archive samples

Archive samples are samples stored for long periods (decades) that may be needed for subsequent evaluations and comparisons, or to secure evidence.

Further literature

Bunge R., Bunge K., 1999, Probenahme auf Altlasten: Minimal notwendige Probenmasse, 3/99, Altlasten Spektrum, 174–179.

3.4.7 Site description

The site description contains the essential information for evaluation and interpretation purposes. Whilst part of this information will already have been obtained during the preliminary investigations *(☞ Chap. 3.2),* the rest is obtained during sampling. The additional information must be added to the sampling plan.

Among other items, the following must be recorded:

- ownership
- sketch of site
- climate and air pollution
- relief
- use and vegetation
- geology and hydrology
- Soil description (soil profile description; for criteria cf. *Annex 5-3*: *Soil profile description* additional monitoring form).

In addition to sampling details, the monitoring forms *(☞ Annex 5)* include certain details of the site. The notes on the monitoring forms *(☞ Chap. 8)* provide assistance in deciding on the required comprehensiveness and detail of the site description. In every monitoring, the site description must include the specified minimum of information (minimum data set).

4 Long-term and reference monitoring – NABO

4.1 Purpose and objectives

4.1.1 Long-term monitoring

With long-term monitoring – for example that in progress in the NABO monitoring network – the assessment of the changes in pollutant content with time are at the centre of interest. They comprise initial and subsequent sampling. The OIS distinguishes between continuous monitoring (NABO; Art. 3 Para. 1 OIS) and continuous observation (KABO; Art. 4 Para. 1 OIS).

4.1.2 Reference monitoring

Reference monitoring is used for site comparisons and are mostly carried out once only. It must meet the requirements for long-term monitoring and must therefore be very carefully documented.

4.2 Preliminary investigations

With long-term monitoring, sampling sites cannot be moved after initial sampling has taken place. The site must therefore be chosen based on carefully planned preliminary investigations *(☞ Chap. 3.2).* The main emphasis is on the acquisition of information for positioning the sampling points within the monitoring area. Site positioning is performed in two steps:

a. *Regional positioning*: the sampling sites are distributed over the monitoring area based on the purpose and objectives, without at this stage specifying their precise location. To do so, the criteria in *Tab. 6* are used.

b. *Local positioning*: each of the sampling sites is precisely defined with the aid of the criteria in *Tab. 7* together with field monitoring.

4.3 Monitoring requirements

For long-term monitoring, a distinction is made between

- monitoring requirements for initial sampling, and
- monitoring requirements for subsequent samplings.

The monitoring requirements are determined in accordance with the specific purpose and objectives *(☞ Chap. 3.3, Tab. 3).* Special attention must be paid to the required accuracy of site positioning to ensure reproducibility of the samples *(☞Chap. 6.10),* and to sample quantity *(☞Chap. 3.4.6).* With long-term monitoring, archive samples are used in

- determining non-investigated charactersistics at a later point in time, and
- performing comparative monitoring to quantify the influence of the analytics (including sample pretreatment).

Tab. 6: Criteria for the positioning of sampling sites for long-term and reference monitoring.

Aspect	Considerations	Sources
Geographical distribution	Representative distribution within the monitoring area (in accordance with the specified purpose)	Topographical maps 1:25 000, 1:50 000
Uses	Consideration of the different uses and intensities of use: - agriculture - forest - semi-natural open areas - residential areas	- maps - aerial photographs - land suitability maps - ecological impact statement according to the Ordinance relating to Direct Subsidies
Soil, geology, hydrology	- consideration of soil types and properties characteristic of the region - parent rock - hydraulic conditions	- land suitability maps - soil maps - soil databases - geological atlas 1:25 000 - geotechnical map 1:200 000 - national monitoring for the continuous monitoring of rivers (NADUF) - national network for the monitoring of groundwater quality (NAQUA)
Climate and air pollution	Consideration of the different climatic conditions and air-pollution situations	- air-pollution monitoring and measurement networks - biomonitoring (moss, lichens, etc.) - climate data
Pollutant content	- identification of pollutant paths - formulation of contamination hypotheses - consideration of the different contamination levels	- observation (cantons, colleges of higher education, research institutes, non-governmental organisations) - geogenic exceedance of guide values *(☞ Annex 3)* - register of contaminated sites and sources of emission - potential pollutants *(☞ Annex 2)*
Coordination	Coordination with the sites of other measurement networks	- National Air Pollution Monitoring Network (NABEL) - SMA-MeteoSwiss measurement network (ANETZ) - cantonal air-pollution measurement networks

In conjunction with this, the time intervals between initial and subsequent samplings, sample archiving *(☞ Chap. 7.2)* and data management must be planned and laid down. Where substance flow monitoring is intended, the content of the monitoring, i.e. the data to be acquired, must also be specified *(☞ Annex 4* for agricultural areas).

Tab. 7: Criteria for the local choice of sites for long-term and reference monitoring.

Aspect	Considerations	Sources
Soil	- soil structure that is representative and as homogeneous as possible - natural soil structure (particularly with long-term monitoring)	Soil maps
Relief	Influence of erosion (accumulation and loss situations)	- topographical maps - soil maps (according to Swiss soil classification system)
Long-term	Safeguarding future samplings	Interviews
Locatability	Subsequent sampling over the same area	- land register - interviews - fixed points (planimetry)
Owner, user	- making contact - information - assuring accessibility and readiness to tolerate monitoring	- land register - interviews
Land management	Influence on the substance fluxes in the sampling area	Interviews

4.4 Sampling plan

4.4.1 Sampling plan for initial sampling and reference monitoring

In formulating the sampling plan for the topsoil and subsoil *(☞ Chap. 3.4), Tab. 8* and *9* are provided as an aid to decision taking. With long-term monitoring, care must be taken that any standardisation procedures applied with the object of providing better reproducibility or comparability remain free of systematic errors.

4.4.2 Sampling plan for subsequent samplings

The sampling plan for subsequent samplings is prepared based on the monitoring requirements. To ensure comparability, sampling is performed in the same way as for the initial monitoring. Except where it is necessary to observe the depth migration of pollutants, no additional section analysis is normally performed. Should a soil profile description be required, the soil pit must either be dug at another point, or bore samples taken (i.e. for *both* the initial and subsequent monitoring).

Tab. 8: Aids to establishment of topsoil sampling plan.

Section (☞ *Chap. 3.4*)	**Long-term and reference monitoring**	**Long-term monitoring**
Sampling pattern	Positioning of sampling sites during preliminary investigation *(☞ Chap 4.2):* 1. regional positioning (particularly for continuous observations) 2. local positioning	
Sample types	3–4 area samples	3–4 area or line samples depending on contamination hypothesis
Obtaining composite samples	Area samples: stratified ad hoc distribution of single samples *(☞ Chap. 4.4.3, Fig. 5)*	- area samples: stratified ad hoc distribution of single samples - line samples: systematic distribution along a line (systematic intervals, *☞ Chap. 3.4.4)*
Sampling depths	- cultivated soils 0–20 cm - non-cultivated soils: 0–20 cm or, when necessary, 0–5 cm or 0–10 cm - forest: humus layer (without litter) and 0–20 cm or, when necessary, 0–5 cm or 0–10 cm	Based on purpose and objectives, at least 0–5 cm (to ensure reproducibility)
Sample quantities	Determination based on monitoring requirements *(☞ Chaps. 3.3* and *4.3)*	
Site description	Determination based on monitoring requirements *(☞ Chaps. 3.3* and *4.3).* Decision taking aids: monitoring forms and notes *(☞ Chap. 8* and *Annex 5)*	As for long-term monitoring, with additional observation to monitor land use

In subsequent sampling, the following additional aspects must be considered:

- critical assessment of the sampling plan based on the results of the initial monitoring
- checking of positioning information: checking of orientation and fixed points and, where necessary, their replacement *(☞ Chap. 6.10)*
- observation of changes: use, farming type, terrain, other relevant changes
- acquisition of data for substance flow analysis.

A further decision aid in preparing the sampling plan is provided by the *Supplementary sampling* monitoring form, together with the relevant notes *(☞ Chap. 8* and *Annex 5).*

Tab. 9: Aids to establishment of subsoil sampling plan.

Section (☞ *Chap. 3.4*)	Long-termand reference monitoring	Long-term monitoring
Sampling pattern	The subsoil is normally analysed from samples of soil pits , which should be taken 1-2 m away from the sampling site area.	
Sample types	- at least 1 soil pit sample per soil horizon should be analysed - 3–5 volume samples per horizon for determining bulk density *(☞ Chap. 3.4.3)* - further types of sample according to monitoring requirements (e.g. for scientific soil monitoring)	- minimum 1 soil pit sample per soil horizon / depth level - additional sample types in accordance with monitoring requirements (e.g. for physical soil monitoring)
Obtaining composite samples	*☞ Chap. 3.4.4*	
Sampling depths	Sampling of soil horizons (biogeochemical units)	Sampling of soil horizons or systematic sampling at fixed depth levels (e.g. monitoring of depth migration) according to purpose and objectives
Sample quantities	Determination based on monitoring requirements *(☞ Chaps. 3.4.6 and 4.3)*	
Site Description	Performance of a soil profile description; determination of data to be acquired based on the monitoring requirements *(☞ Chaps. 3.3* and *4.3)* and the notes *(☞ Chap. 8* and *Annex 5)*	

4.4.3 Obtaining composite samples with area sampling

For long-term monitoring, several composite samples are taken from a specified sampling area in order to determine the reproducibility of the site (total variability of sampling and analytics over the area). *Figure 5* shows the sampling pattern that has proved efficacious in soil monitoring (NABO; *SAEFL 2000e).* To obtain the composite samples, the (square) sampling area is divided into equal sub-areas. One or more randomly distributed samples may be taken from each sub-area *(☞ Chap. 3.4.2).* The composite samples are obtained by mixing one sample from each sub-area *(☞ Chap. 3.4.4).* Under ideal conditions, by taking four composite samples at once, changes in concentration over time can be determined – i.e. no overlapping of measurements – with an error probability of α = 2.9 % *(SAEFL 2000e).* An area of 10x10 m is recommended (NABO method). When sampling in the forest, it may prove necessary to choose a larger area (e.g. 20x20 m).

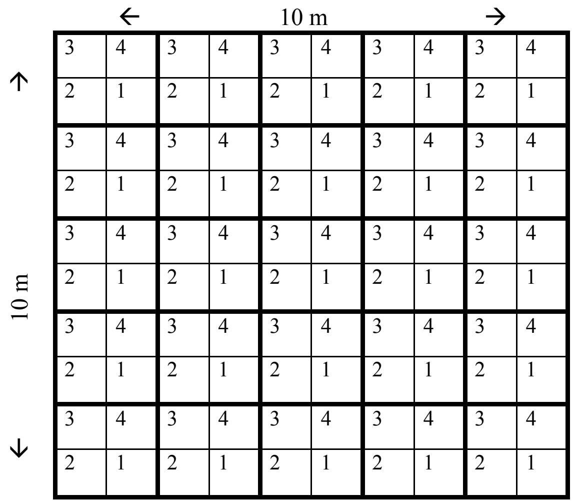


Fig. 5: Sampling pattern for long-term monitoring.

Further literature

Barth N. et al., 2000, Boden-Dauerbeobachtung: Einrichtung und Betrieb von Boden-Dauerbeobachtungsflächen, *in:* Rosenkranz D., Bachmann G., König W., Einsele G., Bodenschutz, Kennzahl 9152, Erich Schmidt Verlag, Berlin.

Bayerische Staatsministerien für Landesentwicklung und Umweltfragen und für Ernährung, Landwirtschaft und Forsten, 1990, Boden-Dauerbeobachtungsflächen in Bayern: Standortauswahl, Einrichtung, Probenahme, Analytik, 44 p., Munich.

Blum W.E.H. et al., 1996, Bodendauerbeobachtung, Österreichische Bodenkundliche Gesellschaft, Umweltbundesamt und Bundesministerium für Umwelt, Jugend und Familie, 101 p., Vienna.

SAEFL, 1993, NABO – Swiss Soil Monitoring Network: results of monitoring 1985–1991, Environmental Series no. 200 – Soil *(copies in German and French language only),* 134 p., Berne.

SAEFL, 2000e, NABO – Swiss Soil Monitoring Network: Veränderungen von Schadstoffgehalten nach 5 und 10 Jahren, Environmental Series no. 320 – Soil *(with a summary in English),* 129 p., Berne.

5 Delimitation of contaminated soils

5.1 Purpose and objectives

The following questions typically arise in setting the boundaries of contaminated areas:

- over what area is a regulatory value according to OIS exceeded (horizontal boundaries)?
- up to what depth is a regulatory value according to OIS exceeded (vertical boundary)?

Boundaries are typically set to achieve the following objectives:

- analysis of excavated soil for further use (Art. 7 OIS; *Guideline for Reuse of excavated Soils*; *SAEFL 2001a)*
- determination of the cause of contamination when the guide value is exceeded (Art. 8 OIS)
- setting the boundaries and analysis of areas in which the trigger or clean-up value is exceeded (Arts. 9 and 10 OIS; *Guideline for Risk Assessment of Polluted Soils; SAEFL).*

5.2 Preliminary investigations

5.2.1 Procedure

The preliminary investigations *(☞ Chap. 3.2)* are performed in steps as follows *(ASTM 1996, 1997):*

Documentation monitoring

- evaluation of aerial photographs, land register entries, historical and current maps, public and private archives
- consultation of the register of contaminated sites (Art. 5 OCS)
- evaluation of farm documentation (ground plans, evaluation of the farm opperations, process diagrams, delivery notes, storage documents, etc.)
- evaluation of official documents (authorisations and orders)
- evaluation of documentation from similar monitoring.

Field inspection

- checking the results of the documentation monitoring
- documentation of additional observations
- gaining a knowledge of the locality as an aid in preparing the sampling plan.

Interviews

Interviews serve to check and supplement the documentary monitoring. The interview partners comprise owners, farmers, present and previous residents and employees, and authorities (building and environmental authorities). The observations are documented and must be carefully scrutinised with regard to quality (relevance, reliability, trustworthiness).

5.2.2 Contamination hypothesis and hazards

The contamination hypothesis is formulated with the aid of the criteria given in *Tab. 2 (☞ Chap. 3.2.2)* and divided into two sections covering the topsoil and subsoil. *Tab. 11* shows typical contamination hypotheses based on these criteria. Where the contamination has occurred along different paths, the corresponding contamination hypotheses are formulated separately, since they can involve different procedures in the sampling plan.

To ensure effective sampling, possible hazards *(☞ Chap. 3.2)* must be considered. These can have various effects, and may influence the sampling depth *(☞ Chap. 5.4.4).*

5.3 Monitoring requirements

The monitoring requirements are determined based on the purpose and objectives, together with the contamination hypothesis *(☞ Chap. 3.3).* In establishing the boundaries, the following must be considered:

Resolution and accuracy

In general, the higher the contamination, the more serious are the consequences (regarding clean-up, disposal, etc.) and the higher is the required resolution (number of sampling sites), and the greater the required accuracy of the results (number of dual samples). Where heavily contaminated excavated soils are to be disposed of, it is worthwhile to invest additional time in the monitoring to reduce the quantity of disposed material and associated costs.

Methods of analysis

The methods for pretreatment, extraction and analysis must be chosen on the basis of the purpose and objectives *(Tab. 10).*

Tab. 10: Methods of analysis.

Purpose and objectives	Method	Source
Assessment of soil contamination according to OIS		
- determination of exceeded guide, trigger and clean-up values according to OIS - hazard assessment for trigger values exceeded - further use of excavated soil	Total and soluble content according to OIS	Sample pretreatment: *Chap. 7.1* Analysis: *Tab. 1*
Disposal of excavated soil		
Disposal of heavily contaminated excavated soil according to TOW	Eluate test, total content according to TOW	Methods of analysis for solid and aqueous samples from contaminated sites and excavated material *(SAEFL 2000b)*
Assessment of the need for monitoring and remediation of contaminated sites (Art. 8 OCS)		
Protected soil category (Art. 12 OCS, assessment according to OIS)	Total and soluble content according to OIS	Sample pretreatment: *Chap. 7.1* Analysis: *Tab. 1*

5.4 Sampling plan

5.4.1 Sampling pattern

Tab. 11 provides assistance in deciding on the sampling pattern *(☞ Chap. 3.4.2)* for typical contamination hypotheses. Where there are several hypotheses, these are unified as far as the purpose and objectives and the need to maintain the representativeness of samples will allow.

Delimitation of soil contamination using the two-value rule

Where the spatial delimitation is performed in stages, it is helpful to apply the two-value rule *(Lamé* and *Bosman 1994)*. In this method, the sampling sites are divided into square grids *(☞ Chap. 3.4.2)* having a width less than the resolution required *(☞ Chap. 5.3)*. Starting at the centre of the exposed area, samples are taken at increasing radial distances from the source until at least two neighbouring (circumferential) samples lie below the limiting contamination value *(Fig. 6)*. This procedure can also be used in a similar way to establish the vertical boundaries. Usually, the samples are taken in one operation for the entire grid, and the analysis then performed stepwise.

5.4.2 Sample types

Tab. 11 provides assistance in deciding on the types of sample for typical contamination hypotheses *(☞ Chap. 3.4.3)*.

5.4.3 Obtaining composite samples

Tab. 11 provides assistance in obtaining composite samples for typical contamination hypotheses *(☞ Chap. 3.4.4)*.

5.4.4 Sampling depth

The sampling depth *(☞ Chap. 3.4.5)* is determined in accordance with the purpose and objectives *(☞ Chap. 5.1):*

- **Sampling depths required to determine exceeded guide, trigger and clean-up values**

To determine whether the guide, trigger and clean-up values are exceeded, the sampling depths given in *Tab. 12* are used. These may be modified in justified cases (OIS: Annex 1 no. 2 and Annex 2 no. 2).

- **Hazard assessment in case of exceeded trigger values**

Where the trigger value is exceeded, the hazard to humans, animals or plants (protected categories) must be assessed for the uses involved (Art. 9 OIS). This is normally performed after setting the boundaries with the objective of determining the vertical pollutant distribution and assessing the contamination in each protected category *(Tab. 12)*. Sampling is performed at fixed depth levels, which should not be less than 5 cm to ensure reproducibility. The thicknesses of the levels and the maximum sampling depth are determined in accordance with the contamination hypothesis, contamination path and protected category. Reference is also made in this connection to the relevant *Guideline for Risk Asssessment of Polluted Soils (SAEFL)*.

Tab. 11: Aids to establishment of the sampling plan.

Contamination hypothesis for topsoil

Case	Examples	Horizontal boundaries	Horizontal dimensions	Contamination pattern	Contamination paths
A	- agricultural plot - vineyard plot	bounded	Restricted area: 100–10 000 m^2	- uniform - slight heterogeneity	Direct input, mainly from a single source or polluter
B	- household garden - warehouse areas, industrial precincts	bounded	Restricted area: 100–10 000 m^2	- non-uniform - very heterogeneous	Direct input from several sources/polluters
C	- roadside verges - high-tension pylons - steel bridges	unbounded	Restricted distances: 10–100 m	Distance dependent	Atmospheric pollution mainly from a single source
D	- waste incineration plants - metalworking industry	unbounded	Large distances: 100–10 000 m	Distance dependent	Atmospheric pollution mainly from a single source
E	- urban areas	unbounded	Large distances: 100–10 000 m	Diffuse	Atmospheric pollution from multiple sources; input of contaminated excavated material

Contamination hypothesis for subsoil / substratum

Case	Examples	Vertical boundaries	Vertical dimensions	Contamination pattern	Contamination paths
0	- agricultural plot - roadside verges - urban area	bounded	Topsoil only	Depth dependent	Direct or atmospheric input at the surface only
1	- site of accident - movement of contaminated soil	unbounded	Topsoil and subsoil	Depth dependent	Direct input to the soil and the substratum
2	- geochemical depth migration of pollutants	unbounded	Topsoil and subsoil	Dependent on horizon	Secondary contamination by migration of pollutants to the substratum

Sampling of topsoil

Case	Sampling pattern: distribution of sampling sites (☞ *Chap. 3.4.2)*	Sample types and obtaining composite samples (☞ *Chaps. 3.4.3 and 3.4.4)*
A	- 1 composite sample for the entire area - 1 composite sample from the reference area in the plot - stratification (for large areas or different uses in the same area)	- 1 area sample for the entire area: systematic distribution, stratified ad hoc or diagonal - 1 area sample for the reference area: systematic distribution, stratified ad hoc or diagonal
B	- systematic distribution - nested distribution	Multiple area samples: systematic distribution or stratified ad hoc
C	- judgmental distribution in accordance with the contamination hypothesis	Multiple line samples: systematic distribution along a line (regular intervals)
D	- judgmental distribution in accordance with the contamination hypothesis - systematic distribution - nested distribution	Multiple area samples on extensively used areas (exclusion of other sources of contamination): systematic distribution or stratified ad hoc
E	- systematic distribution - nested distribution	Multiple area samples: systematic distribution or stratified ad hoc

Sampling of subsoil / substratum

Case	Sampling pattern (☞ *Chap. 3.4.2)*	Sample types and obtaining composite samples (☞ *Chaps. 3.4.3 and 3.4.4)*
0	No monitoring required	
1	Selection of representative sampling sites based on the contamination hypothesis in conjunction with the results for horizontal contamination	Bore sample (inexact): - systematic or stratified ad hoc distribution of the borings over an area in conjunction with the area sample - sampling at fixed depth levels Soil pit sample (exact): - ad hoc composite sample taken over the entire soil profile - sampling at fixed depth levels
2	Selection of representative sampling sites based on the contamination hypothesis in conjunction with the results for horizontal contamination	Section sample: - sampling of soil horizons - separate sampling of the humus layer at forest sites

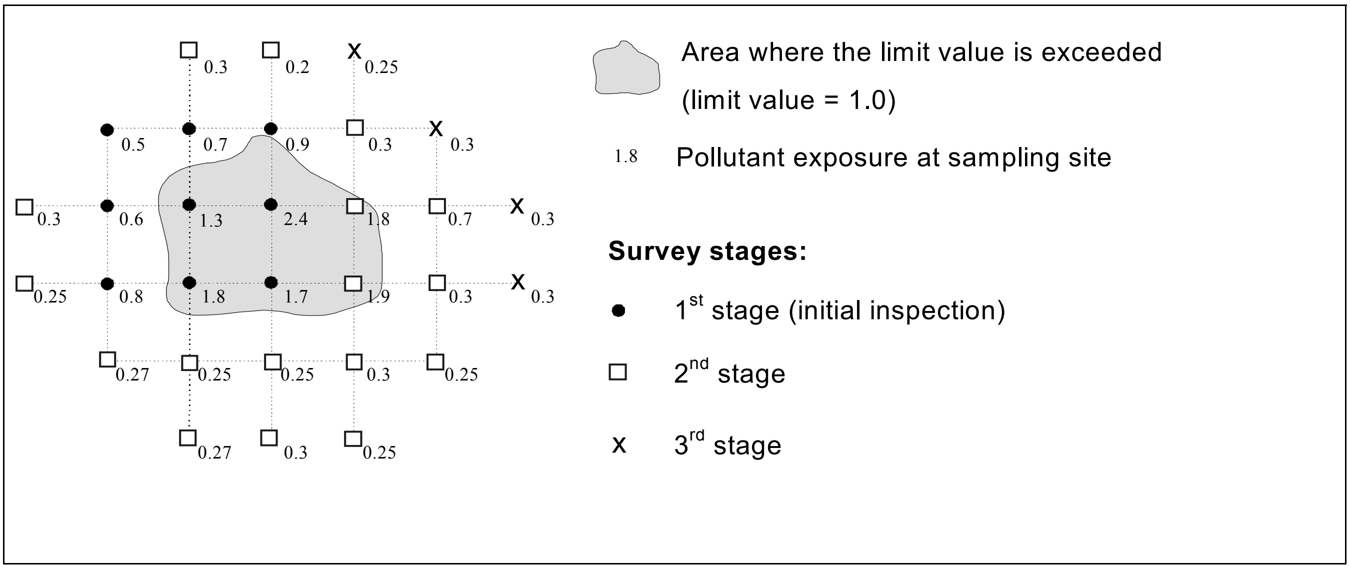


Fig. 6: Using the two-value rule for spatial delimitation.

- **Evaluation of excavated soil**

Where soil is excavated, this is normally done separately for topsoil ("humus") and subsoil. In sampling the topsoil, a sampling depth of 0–20 cm can be used provided that no appreciable gradient is expected at this level. For steeper gradients, the sampling depth must be chosen accordingly (0–5 cm, 5–20 cm, etc.). In this, any disposal costs arising, and the feasibility of stripping the topsoil, must be considered. To ensure correct analysis, the sampling depth must be chosen such that no mixing of contaminated and uncontaminated soil layers can occur (prohibition of mixing, cf. Art. 10 TOW).

5.4.5 Site description

The description of the site is performed as specified in *Chap. 3.4.7.* In sampling for the purposes of setting the boundaries, one or more of the following values must be recorded depending on the situation *(FAL 1997):*

- particle size distribution (tactile assessment)
- lime content (HCl test)
- pH value (quick test).

For the assessment of mobility and phyto-availability in organic pollutants, and for assessing the usability of excavated soil, the following data are required:

- extraneous material in the soil (building debris, wire, plastic, etc.)
- assessment of colour and odour (beware of harmful substances!).

5.4.6 Sample quantity

The necessary sample quantity is determined as given in *Chap. 3.4.6.*

Tab. 12: Sampling depths according to OIS (1998).

Regulatory value	Use	Sampling depth	Protected category	Relevance; pollution path
Guide value	–	0–20 cm	soil plants	Main root area: soil → plants
Trigger value	Plant cultivation for human consumption	0–20 cm	humans	Main root area: soil → plants → humans
	Fodder plant cultivation	0–20 cm	humans animals	Main root area: soil → plants → animals Topsoil layer: soil → animals
	Uses involving possible direct soil uptake	0–5 cm	humans animals	Topsoil layer: soil → humans soil → animals
Clean-up value	Agriculture and horticulture	0–20 cm	humans animals	Main root area: soil → plants → animals soil→ plants → humans Topsoil layer: soil → animals
	Household and family gardens	0–20 cm	humans	Main root area: soil → plants → humans Topsoil layer: soil → humans
	Children's playgrounds	0–5 cm	humans	Topsoil layer: soil → humans

Further literature

Bayerisches Staatsministerium für Landesentwicklung und Umweltfragen, 1997, Probenahme von Böden und Substraten zur Erfassung des Bodenzustandes und Untersuchung kontaminierter Standorte, Umwelt & Entwicklung Materialien, 77 p., no. 129.

SAEFL, 1994, Regional soil contamination surveying, A: technical note, B: case study, Environmental Series no. 25 – Soil, 70 p., Berne.

ISO, 1995a, Soil quality – Sampling, Part 1: Guidance on the design of sampling plans (ISO/DIS 10381-1), 44 p., German Institute for Standardization (DIN), Berlin.

ISO, 2002c, Soil quality – Sampling, Part 5: Guidance on the procedure for investigation of urban and industrial sites with regard to soil contamination (ISO/DIS 10381-5), 24 p., German Institute for Standardization (DIN), Berlin.

Sächsisches Landesamt für Umwelt und Geologie, 1998, Probenahme bei der Technischen Erkundung von Altlasten, Materialien zur Altlastenbehandlung no. 3, 87 p., Dresden.

6 Performance of sampling

6.1 Advising those concerned

There is a legal duty to provide information and to tolerate monitoring and observation (cf. Art. 46 LPE). It is, however, always preferable to advise those concerned (owners, tenants, farmers) of the intended monitoring in good time and to obtain their assent to the monitoring projects.

6.2 Safety precautions

Safety precautions should be taken to avoid accidents. The necessary precautionary measures are established from the preliminary investigations *(☞ Chaps. 3.2, 4.2, 5.2)* and the monitoring requirements *(☞ Chaps. 3.3, 4.3, 5.3).* The measures comprise:

- protection measures for hazardous pollutants (gloves, protective mask, goggles, overalls, etc., and not attempting to assess the smell of the samples)
- securing of trenches against collapse (bracing) and to prevent people falling in (fencing off)
- wearing a helmet when using machines
- wearing safety jackets in traffic areas.

Further literature

ISO, 2002b, Soil quality – Sampling, Part 3: Guidance on safety (ISO/DIS 10381-3), 49 p., German Institute for Standardization (DIN), Berlin.

6.3 Location of cables and piping, and authorisation

Location of cables and piping

Where machines are to be used, information must be obtained in advance whether piping (gas, water, wastewater and district heating), or cables (electricity, telephone, radio, TV, etc.) are present. Cables (particularly those for telephone, radio and TV) may lie close to the surface. It is recommended to document the information obtained, and to obtain written authorisation to begin sampling from the commissioning organisation. A cable detector may be used at the site: note, however, that this cannot detect all materials (e.g. glass fibre cables).

Authorisation

For comprehensive observation, official authorisation must be obtained (e.g. for borings, *Art. 32 Water Protection Ordinance).* Where sampling may affect groundwater in Protection Area A, the cantonal water protection agency should be contacted.

6.4 Personnel

Sampling should be performed only by trained personnel. The personnel should be aware of the purpose and objectives, the sampling plan and the procedure for choosing alternative sites *(☞ Chap. 3.4.2).* The person in charge must have a knowledge of soil science.

6.5 Sampling times and sequence

Farming

Grasslands are most easily accessible following mowing. With arable land, the most suitable time for sampling is after the harvest, and before tilling in preparation for sowing. At these times, the soil is compact, and the ground is of uniform density. Sampling should be avoided after ploughing, since then the soil is loose (leading to incomplete samples) and uneven (hindrance to depth measurement). The time between applications of auxiliary substancess (fertilisers, pesticides) should be as long as possible.

Time of year

Whereas the soluble fraction of inorganic pollutants fluctuates with the season, particularly due to changes in the pH value (in connection with soil moisture and vegetation), the total content is normally independent of time of sampling.

Weather

Sampling should not be done in bad weather (snow, rain, cold periods), since the risk of soiling is higher, experience having shown that sampling is then done with less care. Soil samples are best obtained when the soil is slightly moist. Under these conditions, the sampling device penetrates the soil more easily, and approximately the same volume is obtained for each increment (necessary to ensure representativeness). With excessively dry soils, this is not necessarily the case. With long-term monitoring, samples should be taken under similar weather conditions.

Where heavy machines are used, the topsoil and subsoil should be dry (to avoid compaction).

Sequence

Samples should be taken first at points where the soil is assumed to be less contaminated. In this way, contamination through carrying over of material can be largely avoided. For the same reason, soil pit samples should be taken from below to above.

6.6 Sample quantity

The required sample quantities are recorded in the sampling plan, and must be ensured by taking sufficient single samples, and through choice of suitable devices. Excess material should never be discarded in the field, as then the representativeness of the samples is lost. The rejection of excess material is done under controlled conditions in the laboratory. Should insufficient material have been sampled, the procedure must be repeated.

6.7 Sampling devices

The choice of sampling devices depends on the quantity required, the sampling depth, the number of single samples, the diameter of the device, the rock fragment content of the soil and the risk of contamination. *Tab. 13* shows the principal sampling devices and their suitability for particular purposes.

Tab. 13: Suitability of sampling devices and possible problems.

Sampling device	Suitability (☞ *Chap. 3.4.3)*
Half core auger with core ejector (gouge or grooved sampler)	- suitable for routine purposes and a broad range of soil characteristics - area and line samples of mineral topsoils of 5-30 cm thickness - borings up to about 120 cm (Pürckhauer borer) - very robust and suitable for soils containing rock fragments - where division into different depth levels required, depth measurement imprecise and risk of cross-contamination and compaction, particularly in clay-rich soils and those containing rock fragments - dry and sandy material falls out of the borer, particularly if the diameter is too large - not suitable for organic soils
Core borer (Humax, folding borer)	- disturbed volume samples up to 30 cm in soils largely free of rock fragments - tendency to compact in clayey soils - of limited use in organic soils
Hand auger	- qualitative soil assessment - hardly suited for sampling to determine pollutant content (inexact depth definition and sample quantity) - Edelmann borer: sandy to clayey soils, those containing rock fragments, low penetration resistance - Riverside borer: hard, encrusted, soils and those containing fine gravel, low risk of cross-contamination - gravel borer: gravel-rich soils
Cutting frame	- humus including litter - undisturbed volume samples of thin soil layers and horizons of <5 cm in the topsoil (not very accurate) - not suited for composite samples
Cutting cylinder	- undisturbed volume samples - less suited for soils with high rock fragment content
Spatula	- soil pit samples - less suited for soils with high rock fragment content

Diameter of the sampling devices and soil properties

The suitability with regard to rock fragment content, penetration resistance and sample quantity depends intimately on the diameter of the sampling device. For optimum sampling, the soil moisture should be as uniform as possible. Dry, clay-rich, soils are very hard, and dry, sandy, material easily falls out of the borer. Conversely, wet soils compact and smear if they are rich in clay; they flow if they are sandy. For organic soils and humus (A_o horizon), devices with good cutting properties and large sampling volume are required *(☞ Chap. 6.8)*.

Avoidance of contamination

The sampling devices must be robust and must not contaminate the samples. This condition is fulfilled by devices in iron or mild steel *(Desaules 1989)*. However, high-tensile alloy steels should not be used. Also, they should not be chromium plated, nickel plated or painted. Any existing protection (e.g. oil) or oxidation (rust) films must be completely removed before use. Prior to sampling proper, several increments are taken and the resulting material discarded. If machines are used (excavator, rotating auger), care should be taken to ensure that no lubricants, fuels or exhaust gases contaminate the samples. Methods for detecting contamination comprise material analyses *(Desaules 1989)* and analyses of rinsing residues *(Black 1988).*

Further literature

ISO, 2002a, Soil quality – Sampling, Part 2: Guidance on sampling techniques (ISO/DIS 10381-2), 48 p., German Institute for Standardization (DIN), Berlin.

6.8 Taking volume samples

In pollutant observation, volume samples are required to determine the bulk density to convert the data from weight (mg/kg) to volume (mg/dm^3) units for soils with over 15 % humus (OIS 1998, Annex 1). Since the bulk density often varies greatly, a minimum of five samples per site and depth level (or horizon) are required.

Volumetric sampling of topsoil

Taking volume samples causes substantial disturbance of the topsoil, since the sample volumes are very large. With long-term monitoring *(☞ Chap. 4),* this is not advisable. Therefore volume samples must not be taken directly in areas reserved for long-term monitoring. Instead, they must be taken immediately adjacent. As an exception, if only one sampling is to be carried out, this may be done within the reserved area.

Volumetric sampling of subsoil

For the same reasons as above, volume samples of subsoil are taken from soil pits after the other samples have been obtained.

6.9 Monitoring forms

Monitoring forms are used to record the data required for evaluation and interpretation, for quality assurance *(☞ Chap. 2)* and to ensure comparability with other monitoring or observation. The following monitoring forms are presented in *Annex 5:*

- *Sampling* monitoring form
- *Sample pretreatment* monitoring form
- *Soil profile description* additional monitoring form
- *Subsequent sampling* additional monitoring form
- *Agriculture* additional monitoring form
- *Forestry* additional monitoring form.

Notes on the monitoring forms are contained in *Chap. 8.* Each of the monitoring forms contains a minimum data set in **bold type.** The minimum data set is absolutely essential to ensure a professionally correct procedure and for comparison purposes. Beyond that, the necessary data extent and degree of detail depend on the monitoring requirements and on those of the sampling plan.

6.10 Surveying the sampling site

Surveying of the sampling site *(Fig. 7)* must be done with the utmost precision to fulfil the monitoring requirements *(☞ Tab. 3, Chap. 3.3).* This involves the following:

- *an orientation point*, i.e. point that can be located on the national monitoring map 1:25 000 (e.g. road crossing, house, etc.) with its coordinates
- *at least three fixed points*, i.e. long-term immovable points (e.g. boundary-stones, masts, and corners of buildings, to avoid the risk of their being lost) that may easily be located in the field, are independent of one another, and are if possible within 50 m from the site (= length of tape measure)
- *reference point*, i.e. corner or middle of the sampling area
- *orientation*, i.e. direction of the sampling area measured with compass (inaccurate) or better, small theodolite.

Using a tape measure, the area may be measured out to ±0.5 m, provided that the angles between the fixed points and the reference point are not too acute (or too obtuse). The details are taken down in a sketch in the S*ampling* monitoring form.

As an additional measure where precise relocation of a point is necessary (e.g. for long-term monitoring), magnets or iron pipes can be buried at the corners of the sampling area at a depth of at least 60 cm (to give sufficient clearance from ploughing, ground frost, etc.). These points may then be relocated using electronic detectors. However, magnets must not be used at the reference point itself, since the magnetic field could distort the compass reading.

In many places, GPS systems provide adequate precision (especially with the SWIPOS system, current information on which may be obtained from the *Federal Office of Topography – swisstopo).*

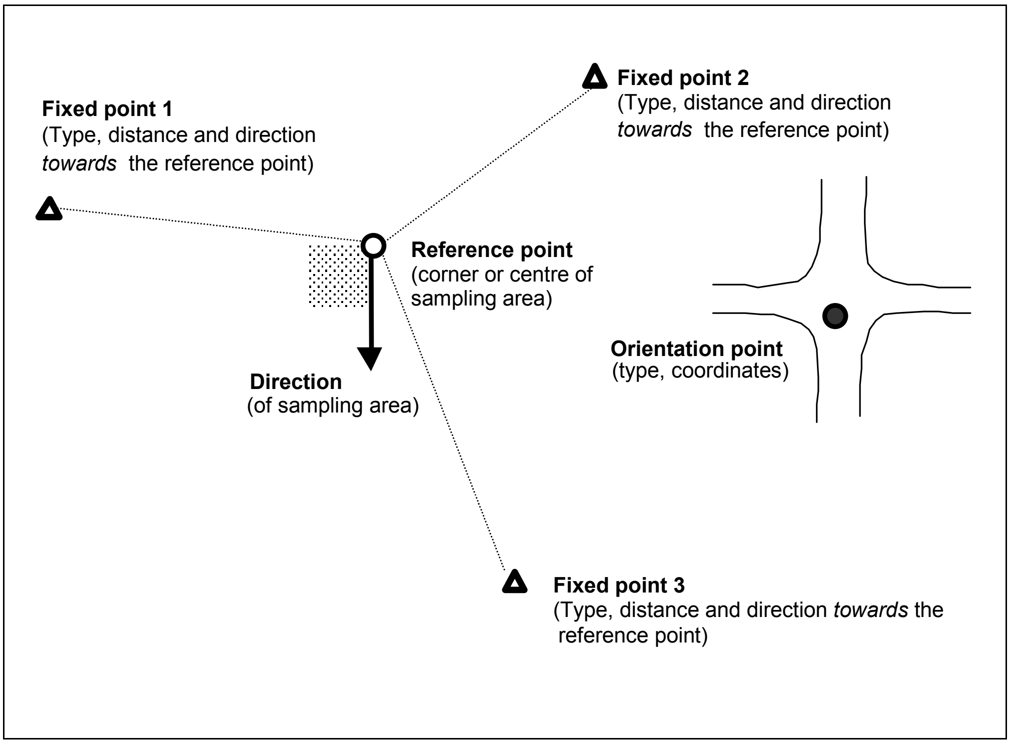


Fig. 7: Surveying the sampling site.

6.11 Packing, labelling and transport of samples

Packing

The containers must be such so that no sorption of pollutants can occur in and on the walls of the container, and the samples cannot be contaminated by substances contained in the packing materials. Checks of contamination are made by means of blind samples *(Black 1988).* The containers must not be reused.

For inorganic pollutants, plastic containers or plastic bags can be used. This also applies to routine monitoring of PAH and PCB *(Desaules* and *Dahinden 2000).* The void spaces must be kept as small as possible. Plastic bags are best protected by a second bag, thereby avoiding damage to the inner bag.

With dioxins and other organic pollutants (excepting routine monitoring of PAH and PCB), glass containers with stoppers free of plastics should be used.

Labelling

Immediately after filling, the samples must be clearly, unmistakably and indelibly labelled directly on the container. The labelling must be done so that the samples can be clearly identified. The following data are essential:

- project (name, identification number)
- sample (identification number)
- date.

These data must also be entered together with other data in the *Sampling* monitoring form to ensure that the origin of the sample can always be determined. Where two-part containers are used, both parts should at least carry the sample number. This is necessary to avoid inadvertent misplacement of the covers. This information should be stated on the delivery note addressed to the analysing laboratory, together with details of any accompanying reserve or archive samples.

Transport

The samples must be delivered to the laboratory within two days at the latest, and must there be dried immediately *(☞ Chap. 7.1).* Samples to be analysed for organic pollutants should, if possible, be refrigerated during transport. If not, their temperature should at all times be kept below 30 °C. Undisturbed samples must be maintained free of vibration during transport.

Laboratory deliveries must be accompanied by a delivery note or order containing the following data:

- project (name, identification number)
- samples delivered (sample identification)
- analysis programme in accordance with monitoring requirements *(☞ Chap. 3.3)*
- brief details of the purpose and objectives of the monitoring or observation
- date and signature.

This procedure ensures the traceability of the samples, and enables the laboratory personnel to perform sample pretreatment and analysis in accordance with the purpose and objectives.

7 Sample pretreatment and archiving

7.1 Sample pretreatment

There is an acute risk of contamination during sample pretreatment. Contamination can occur through carrying over of sample material containing pollutants, soiled devices, dirty hands, dust from samples and the use of unsuitable materials for the devices (owing to the high mechanical strain). For organic pollutants, blanck quartz sand samples, and for inorganic pollutants, samples of known content, are used to accompany the soil samples to demonstrate their freedom from contamination *(Black 1988).*

Arrival of samples at the laboratory

1. On arrival at the laboratory, the samples are checked against the delivery note, and their suitability for the intended analyses checked.

2. The weight of the wet field samples ("gross field weight") is determined as an aid in interpreting the results.

Temporary storage of the fresh field samples should be avoided whenever possible. Storage can influence the results of the analysis (e.g. through microbial action). If temporary storage is unavoidable, the following criteria must be observed:

- hermetically sealed containers
- maximum storage duration: 10 days
- maximum storage temperature: +4 °C.

Drying

3. After arrival at the laboratory, each sample must be dried in its entirety at 40 °C until its weight remains constant. Drying should be done quickly, and if possible within two days. This requires that the samples be spread out in thin layers.

Clay-rich samples should be broken up by hand during drying, whereby care must be taken to avoid material being carried over between samples. Owing to the high volatility of mercury (Hg), the content is very sensitive to drying time *(Schwab et al. 2002).*

4. The dried samples are weighed (gross dry weight, water content) to enable the results of the analysis to be converted *(☞ step* ***12).***

Temporary storage following drying

5. Where further pretreatment is to be carried out later, the samples may be temporarily stored under the following conditions:
   - containers covered and unmistakably marked (avoidance of contamination by dust, and to avoid any possibility of their being mixed-up)
   - maximum storage temperature +20 °C (inhibition of microbial action).

Crushing

6. As far as possible, stones, organic constituents (plant residues) and other extraneous material (e.g. building debris) must be removed from the fully dried samples by hand, and set aside for subsequent weighing *(☞ step **9**)*. Where extraneous material arises, this must be recorded in the *Sample pretreatment* monitoring form.

7. The samples are usually crushed (and not milled), since this can appreciably influence the content of the soluble pollutants *(Houba et al. 1993)*. Crushing can be done with mortars, rollers, jaw crushers or other tools.

The risk of contamination is greatest at this stage of the procedure owing to the high mechanical strain. The risk of contamination can be reduced by choosing materials that are appropriate to the characteristics to be determined in the analysis. Following each crushing operation, the tools used must be cleaned to avoid material being carryied over.

Sieving

8. Following crushing, the sample is sieved using a 2 mm mesh sieve.

9. Following sieving, the fine earth (fraction <2 mm) and the sieving residue, together with the extraneous material from hand sorting, are weighed. This enables any loss in weight of the samples to be determined *(☞ step **6**)*.

For routine monitoring, the material of which the sieve is made is not decisive, since the sampling procedure and the crushing operation themselves present a substantially greater risk of contamination. However, for special monitoring (e.g. trace analyses of pollutants and highly sorbent substances), the material must be chosen accordingly.

Note that since the subsequent steps, and the analysis itself, are performed on the fine earth, the results apply only to this fraction called fine earth.

Milling

Soil samples are fine milled only if they contain contaminants in particulate form (e.g. bullets), and when the total content is to be determined. The total content is not significantly affected by milling *(Houba et al. 1993)*.

Splitting

10. Following sieving, the samples are splitted into representative sub-samples, from which the laboratory samples, the reserve samples and – where necessary – the archive samples are taken *(☞ Chap. 3.4.6)*.

Splitting must be performed so that every sub-sample has the same pollutant content as the original sample *(☞ Chap. 2.2)*. This is only possible when the sample is pourable, i.e. has been dried, crushed and sieved. For the fine earth <2 mm, samples of 5 g are usually "representative" *(Houba et al. 1993)*. This does not apply to samples with particulate contaminants (e.g. shrapnel from projectiles). With clay-rich samples, dust formation must be prevented to avoid loss of weight and contamination. Splitting may be performed with the following tools: riffle splitter, rotary splitter and laboratory splitter. Alternatively, the coning and quartering procedure may be used. To obtain a representative sub-sample, the splitting procedure must be applied repeatedly until the quantity necessary for the analysis has been obtained.

Determination of dry matter

11. To determine the dry matter (DM), a representative sub-sample is weighed (at 40 °C) and then further dried at a temperature of 105 °C until the weight remains constant (weight at 105 °C).

12. The pollutant content at 40 °C is converted to 105 °C using the following formula:

$$\text{Pollutant content}_{T=105\,^\circ C}\left[\text{mg/kg DM}\right] = \frac{\text{weight}_{T=40\,^\circ C}\left[\text{g}\right]\cdot \text{result of analysis}_{T=40\,^\circ C}\left[\text{mg/kg}\right]}{\text{weight}_{T=105\,^\circ C}\left[\text{g}\right]}$$

13. For soils containing more than 15 % humus, the pollutant content must be converted to volumetric units, and the bulk density must be converted to T = 105 °C:

$$\text{Pollutant content}_{\text{Volumen}}\left[\text{mg/dm}^3\right] = \text{pollutant content}_{T=105\,^\circ C}\left[\text{mg/kg DM}\right]\cdot \text{dry bulk density}_{T=105\,^\circ C}\left[\text{kg/dm}^3\right]$$

7.2 Sample archiving

7.2.1 Archive samples

The archive samples must be dry. The containers must be clean, hermetically sealed and unmistakably and durably labelled.

7.2.2 Storage conditions

The compartment used for the long-term storage of samples containing inorganic pollutants must be dry and dark, with minimum temperature and moisture fluctuations. The storage temperature must not exceed +20 °C. For long-term monitoring, archive samples for the analysis of persistent organic pollutants must not be stored at temperatures exceeding –20 °C, since otherwise volatilisation cannot be excluded.

Further literature

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8 Notes on the monitoring forms

The following monitoring forms are contained in *Annex 5*:

- ***Sampling* monitoring form** *(Annex 5-1)* – the basic *Sampling* monitoring form.
- ***Sample pretreatment* monitoring form** *(Annex 5-2)* for the documentation of sample pretreatment.
- ***Soil profile description* additional monitoring form** *(Annex 5-3)* for the pedological description of soil structure and the documentation of soil pit samples.
- ***Subsequent sampling* additional monitoring form** *(Annex 5-4)* for sampling documentation for long-term monitoring.
- ***Agriculture* additional monitoring form** *(Annex 5-5)* for recording the operational data of agricultural sites.
- ***Forestry* additional monitoring form** *(Annex 5-6)* for recording the operational data of forestry sites.

For each monitoring form, notes are made on which, how and why data is to be taken. To do so, reference is made to the corresponding information in this manual.

The individual text items in the monitoring forms are provided with numbers referring to the sections in the manual. The minimum data set marked in **bold type** in the monitoring forms must always be taken, since it contains the basic information and is essential for comparison purposes. The monitoring forms must be filled out legibly, and be suitable for copying. The additional monitoring forms – even if they have not been filled out – must always be included with the *Sampling* monitoring form.

Sampling monitoring form (Annex 5-1)

1 Identification

Which?	How?	Why?
11 Project	**Designation or no. of project and site/plot, date, name of sampler responsible (company, address, telephone number)**	- Documentation *(☞ Chap. 2.2)* - Traceability *(☞ Chap. 2.2)*
12 Location	**Municipality, place, canton, name of field, coordinates (X, Y, tolerance), altitude, national monitoring map number, and register number**	- Relocation of site
13 Contacts	**Owner, farmer (company, contact person, address, telefone),** others concerned	- Inquiries - Traceability (name of sampler responsible)
14 Contamination hypothesis	**Pollutant input paths, geographical extent, boundaries, contamination pattern**	- Influence of contamination hypothesis *(☞ Chap. 3.2)* on sampling plan
15 Additional monitoring forms	List of relevant additional monitoring forms	- Reference to more extensive investigations - Establishment of relationship to *Sampling* monitoring form (traceability)
16 Subsequent monitoring	Intended/not intended	- List of monitoring that have either been performed, are more extensive or are intended *(☞ Subsequent sampling* additional monitoring form)

Bold type: minimum data set

2 Location of sampling site

Which?	How?	Why?
21 Sketch of site	**Sampling site (sampling area, borings, soil pits), reference point, fixed points, photos**	- Sufficiently accurate relocation of sampling site *(☞ Chap. 6.10)*
22 Legend	**Map symbols, reference point, fixed points**	
23 Additional information	Description	- Listing of further information for relocation purposes (e.g. magnets)

Bold type: minimum data set

3 Sampling and sample transport

Which?	How?	Why?
31 Sampling pattern	**Sketch**	- Traceability - Obtaining of composite samples (☞ *Chap. 3.4.4)*
32 Legend	Map symbols	
33 Weather during sampling	Dry, rain, snow, duration (for how many days)	- Assessment of sampling quality (☞ *Chap. 6.5)*
34 Soil condition	Dry, moist, wet, frozen	- Assessment of sampling quality (☞ *Chap. 6.5)*
35 Safety precautions	Yes, no. If yes: which?	- Documentation of safety precautions taken if these are necessary (☞ *Chap. 6.2)*
36 Additional information	Description	- Provision of more extensive information for sampling (e.g. "sampling pattern could not be consistently applied owing to high penetration resistance")
37 Sample transport	Refrigerated/not refrigerated, transport duration (days)	- Sample stability

Bold type: minimum data set

4 Use and vegetation

Which?	How?	Why?
41 Present use Duration of use	**Agriculture:** **permanent grassland, pasture, Alpine pasture, arable farming, viniculture, horticulture, orchard, others (which?)** Road distance from farm **Forest:** **Conifers, deciduous forest, mixed forest, others (which?)** **Residential area:** **household garden, family garden, children's playground, others (e.g. leisure park)** **Others (e.g. unused industrial land)** Since (year), duration (years)	- Land use is a significant criterion in assessing pollutant input and possible hazards to humans, animals and plants - Farming intensity (e.g. farmyard plot) - Agriculture and forestry: for more extensive observation (e.g. determination of the influence of the type of farming on pollutant content), the following are used: ☞*Agriculture* additional monitoring form ☞*Forestry* additional monitoring form - Forest, forest fringe: reference to pollutant filtering effect - Residential area: classification depends on the relevance of the trigger and clean-up values. Uses other than those listed here must be mentioned (e.g. unused industrial land, road or railway embankment) - Estimate of percentage soil contamination
42 Earlier uses	Use/s from .... to (year); duration eight years	- Influence of earlier uses on soil contamination
43 Soil cover	**Vegetation and percentage cover (%), humus cover (cm)**	- Assessment of current use - Reference to possible damage from pollutants (plant growth, inhibited humus decomposition)

44 Additional information	Description	- Provision of more extensive information on use and vegetation (e.g. *"previous use mentioned in report of 23 June 2001 on Historical monitoring of company …….. precinct")*

Bold type: minimum data set

5 Climate and air pollution

Which?	How?	Why?
51 Type of site	**Countryside, urban area, city, nearby road, nearby industry, Alpine**	- Assessment of atmospheric inputs (qualitative assessment of background contamination)
52 Emitters	Listing of sources of atmospheric emission (*Annex 2*) relevant to the sampling site (direction <u>towards</u> the site, distance, elevation difference, obstacles)	- Assessment of local and regional atmospheric inputs
53 Climate and exposition	Annual precipitation (mm/year), principal wind directions, exposed/ sheltered	- Assessment of atmospheric inputs - Hydrological assessment of site (influence on soil and soil formation)
54 Additional information	Description	- Provision of more extensive information on the climate and air pollution (e.g. *"continuous air pollution measurement by cantonal weather station, 100 m south-west, coordinates 635.420/-289.150")*

Bold type: minimum data set

6 Relief

Which?	How?	Why?
61 Landform	**Plateau/terrace/plain, valley floor/valley hollow, hillock/-ridge/rib/wall, slope, foot slope, channel, alluvial fan/debris cone**	- Assessment of input/output through erosion
62 Situation and exposition	**Loss conditions, accumulation conditions, equilibrium, slope (%), exposition (direction)**	- Assessment of input/output through erosion - Assessment of wind effects on atmospheric inputs
63 Additional information	Description	- Provision of more extensive information on the relief (e.g. *"artificial railway embankment, coordinates 635.420/-289.150")*

Bold type: minimum data set

7 Geology and hydrology

Which?	How?	Why?
71 Geology	**Parent rock: rock type and classification (using geological maps, determination by expert), lime content?**	- Assessment of basic geogenic content *(☞ Annex 3)*
72 Hydrology	Groundwater level, floodplain, karst area (using groundwater maps)	- Assessment of possible groundwater hazards
73 Additional information	Description	- Provision of more extensive information on the geology and hydrology (e.g. *"area known to be subject to geogenic cadmium pollution")*

Bold type: minimum data set

8 Sample data

Which?	How?	Why?
81 Sample designation	**Designation or number resp.**	- Traceability - Precautions against confusing identity
82 Soil horizon	*FAL* classification *(2002) / BGS (2002)*	- Traceability - Relevant to scientific soil monitoring (relationship between soil horizon and sampling depth)
83 Sampling depth	**Depth from ... to ... (cm), with/ without humus cover (cm)**	- Traceability, performance according to sampling plan - Definition of fiducial level (0 cm) *(☞ Chap. 3.4.5)* - Assessment and interpretation
84 Sample type	**Area sample, line sample, soil pit sample, bore sample, volume sample**	- Traceability, performance according to sampling plan *(☞ Chap. 3.4)* - Assessment and interpretation
85 Number of single samples	**Number**	- Traceability, obtaining composite samples *(☞ Chap. 3.4.4)* - Assessment of representativeness
86 Sampling devices	**Auger type (Gouge, Edelmann, Riverside, Humax, others; diameter**	- Traceability - Quality assurance: employment of suitable sampling device *(☞ Chap. 6.7)*
87 Packing	**Plastic, aluminium foil, glass, others**	- Assessment of risk of contamination *(☞ Chap. 6.11)*
88 Soil characteristics	Humus (type and content), lime, granulate size distribution, rock fragment content	- On-site sample assessment with respect to subsequent evaluation and interpretation of analysis results (e.g. outlier values)

Which?	How?	Why?
89 Condition of sample	**Moisture, integrity**	- Influence of moisture on sample integrity (e.g. in "Pürckhauer") - Influence of sampling device *(☞ Chap. 6.7)* - Assessment of sample quality with respect to subsequent evaluation and interpretation of analysis results (e.g. outlier values)
810 Additional information		- Provision of more extensive information on the samples (e.g. extraneous material)
811 Legend		- Information on filling out

Bold type: minimum data set

9 Date and signature

Which?	How?	Why?
91 Date and signature	**By person responsible**	- Quality assurance *(☞ Chap. 2.2)*

Bold type: minimum data set

Sample pretreatment monitoring form (Annex 5-2)

Always accompanies ***Sampling*** monitoring form *(Annex 5-1)* and ***Subsequent sampling*** additional monitoring form *(Annex 5-4)*.

1 Identification

Which?	How?	Why?
11 Project	**Designation or no. of project and site/plot, date of sampling, name of sampler responsible**	- Documentation (quality assurance ☞ *Chap. 2.2)* - Traceability (quality assurance ☞ *Chap. 2.2)*
12 Person responsible	**Name, dates (delivery of samples, begin and end of pretreatment)**	

Bold type: minimum data set

2 Pretreatment

Which?	How?	Why?
21 Sample designation	**Number according to delivery note and *Sampling* monitoring form**	- Quality assurance *(☞ Chap. 2.2)*
22 gross weight (wet)	Weight of fresh field samples	- Interpretation of results
23 gross weight (dry)	Weight of dry samples	- Interpretation of results
24 Tare	Weight of drying container	- Interpretation of results
25 Water content (g)	Difference between gross weight wet and dry	- Interpretation of results
26 Water content (%)	Percentage weight of water	- Interpretation of results
27 Drying temperature	**Specification of drying temperature**	- Conformity with regulations on sampling pretreatment *(☞ Chap. 7)*
28 Drying time	Duration of drying process	- Quality assurance *(☞ Chap. 2.2 and 7)*
29 Duration of temporary storage	Duration of temporary storage (if any) prior to sampling pretreatment	- Quality assurance *(☞ Chap. 2.2 and 7)*
210 Crushing	**Crushing equipment (material)**	- Assessment of contamination risk
211 Sieving mesh diameter	Mesh diameter in mm	- Conformity with regulations on sampling pretreatment *(☞ Chap. 7)*
212 Screen material	Specification of material	- Assessment of contamination risk
213 Weight of sieving residue	Specification of weight of sieving residue including manual sorting	- Interpretation of results (e.g. concerning rock fragment content)
214 Weight of fine earth	**Specification of weight of fine earth (<2 mm)**	- Interpretation of measured content (percentage fine earth)
215 Number of portions	**Number of portions obtained by sample separation**	- Quality assurance *(☞ Chap. 2.2)*

Which?	How?	Why?
216 Splitting method	**Riffle splitter open, closed, coning and quartering, rotary splitter, etc.**	- Assessment of representativeness (source of error) and contamination risk
217 Container	**Container type and material**	- Assessment of contamination risk
218 Remarks	Further details	Legend

Bold type: minimum data set

3 Date and signature

Which?	How?	Why?
31 Date and signature	**By person responsible**	- Quality assurance *(☞ Chap. 2.2)*

Bold type: minimum data set

Soil profile description additional monitoring form (Annex 5-3)

For recording the additional scientific soil data for the ***Sampling*** monitoring form *(Annex 5-1).*

Soil profile description for agricultural soils according to *FAL (1997),* for forest soils according to *SAEFL (1996b)* and for soil classification according to *FAL (2002)* and *BGS (2002).*

1 Identification

The principal data for the identification and localisation of the site (site sketch) should be entered in the ***Sampling*** monitoring form.

Which?	How?	Why?
11 Project	**Designation or no. of project and site/plot, date of sampling, name of sampler responsible (company, name, address)**	- Quality assurance *(Chap. ☞ 2.2)*
12 Location	**Reference to *Sampling* monitoring form**	- Traceability: this data is recorded in the *Sampling* monitoring form.
13 Situation/site sketch	**Reference to *Sampling* monitoring form**	- Traceability: this data is recorded in the *Sampling* monitoring form.

Bold type: minimum data set

2 Topography and geology of the soil profile

Which?	How?	Why?
21 Transect	Sketch of topography, geology (vertical section)	- Assessment of basic geogenic content and pedogenesis *(☞ Annex 3)*

3 Soil classification

Which?	How?	Why?
31 Soil classification	**Soil type, sub-type, classification according to** *FAL (2002) / BGS (2002)*	- Assessment of pedogenesis, vertical pollutant distribution, bio-geochemical processes, risk assessment (potential movement of pollutants) - Uniform classification in Switzerland

Bold type: minimum data set

4 Soil profile

Instructions for the preparation of a soil profile sketch are contained in the publication *Mapping and Assessment of Agricultural Soils (FAL 1997);* for legend see reverse of ***Soil profile description*** monitoring form).

Which?	How?	Why?
41 Soil profile sketch	- **Horizons, depth in cm (horizontal boundaries), symbols (according to legend)** - **Soil profile sketch with symbols** - **Soil profile description: structure, voids, density, soil type, humus, rock fragment content, lime test, pH *("Hellige")*, hydromorphy, colour according to Munsell (cf. legend)** - **Comments/sample numbers**	- Soil classification, assessment of natural pollutant content and distribution - Details of soil classification, assessment of natural pollutant content and distribution, anomalies (e.g. extraneous material)
42 Legend	Standard map symbols	- Documentation, traceability - Additionally, the samples are recorded in the *Sampling* monitoring form no. 8

Bold type: minimum data set

5 Date and signature

Which?	How?	Why?
51 Date and signature	**By person responsible**	- Quality assurance (documentation and responsibility)

Bold type: minimum data set

Subsequent sampling monitoring form (Annex 5-4)

For recording subsequent samplings in long-term monitoring. The initial sampling is recorded in the ***Sampling*** monitoring form *(Annex 5-1)*.

1 Identification

Which?	How?	Why?
11 Project	**Designation of project and site/ plot, date, name of sampler**	- Quality assurance *(☞ Chap. 2.2)*
12 Location	**Municipality, place, canton, name of field, altitude, national monitoring map number, land register number**	- Relocation of sampling site
13 Contacts	**Land owner, farmer**, those interested, name of **sampler responsible (address, telephone)**	- Quality assurance *(☞ Chap. 2.2)*

Bold type: minimum data set

2 Changes

Which?	How?	Why?
21 Site sketch with changes	**Documentation of changes in the *Sampling* monitoring form no. 21**	- Site relocation with subsequent monitoring in long-term monitoring *(☞ Chap. 4)* - High risk of loss of fixed points *(☞ Chap. 6.10)* - Changes in position designation: e.g. subsequent marking with magnets *(☞ Chap. 6.10)*, additional fixed points, etc.
22 Legend	**Map symbols, fixed points, reference points**	
23 Changes in land use	**Documentation of changes according to the *Sampling* monitoring form no. 41**	- Documentation - Assessment and interpretation of results
24 Changes in soil cover	**Documentation of changes according to the *Sampling* monitoring form no. 43**	- Reference to possible damage from pollutants (inhibited plant growth, inhibited humus decomposition) - Observation of changes
25 Additional information	Remarks, descriptions	- Documentation of other relevant changes (e.g. levelling of the terrain by farmer, spreading of foreign soil material together with data on its origin)

Bold type: minimum data set

3 Sampling

Which?	How?	Why?
31 Sampling pattern	**Sketch**	- Quality assurance *(☞ Chap. 2.2)*
32 Weather during sampling	Dry, rain, snow (number of days)	- Assessment of sampling quality *(☞ Chap. 6.5)*
33 Additional information	Description	- Recording of more extensive information on the sampling (e.g. *"soil very dry, samples could not all be taken completely ")*
34 Soil condition	Dry, moist, wet, frozen	- Assessment of sampling quality *(☞ Chap. 6.5)*
35 Safety precautions	Yes, no. If yes: which?	- Documentation of safety precautions taken, if these were necessary *(☞ Chap. 6.2)*
36 Additional information	Description	- Recording of more extensive data on sampling (e.g. *"sampling pattern could not be consistently applied owing to high penetration resistance")*
37 Sample transport	Refrigerated/unrefrigerated, duration (days)	- Sample stability

Bold type: minimum data set

4 Sample data

Which?	How?	Why?
41 Sample designation	**Designation or number**	- Traceability - Precautions against confusing identity
42 Soil horizon	*FAL* classification *(2002) / BGS (2002)*	- Traceability - Relevant to scientific soil monitoring (relationship between soil horizon and sampling depth)
43 Sampling depth	**Depth from ... to ... (cm), with/-without humus cover (cm)**	- Traceability, performance according to sampling plan - Definition of fiducial (0 cm) *(☞ Chap. 3.4.5)* - Assessment and interpretation
44 Sample type	**Area sample, line sample, soil pit sample, bore sample, volume sample**	- Traceability, performance according to sampling plan *(☞ Chap. 3.4)* - Assessment and interpretation
45 Number of single samples	**Number**	- Traceability, obtaining composite samples *(☞ Chap. 3.4.4)* - Assessment of representativeness
46 Sampling device	**Auger type (Gouge, Edelmann, Riverside, Humax, others; diameter**	- Traceability - Quality assurance: employment of suitable sampling device *(☞ Chap. 6.7)*

Which?	How?	Why?
47 Packing	**Plastic, aluminium foil, glass, others**	- Assessment of risk of contamination *(☞ Chap. 6.11)*
48 Soil characteristics	Humus (type and content), lime, type of soil, rock fragment content	- On-site sample assessment with respect to subsequent evaluation and interpretation of analysis results (e.g. values outside normal statistical range)
49 Condition of sample	**Moisture, integrity**	- Influence of moisture on sample integrity (e.g. in "Pürckhauer") - Influence of sampling device *(☞ Chap. 6.7)* - Assessment of sample quality with respect to subsequent evaluation and interpretation of analysis results (e.g. values outside normal statistical range)
410 Additional information		- Provision of more extensive information on the samples (e.g. extraneous material)
411 Legend		- Information on filling out

Bold type: minimum data set

5 Date and signature

Which?	How?	Why?
51 Date and signature	**By person responsible**	- Quality assurance *(☞ Chap. 2.2)*

Bold type: minimum data set

Agriculture additional monitoring form (Annex 5-5)

For recording the additional data to the ***Sampling*** monitoring form *(Annex 5-1)* for agricultural use.

1 Identification

Which?	How?	Why?
11 Project	**Designation or no. of project and site/plot, date, taken by ... (person responsible)**	- Quality assurance *(☞ Chap. 2.2)*
12 Location	**Cf. no. 12 *Sampling* monitoring form**	- Quality assurance *(☞ Chap. 2.2):* this data is recorded in the *Sampling* monitoring form.
13 Contacts	**Cf. no. 13 *Sampling* monitoring form**	- Quality assurance *(☞ Chap. 2.2):* this data is recorded in the *Sampling* monitoring form.

Bold type: minimum data set

2 General operational data

Which?	How?	Why?
21 Type of production	Organic, integrated, conventional	- Assessment of data availability (farm bookkeeping), interpretation of topsoil pollution in accordance with type of production
22 Division of zones	Arable zone, extended transitional zone, transitional zone, hill zone, mountain zones 1–4	- Assessment of topsoil pollution in accordance with the zone boundaries
23 Farmed areas	Agricultural area, fertilisable area, arable area (ha)	- Assessment of topsoil pollution in accordance with type of farming - This data is contained in the total nutritional balance
24 Farmer	Years worked by same farmer	- Assessment of continuity, influence of previous farming practice

3 Land use

Which?	How?	Why?
31 Permanent grassland/pasture	Mown meadow, pasture, mown pasture (total periods of use grazing/cutting)	- Interpretation of topsoil pollution through application of fertilisers and pesticides in relation to land use - This data is partly contained in the total nutrient balance of the farm
32 Arable farming	Specification of crop rotation (culture/s, year)	
33 Orchard	Apples, pears, damsons, cherries, others	
34 Horticulture	Fresh vegetables, vegetable pre-serves	
35 Viniculture	Time used as vineyard, age of vines	

4 Number of livestock

Which?	How?	Why?
41 Cattle manure units (CMU)	Total CMU and total pig FPU	- Interpretation of topsoil pollution with respect to pollutant content and intensity of use (CMU per unit area, livestock per unit area; CMU calculated from fattening pig units FPU) - This data is contained in the total nutrient balance of the farm - Classification of farmyard manure according to *Guidelines for fertilisation in crop and fodder production (FAL 2001).* Also cf. no. 5, *External fertilisers*
42 Number of livestock	Pigs, cattle, horses, small ruminants, poultry, others (number)	
43 Farmyard manure	Type, quantity (supplied/delivered)	

5 External fertilisers

Which?	How?	Why?
51 Mineral fertilisers containing phosphorus	Product name, manufacturer	Pollutant spectrum
52 Recycling fertilisers	Compost, sewage sludge, others (quantity/year, origin)	- Interpretation of topsoil pollution with respect to external fertilisers (external pollutant source) - Classification of farmyard manure according to *Guidelines for fertilisation in crop and fodder production (FAL 2001)* - This data is partly contained in the total nutrient balance of the farm
53 Additional information	Comments, descriptions	e.g.: - intensity of fertiliser application - application of fertilisers

6 Pesticides

Which?	How?	Why?
61 Pesticides	Name of product, manufacturer, quantity, supply/delivery	- Pollutant spectrum - Interpretation of topsoil contamination with respect to the substance (external pollutant source)
62 Additional information	Remarks, descriptions	e.g.: - intensity of application - application of pesticides

7 Date and signature

Which?	How?	Why?
71 Date and signature	**By person responsible**	- Quality assurance *(☞ Chap. 2.2)*

Bold type: minimum data set

Forestry additional monitoring form (Annex 5-6)

For recording the additional data to the ***Sampling*** monitoring form *(Annex 5-1)* in forestry.

1 Identification

Which?	How?	Why?
11 Project	**Designation or no. of project and site/plot, date, taken by ... (person responsible)**	- Quality assurance (☞ *Chap. 2.2)*
12 Location	**Cf. no. 12 *Sampling* monitoring form**	- Quality assurance (☞ *Chap. 2.2):* this data is recorded in the *Sampling* monitoring form.
13 Contacts	**Cf. no. 13 *Sampling* monitoring form, also forester**	

Bold type: minimum data set

2 Operational data

Which?	How?	Why?
21 Forestry type	High forest, medium forest, coppice	- Assessment of negative effects of pollutants with respect to the type of operation
22 Forestry operation	Group felling, strip felling, clear felling, selective felling	

3 Inventory

Which?	How?	Why?
31 Composition	Conifers, mixed conifers, mixed deciduous forest, deciduous forest	- Assessment of impact effects of pollutants with respect to the type of operation
32 Percentage cover	Relationship of crown area in % to total area	
33 Development stage	Recruitment, pole wood, small, medium and large diameter roundwood, mixture	
34 Structure of stands	Uniform, stepped, multi-layered (state height of layers)	
35 Top height	Average height of the 100 largest trees per ha	
36 Age of stand	Average age (years)	
37 Additional information	Comments, descriptions	

4 Date and signature

Which?	How?	Why?
41 Date and signature	**By person responsible**	Quality assurance (☞ *Chap. 2.2)*

Bold type: minimum data set

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Annexes

Annex 1: *Quality* check list
Annex 2: Identification of possible soil pollution
Annex 3: Exceedance of guide values due to contents in parent rocks
Annex 4: Data recording for mass balances in agriculture
Annex 5: Monitoring forms

Annex 1 *Quality* check list

Project
Project designation..
Project no. ....

Purpose and objectives ☞ *Chap. 3.1*	**YES**	**NO**
Is the purpose explicitly stated? Documentation:..	☐	☐
Has this been agreed with the commissioning organisation? Date of agreement:..........	☐	☐
Are the purpose and objectives explicitly stated? Reason:	☐	☐

Preliminary investigations ☞ *Chap. 3.2*	**YES**	**NO**
Monitoring area Are the size and boundaries of the monitoring area precisely defined? Reason:	☐	☐
Past uses Have the past uses of the monitoring area been sufficiently well determined? Reason, documentation:...	☐	☐
Contamination hypothesis Is the documentation monitoring complete with respect to the stated purpose? Reason:	☐	☐
Are the documents reliable? Reason (where partly unreliable):	☐	☐
Have all necessary and possible interviews been performed? Reason:	☐	☐
Are the responses of the interviewees reliable? Reason (where partly unreliable):	☐	☐
Is the contamination hypothesis sufficiently precise to establish the sampling plan? Reason:	☐	☐
Can other contamination hypotheses be excluded? Reason:	☐	☐
Local knowledge Was a field inspection carried out? Date:.. Reason:	☐	☐

Have all necessary site characteristics relevant to sampling been determined? Reason:	☐	☐
Is sufficient local knowledge available to plan and carry out the sampling? Reason:	☐	☐
Has it been established what safety precautions are necessary for sampling? Documentation:	☐	☐

Monitoring requirements ☞ *Chap. 3.3*	**YES**	**NO**
Has the necessary resolution been determined? Reason:	☐	☐
Has the analysis programme been established? Reason:	☐	☐
Is accompanying monitoring necessary? Reason:	☐	☐
Does the size of the monitoring require a stepwise procedure? Reason:	☐	☐

Sampling plan ☞ *Chap. 3.4*	**YES**	**NO**
Sampling pattern		
Does the sampling pattern (distribution and number of samples) fulfil the resolution requirements? Reason:	☐	☐
Can a representative picture of the pollution situation be obtained using the chosen sampling pattern? Reason:	☐	☐
Have other sampling patterns been considered? Reason:	☐	☐
If the contamination hypothesis proves to be inapplicable, can this affect the result? Reason:	☐	☐
Has the procedure for determining alternative sites been laid down? Reason:	☐	☐
Sample types		
Have the necessary types of sample been determined? Reason:	☐	☐
Composite samples		
Has the procedure for obtaining composite samples (number and distribution of single samples) been determined? Reason:	☐	☐

Does this procedure enable a representative sample to be taken? Reason:	☐	☐
Sampling depths		
Have the sampling depths been determined? Reason:	☐	☐
Sampling of topsoil		
Have the provisions of the OIS been taken into account? Reason:	☐	☐
Can the purpose be fulfilled using the chosen sampling depths? Reason:	☐	☐
Sampling of subsoil		
Have the sampling depths of the subsoil been determined? Reason:	☐	☐
Is sampling at fixed depth levels or soil horizons suitable? Reason:	☐	☐
Sample quantities?		
Have the necessary sample quantities been determined in accordance with the intended analyses? Reason:	☐	☐
Have reserve and archive samples been considered? Reason:	☐	☐
Site description		
Has the necessary precision of site identification been determined? Reason:	☐	☐
Have all the site characteristics to be recorded been determined? Reason:	☐	☐

Sampling ☞ *Chap. 6*	**YES**	**NO**
Have the owners and tenants been informed of the monitoring pending? Reason:	☐	☐
Have safety precautions been taken (protection measures, fencing off, etc.)? Reason:	☐	☐
Have cables and piping been recorded and authorisations obtained? .... Reason:	☐	☐
Is personnel adequately qualified and sufficiently well instructed? Reason:	☐	☐

Is the intended monitoring time adequate? Reason:	☐	☐
Has the risk of contamination been considered in connection with the intended sampling sequence? Reason:	☐	☐
Can the necessary sample quantity be taken with the intended number of single samples and sampling devices? Reason:	☐	☐
Have the monitoring forms been completed in sufficient detail? Reason:	☐	☐
Do sample packaging and transport facilities fulfil the requirements (size, risk of contamination, vibration)? Reason:	☐	☐

Sampling pretreatment ☞ *Chap. 7*	**YES**	**NO**
Does the temporary storage correspond to the requirements (containers, temperature, duration)? Reason:	☐	☐
Will the complete samples be dried as rapidly as possible? Reason:	☐	☐
Is there a risk of contamination during crushing and sieving? .... Reason:	☐	☐
Is the procedure of sample splitting adequate to produce representative sub-samples? Reason:	☐	☐

Sample archiving ☞ *Chap. 7.2*	**YES**	**NO**
Does an archive plan exist? Reason:	☐	☐
Are the conditions for long-term archiving of samples fulfilled? Reason:	☐	☐

Annex 2 Identification of possible soil pollution

The following *Tab.* provides a rough guide to the identification of possible soil pollution. A preliminary investigation must be made to determine a monitoring is in fact necessary at a particular site.

Chemical soil pollution may arise from emissions from installations, through dumping of waste, or by farming practices. *Annex 2* provides a rough guide to the occurrence and type of possible pollution. In deciding whether – and if so, what – monitoring is necessary, the local conditions must always be considered (past uses, age of installation, etc.).

Soil containing pollutants	Principal pollutants											
	Pb	Cd	Cr	Cu	Ni	Hg	Zn	F	PAH	PCB	Dioxins	others
1 Surroundings of installations **1.1 Transport infrastructure**												
• roads	X	X					X		X			
• airfields	X	X		X			X		X			
• railway installations				X								
• tunnel ventilation shafts	X	X					X		X			
1.2 Energy installations												
• furnaces (excluding gas and extra-light heating oil)	X	X	X				X		X		X	
• gasworks premises (incl. coal depots)	X	X					X		X			
1.3 Disposal facilities												
• waste incineration plants (particularly older plant)	X	X		X		X	X		X	X	X	
• landfills	X	X	X	X	X	X	X	X	X	X	X	
• infiltration sites	X	X		X			X		X			
• scrapyards/shredders	X	X	X	X	X	X	X			X		
1.4 Shooting ranges and installations	X			X		X	X					Sb
1.5 Industrial installations												
• smelting works	X	X		X			X				X	
• foundries	X	X	X	X			X					
• zinc plating works		X					X					
• metal works	X	X	X	X	X		X					
• glass production	X	X				X	X	X				
• ceramics production	X	X				X	X	X				
• cement works	X					X		X			X	
• textile works			X	X								
• plastics processing		X							X	X		
• printing works	X	X	X	X			X					
• sawyeries			X	X					X			
• tanneries			X			X		X	X			
• paint and lacquer production	X	X	X	X		X	X		X	X		

(*Tab. continued*)

1.6 Corrosion protected metal-buildings and constructions	X	X	X				X		X	X		
2 Soils with particular farming practices												
• soils with intensive use of sewage sludge	X	X	X	X	X	X	X		X	X	X	
• household and family gardens	X	X		X		X	X					
• vineyard soils	X	X		X								
• intensive cultivation soils	X			X								
• soils with intensive use of pig manure				X								

Sources: SAEFL (2001a), SAEFL (1996a), SAEFL and *FAC (1987).*

Annex 3 Exceedance of guide values due to contents in parent rocks

Mineral types and the frequency with which guide values are exceeded according to *Tuchschmid (1995)* and *Desaules* and *Dahinden (1996):*

Mineral types		Guide values exceeded (guide value in mg/kg)										
Code		Pb *50*	Cd[1] *0.8*	Zn *150*	Hg *0.5*	Cu *40*	Ni *50*	Cr *50*	Mo *5*	F *700*	Co[2] *25*	Tl[2] *1*
GF1	**Acidic crystalline minerals**											
LF1	Granite, granodiorites, etc.	-	-	-	-	-	-	-	-	2	2	2
LF3	Orthogneisses	-	-	-	-	1	-	-	-	2	-	3
GF2	**(Ultra) alkaline crystalline minerals**											
LF2	Diorites, gabbros, porphyrites	-	-	-	-	-	-	1	-	1	1	2
LF4	Amphibolites, hornblendes	-	-	-	-	2	3	3	-	2	3	-
LF5	Peridotites	-	-	-	-	1	3	3	1	-	2	-
LF15	Greenschist	-	-	1	-	3	3	3	-	-	3	-
LF16	Serpentinites	-	-	-	-	-	3	3	2	-	-	-
GF3	**Clayey minerals (pelites)**											
LF6	Paragneisses	-	-	1	-	-	-	2	-	3	2	2
LF9	Clay slates to phyllites	-	-	1	-	2	1	3	-	1	-	3
LF11	Flysch / Grisons shale	1	1	1	-	2	2	3	-	3	1	2
LF17	Marl, marl clay, slate clay	1	1	2			2	2		1	2	2
LF21	Molasse marls and clays	1	-	-	-	-	2	3	-	2	2	2
LF23	Paleokarst [German: Boluston]	2	-	2	-	2	3	3	2	1	3	1
LF24	Glacial limestones and clays	-	-	-	-	1	2	3	-	2	1	-
LF25	Alluvial limestones and clays	1	-	-	1	2	3	3	-	1	2	1
GF4	**Sandy minerals (psammites)**											
LF7	Meta psammites, quartzites	-	-	-	-	-	-	-	-	-	1	1
LF10	Arkoses, sandstones, fine breccias	1	1	1	-	2	1	2	-	2	1	2
LF13	Flysch	-	-	-	-	-	2	2	-	2	2	-
LF14	Radiolarites	-	-	-	-	-	-	-	-	-	-	-
LF26	Alluvial sands	-	-	-	-	1	-	1	-	-	-	-
LF32	Molasse sandstones	-	-	-	-	-	1	2	-	-	1	-
GF5	**Carbonaceous and sulphurous minerals**											
LF8	Carbonaceous marbles and silicates	-	-	-	-	1	2	1	-	-	2	-
LF12	Grisons shale / flysch	-	-	-	-	-	-	-	-	-	-	-
LF18	Limestones, micaceous chalks	-	1	2	-	-	1	1	1	-	1	-
LF19	Dolomites, wackes	-	-	-	-	-	-	-	-	1	-	-
LF20	Gypsum	-	-	-	-	-	-	-	-	-	-	-
GF6	**Coals/bituminous minerals**											
LF27	Coals, bituminous minerals	2	-	2	3	2	2	2	3	-	2	2

– = none
1 = seldom (maximum >guide value)
2 = occasional (90 percentile >guide value)
3 = frequent (median >guide value).

[1] Coarse grain chalks (German: sparites) often exceed the guide value for Cd *(Benitez Vasquez 1999)*.
[2] Since the OIS does not specify a guide value, the guide value stated in the former OPS (1986) is cited.

With large-grain mixed minerals (moraine, gravel, nagelfluh, etc.), it is scarcely possible to obtain reliable datas. Rough estimates are, however, possible based on the percentages of the different rocks. By means of a table *(Desaules* and *Dahinden 1996),* the listed rocks (LF) can be correlated on an area basis with the units contained in the Swiss geotechnical map (1:200 000). Also, digital maps (1:1.5 million) show the frequencies with which the guide values are exceeded due to parent rocks on an area basis *(Keller* and *Desaules 2001)*.

Although the pollutant contents of the parent rock and related soils cannot readily be compared, they do have practical applicability as approximate values *(Desaules* and *Dahinden 1996)*. This does not apply to organic soils and heavily weathered mineral soils. In soils lying above limestone and gypsum substrata with heavy leaching, e.g. high residual concentrations of Cd and F occur.

Annex 4 Data for mass balances in agriculture

Method

Mass balances are a useful supplement to long-term monitoring of soil pollutant content. Not only do they permit early detection of soil quality changes, such as the accumulation of heavy metals, but also enable appropriate measures for the reduction of pollutant input to be determined and critical input levels to be defined *(von Steiger* and *Obrist 1993, SAEFL 1993, van der Zee* and *de Haan 1998, Keller 2000).*

To perform mass balances for pollutants in agricultural soils, a reference area must be chosen, and the datas of interest aggregated. Depending on the purpose of the monitoring, mass balances may be performed at the national level (cf. *Moolenaar 1998, Schütze* and *Nagel 1998),* the regional level (e.g. *Tiktak et al. 1998, Keller 2000)* or the level of individual farms (e.g. *von Steiger* and *Baccini 1990, Reiner et al. 1996, LBP 1997, Moolenaar* and *Lexmond 1998).* Whilst monitoring at the national level enables trends in the mass balance to be identified, they cannot be applied to smaller areas. Conversely, mass balances performed for individual farms cannot normally be extrapolated to larger areas.

Pollutant fluxes and data sources

Pollutant inputs arise particularly from used substances such as farmyard manure, mineral fertilisers, recycling fertilisers and pesticides, whilst pollutant outputs occur via field crops and other agricultural products. Furthermore, the fluxes arising from atmospheric deposition, erosion and the migration of pollutants to deeper soil horizons must be taken into account. Input and output data obtained from other sources may be used in the calculation depending on the reference scale of the mass balance. In fulfilling the ecological impact specifications, farmers must keep a farm nutrient balance and fill out crop forms showing the measures taken in each plot.

The *Agriculture* additional monitoring form *(☞ Chap. 8, Annex 5)* lists the data required for the nutrient balance. Regional agricultural data may be obtained from the farm monitoring of the Swiss Federal Statistical Office. The following *Tab.* lists data sources that may be used in preparing pollutant inputs and outputs for mass balances. The substance fluxes through agricultural plots can vary with time. For this reason, it is recommended that for arable farming, the calculation be based on a minimum of one crop rotation period. For shorter periods, other plots with the same crop rotation as the test plot can also be included in the substances flux investigation. Uncertainties arising from the fluctuations of characteristic values from one area to another, and through unreliable or missing data, can be quantified using statistical methods *(Keller 2000).*

Pollutant sources	Reference area	Suggested data sources
Farmyard manure		
Total livestock	Farm/regional	Crop forms, Swiss Federal Statistical Office (SFSO)
Farms	Farm/regional	Crop forms, Swiss Federal Statistical Office (SFSO)
Quantity per livestock unit	Regional/nation	Fertiliser data and fertilisation guidelines (e.g. *BLW 2001)*
Concentration	Farm/regional/nation	Quality monitoring (e.g. *Menzi and Kessler 1998)*
Compost / sewage sludge		
Quantities	Regional/municipality	Compost works, sewage sludge databases
Concentration	Regional/municipality	Compost works, sewage sludge databases
Mineral fertilisers		
Quantities	Farm	Fertiliser specifications/agricultural advisory services and collectives/cropping information leaflets
Concentration	Nation	Quality monitoring
Pesticides	Regional/nation	Product information (e.g. *BLW 2002),* cropping information leaflets
Atmospheric deposition	Regional	Cantonal environmental authorities National Air Pollution Monitoring Network NABEL (e.g. *SAEFL 2000f)*
Heavy metal outputs		
Crop		
Cultivated areas	Farm/regional	Crop forms, Federal Statistical Office (SFSO)
Harvest	Farm/regional	Crop forms, agricultural collectives
Concentration	Farm/regional	Quality monitoring
Leaching		
Soil types	Regional	Soil maps, cantonal environmental authorities
Concentration in soil	Farm	Soil observation, National Soil Monitoring Network (NABO)
	Regional	Cantonal Soil Monitoring Networks (KABO)
Erosion		
Risk of erosion	Field/farm	Soil maps, cantonal environmental authorities

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Annex 5 Monitoring forms

- ☞ **Annex 5-1:** *Sampling* monitoring form
- ☞ **Annex 5-2:** *Sample pretreatment* monitoring form
- ☞ **Annex 5-3:** *Soil profile description* additional monitoring form
- ☞ **Annex 5-4:** *Subsequent sampling* additional monitoring form
- ☞ **Annex 5-5:** *Agriculture* additional monitoring form
- ☞ **Annex 5-6:** *Forestry* additional monitoring form

The monitoring forms can be downloaded as pdf files in internet under *www.nabo.admin.ch*.

1 Identification

Bold type: minimum data set

11 Project

Project: .... **site/plot:** ....

Sampler responsible: .... **date:** ....

12 Site

Location/municipality: .... **canton:** ....

Name of field: .... **land register no.:** ....

Coordinates: .... **altitude:** .... **national monitoring map no.:** ....

13 Contacts

Owner: ....

Farmer: ....

Persons interested: ....

14 Contamination hypothesis

Pollutant input paths: ....

Extension (horizontal/vertical): ....

Delimitation (horizontal/vertical): ....

Contamination pattern (homogeneous/heterogeneous): ....

15 Additional monitoring forms

❑ soil profiledescription ❑ agriculture ❑ forestry ❑ sample pretreatment

16 Subsequent monitoring

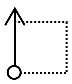
❑ intended ❑ not intended

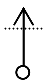
2 Position of sampling site

21 Sketch of site

Indicate North and distances in m

22 Legend


Sampling area with reference point and direction (degrees)


sampling line with reference point and direction (degrees)


soil pit


boring sample


slope (%)

● **Orientation point:** .... **coordinates:** ....

▲ **Fixed points (description):** **distance to reference point (m):** **direction (degrees):**

No. 1 ...., ..., ...

No. 2 ...., ..., ...

No. 3 ...., ..., ...

Photographs: ...., ..., ...

23 Additional information for relocation

3 Sampling and sample transport

Bold type: minimum data set

31 Sketch/sketches with positions of the single samples for obtaining composite samples (sampling pattern)

Indicate North and distances in m

32 Legend of sketch

⊙	reference point	╳	increment	●	corner points of the sampling area/line
↑	direction (degrees)	⊗	boring	⊟	soil pit

33 Weather during sampling

❑ dry weather ❑ rain ❑ snow temperature (°C): ....

34 Soil condition

❑ dry ❑ moist ❑ wet ❑ frozen

35 Safety measures

❑ no ❑ yes, measures taken: ....

36 Additional information for sampling

37 Sample transport

❑ unrefrigerated ❑ refrigerated, duration: .... day/s: ....

Comments: ....

....

4 Land use and vegetation

Bold type: minimum data set

41 Use

- ❑ **forest**
  - ❑ **conifers**
  - ❑ **deciduous forest**
  - ❑ **mixed forest**
  - ❑ **others:** ....
  ....
  ....
- ❑ **other uses**
  ....
  ....
  ....
- ❑ **residential area**
  - ❑ **household garden**
  - ❑ **family garden**
  - ❑ **children's play area**
  - ❑ **others:**......................................
  ....
  ....
- ❑ **agriculture**
  - ❑ **permanent grassland**
  - ❑ **pasture**
  - ❑ **Alpine pasture**
  - ❑ **arable farming incl. (artificial) meadow ley grass farming**
  - ❑ **horticulture**
  - ❑ **orchard**
  - ❑ **vineyard**
  - ❑ **others:** ....

Cultivated since (year): .... duration (years): .... driving distance from farm (km): ....

42 Earlier uses

use: .... from/to (year): .... duration (years):...........

use: .... from/to (year): .... duration (years):...........

43 Soil cover

Vegetation/crop: ....

Degree of cover (%): .... **humus cover (cm):** ....

44 Additional information concerning use and vegetation

5 Climate and air pollution

Bold type: minimum data set

51 Type of site

❑ **Alpine** ❑ **country area** ❑ **urban area** ❑ **town**

52 Emitters of atmospheric pollution

❑ road(s): ....

❑ industry: ....

❑ others: ....

53 Climate and contamination of sampling site

Precipitation (mm/year):....................... principal wind directions: .... ❑ exposed ❑ sheltered

54 Additional information on climate and air pollution

6 Relief

61 Landform

❑ **plateau/terrace/plain** ❑ **valley floor/hollow** ❑ **hillock/ridge/rib/wall**

❑ **slope** ❑ **footslope** ❑ **channel** ❑ **alluvial fan/debris cone**

62 Situation and contamination of sampling site

❑ **loss prone** ∩ ❑ **accumulation prone** ∪ ❑ **flat** — **slope (%):**................. **exposition (direction):** ....

63 Additional information on the relief

7 Geology and hydrology

71 Geology

Parent rock: .... **contains lime:** ❑ **yes** ❑ **no**

72 Hydrology

❑ groundwater area ❑ floodplain ❑ karst area

73 Additional information on geology and hydrology

8 Sample data

Bold type: Minimum data set

81 **Sample designation**	82	83 **Sampling depth**	**84**	**85**	**86 Sampling device**[2]		**87**	88 Soil characteristics						**89 Condition**		810 Additional information
	Soil horizontal	**definition 0 cm:** ☐ **with** ☐ **without humus cover**	[1]**Type of sample**	**Number of single samples**	[2] **Type**	Diameter of sample (cm)	**Packing**[3]	Humus: [4]org./min.	Humus: [5]humus type	[6]humus content	[7]lime	[8]texture	[9]rock fragment content	[10]moisture	[11]**completeness of increments**	

811 Legends

1 **Fl** = area sample, **Li** = line sample, **Pr** = soil pit sample, **Bo** = bore sample, **Vo** = volume sample

2 **1** = Gouge, **2** = Edelmann, **3** = Riverside, **4** = Humax, **5** = other *(☞ 810 additional information)*

3 **1** = plastic, **2** = alum. foil, **3** = glass, **4** = other *(☞ 810 additional information)*

4 **m** = mineral (<15 % humus), **o** = organic (>15 % humus)

5 **1** = mull, **2** = mor, **3** = raw humus, **4** = peat

6 **1** = very low humus (<2 %), **2** = low humus (up to 5 %), **3** = humic (up to 10 %), **4** = rich in humus (up to 20 %), **5** = very rich in humus (up to 30 %), **6** = organic (>30 %)

7 **0** = no $CaCO_3$, +/- = only present in rock fragments, + = weak effervescence, ++ = average effervescence, +++ = strong effervescence with 10 % HCl solution

8 **S** = sand, **uS** = silty sand, **lS** = loamy sand, **lrS** = loam-rich sand, **sL** = sandy loam, **L** = loam, **sU** = sandy silt, **U** = silt, **lU** = loamy silt, **tU** = clayey silt, **tL** = clayey loam, **lT** = loamy clay, **T** = clay

9 **skf** = rock fragment free, **ska** = low rock fragment (<5 %), **sws** = very low rock fragment (<10 %), **skh** = medium rock fragment (<20 %), **sts** = heavy rock fragment (<30 %), **skr** = rock fragment rich (<50 %), **esk** = extremely rock fragment rich (>50 %)

10 **1** = wet, **2** = very moist, **3** = medium moist, **4** = low moist, **5** = dry

11 **1** = no losses, **2** = loss approx. ⅓, **3** = loss approx. ⅔, **4** = sample falls out

9 Date and signature

Bold type: Minimum data set

91 Date and signature

Date: .... **signature:** ....

***Sample pretreatment* monitoring form**
Annex 5-2

1 Identification

Bold type: minimum data set

11 Project

Project: .... **site/plot:** .... **date of sampling:** ....

12 Collaborator

Name: .... **samples delivered on:** .... sample pretreatment (date) from .... to ....

2 Sample pretreatment

Bold type: minimum data set

21	22	23	24	25	26	**27**	28	29	**210**	211	212	213	**214**	**215**	**216**	**217**	218
Sample designationon	Gross weight wet	Gross weight dry	Tare	Water content	Water content	**Drying temperature**	Drying time	Temporary storage	**Crushing**	Sieving mesh diameter	fine earth	Sieving residue	**Weight of fine earth**	**Number of portions**	**Splittingn method**	**Containers**	Comments
	g	g	g	g	%	°**C**	days	days	**1**	mm	2	g	**g**		**3**	**4**	

219 Legends

1 **B** = jaw crusher, **K** = cross hammer mill **M** = mortar, **a** = others ☞ *218 comments*

2 **KS** = plastics, **ME** = metal, **a** = others ☞ *218 comments*

3 **RT** = riffle splitter, **DPT**= rotary splitter, **LPT** = laboratory sample splitter, **KV**= coning and quartering, **a** = others ☞ *218 comments*

4 **KS** = plastics, **GL** = glass, **Al** = aluminium **a** = others ☞ *218 comments*

3 Date and signature

Bold type: minimum data set

31 Date and signature

Date: .... **signature:** ....

Soil profile description additional monitoring form **Annex 5-3**

1 Identification

Bold type: minimum data set

11 Project

Project: ....**site/plot:** ....

Sampler responsible: .... **date:** ....

12 Place

❑ **cf. accompanying *Sampling* monitoring form (11)**

❑ **Location/municipality:** .... **canton:** ....

Name of field: .... **land register no.:** ....

Coordinates: ....**altitude:** .... **national monitoring map no.:** ....

13 Situation/sketch of site

❑ **cf. *Sampling* monitoring form** ❑ **cf.:** ....

2 Topography and geology

21 Transect/comments

3 Soil classification

31 Soil classification according to *FAL (2002) / BGS (2002)*

soil type:..sub-type: ....

4 Soil profile

41 Sketch of soil profile

		1		2/3	4/5/6	7	8	9/10	11/12	13		14		
horizon			Soil profile section sketch	structure	voids	density	texturen	humus	rock fragment content	lime test	pH (Hellige)	hydro-morphys	colour Munsell	comments/ sample description
no.	depth (cm)	designationtion												
		0												
		10												
		20												
		30												
		40												
		50												
		60												
		70												
		80												
		90												
		100												
		120												
		140												
		160												

42 Legends

(1) Description of horizon

A topsoil horizon (<30 % OS)
B intermediate horizon
C mineral substratum
D rock transition
E leaching horizon
I illuvial horizon
O organic bearing horizon
R rock
T peat
( ) slight indications
AB transitional horizon
B/C complex horizon

a histic property
b buried
ch chemically weathered
cn with concretions
f partly decomposed (mor)
fe Fe enrichment
fo fossil
g rust mottled
gg coloured (hydromorphous)
h humus enrichment
k downy lime
l not decomposed (raw humus)
m massive, cemented
na Na enrichment
ox Fe/Al oxide enrichment
p plough layer
q quartz grains
r reduced
sa salt enrichment
st well structured
t clay enrichment
vt vertisolic, shrinkage cracks
w weathered
x compact
y foreign deposition
z physically weathered
( ) slight indications

(2) Soil structure

1 single grain structure
2 coherent structure
3 aggregated/segregated structure
4 anthropogenic

(3) Aggregated structure

1 crumbly
2 polyedric
3 subpolyeedric
4 prismatic
5 platy
6 friable
7 coherent-
8 cutans

(4) Macro-pores

0 no pores
1 fine/slight
2 fine/average
3 fine/high
4 average/slight
5 average/average
6 average/high
7 coarse/slight
8 coarse/average
9 coarse/high

(5) Cracks/voids

(between the aggregates)

1 fine (<1 mm)
2 average (1–2 mm)
3 coarse (>2 mm)

(6) Worm casts

0 none
1 few (not immediately apparent)
2 many (immediately apparent)

(7) Density

1 very loose (<0.8 g/cm^3, org. material)
2 loose (0.8–1.2 g/cm^3, topsoil)
3 average (1.2–1.4 g/cm^3, B horizon)
4 compact (1.4–1.8 g/cm^3, compacted)
5 very compact (>1.8 g/cm^3)

(8) Texture

		clay %	silt %
1	sand	0–5	0–15
2	silty sand uS 0–5	15–50	
3	loamy sand lS 5–10	0–50	
4	loam-rich sand lrS	10–15	0–50
5	sandy loam sL15–20	0–50	
6	loam L	20–30	0–50
7	clayey loam tL	30–40	0–50
8	loamy clay lT	40–50	0–50
9	clay T	50–100	0–50
10	sandy silt sU	0–10	50–70
11	silt U	0–10	70–100
12	loamy silt lU	10–30	50–90
13	clayey silt tU	30–50	50–70

(9) Humus content

			% humus from to
1	hfr	humus free	0.0
2	har	very low humus	0.1–1.9
3	swh	low humus	2.0–4.9
4	hos	humus	5.0–9.9
5	hr1	humus rich	10.0–14.9
6	hr2	humus rich	15.0–19.9
7	shr	very humus rich	20.0–29.9
8	org	organic	30.0–100

(10) Humus form

1 mull
2 mor
3 raw humus
4 peat

11) Rock fragment content

			vol. % rock fragment from to
0	skf	rock fragment free	0.0
1	ska	very low rock fragment	<5.0
3	sws	low rock fragment	5.0–9.9
4	skh	rock fragment	10.0–19.9
5	sts	high rock fragment	20.0–29.9
6	skr	rock fragment rich	30.0–49.0
7	esk	extra. rock fragment rich	>50.0

(12) Rock fragment size

FS fine rock fragment (0.2 cm – 5 cm)
GS coarse rock fragment (5 cm – 20 cm)
BL blocks (>20 cm)

1 >75 % FS
2 >50 % FS, >25 % GS
3 >50 % FS, >25 % BL
4 >75 % GS
5 >50 % GS, >25 % FS
6 >50 % GS, >25 % BL
7 >75 % BL
8 >50 % BL, >25 % FS
9 >50 % BL, >25 % GS

(13) Lime test

(with 10 % HCl solution)

0 no $CaCO_3$
1 present only in rock fragment
2 weak effervescence
3 medium effervescence
4 heavy effervescence

(14) Hydromorphy

0 none
1 black concretions
2 mottled rust patches
3 contrasting rust patches
4 pale red colouring (marbling)
5 reduction colours (grey/blue/green)
6 multi colored
7 wet bleaching

5 Date and signature

Bold type: minimum data set

51 Date and signature

Date: .... signature: ....

Subsequent sampling additional monitoring form

Annex 5-4

1 Identification

Bold type: minimum data set

11 Project

Project: ....site/plot: ....

Sampler responsible: ....date: ....

12 Ort

❑ **cf. accompanying *Sampling monitoring form* (11)**

13 Contacts

❑ **cf. accompanying *Sampling* monitoring form (11) or:**

❑ **new owner: ....**

new farmer: ....

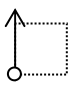
new persons interested: ....

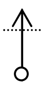
2 Changes

21 Sketch of site with changes

Indicate North and distances in m

22 Legends

 **Sampling area with reference point and direction (degrees)**

 **sampling line with reference point and direction (degrees)**

 **soil pit**

 **bore sample**

 **slope (%)**

● **orientation point:..................................... coordinates: ....**

▲ **fixed points (description): distance to reference point (m): direction (degrees):**

No. 1 ...., ..., ...

No. 2 ...., ..., ...

No. 3 ...., ..., ...

Photographs: ...., ..., ...

23 Changes in land use

❑ **Land use unchanged**

❑ **Change in land use since (year):**

...

Present land use (classification according to *Sampling* monitoring form no. 41)**: ....**

24 Changes in soil cover

❑ **Soil cover unchanged**

❑ **Observed changes:**

Vegetation/crop: ....

Degree of cover (%): ....humus layer (cm): ....

25 Additional information for relocation (changes)

3 Sampling and sample transport

Bold type: minimum data set

31 Sketch/es with positions of the single samples for obtaining composite samples (sampling pattern)

Direction from North, distances in m

32 Legends in sketch

⭘	reference point	╳	increment	●	corner points of the sampling area/line
↑	direction (degrees)	⊠	boring	⊓	soil pit

33 Weather during sampling

❑ dry weather ❑ rain ❑ snow temperature (°C): ....

34 Soil condition

❑ dry ❑ moist ❑ wet ❑ frozen

35 Safety measures

❑ no ❑ yes, measures taken: ....

36 Additional information for sampling

37 Sample transport

❑ unrefrigerated ❑ refrigerated duration:.........day/s:......... Comments:...

....

Subsequent sampling additional monitoring form

Annex 5-4

4 Samples

Bold type: minimum data set

41 **Sample designation**	42 Soil horizontal	**43** **Sampling depth** **definition 0 cm:** ☐ **with** ☐ **without humus cover**	**44** [1] **Type of sample**	**45** **Number of single samples**	**46** **Sampling devicelian ce**[2] [2] **Type**	Diameter of sample (cm)	**47** **Packing** [3]	48 Soil characteristics Humus [4] org. / min.	[5] humus form	[6] humus content	[7] lime	[8] texture	rock fragment content	**49** **Condition** [10] moisture	**completeness of increments**	410 Additional information

42 Legends

1 **Fl** = area sample, **Li** = line sample, **Pr** = soil pit sample, **Bo** = bore sample, **Vo** = volume sample

2 **1** = Gouge, **2** = Edelmann, **3** = Riverside, **4** = Humax, **5** = other *(☞ 810 additional information)*

3 **1** = plastic, **2** = alu foil, **3** = glass, **4** = other *(☞ 810 additional information)*

4 **m** = mineral (<15 % humus), **o** = organic (>15 % humus)

5 **1** = mull, **2** = mor, **3** = raw humus, **4** = peat

6 **1** = very low humus (<2 %), **2** = low humus (up to 5 %), **3** = humic (up to 10 %), **4** = humus rich (up to 20 %), **5** = very rich in humus (up to 30 %), **6** = organic (>30 %)

7 **0** = no $CaCO_3$, **+/-** = only present in rock fragments, **+** = weak effervescence, **++** = average effervescence, **+++** = strong effervescence with 10 % HCl solution

8 **S** = sand, **uS** = silty sand, **lS** = loamy sand, **lrS** = loam-rich Sand, **sL** = sandy loam, **L** = loam, **sU** = sandy silt, **U** = silt, **lU** = loamy silt, **tU** = clayey silt, **tL** = clayey loam**,** **lT** = loamy clay, **T** = clay

9 **skf** = rock fragment free, **ska** = low rock fragment (<5 %), **sws** = very low rock fragment (<10 %), **skh** = medium rock fragment (<20 %), **sts** = heavy rock fragment (<30 %), **skr** = rock fragment rich (<50 %), **esk** = extremely rock fragment rich (>50 %)

10 **1** = wet, **2** = very moist, **3** = medium moist, **4** = weakly moist, **5** = dry

11 **1** = no losses, **2** = loss approx. ⅓, **3** = loss approx. ⅔, **4** = sample falls out

5 Date and signature

Bold type: minimum data set

51 Date and signature

Date: .... **signature:** ....

Agriculture additional monitoring form

Annex 5-5

1 Identification

Bold type: minimum data set

11 Project

Project: ....site/plot: ....

Person responsible for recording: .... date: ....

12 Site

❑ **cf. accompanying *Sampling* monitoring form (11)**

❑ **Location/municipality: ....canton: ....**

Name of field: ....land register no.: ....

Coordinates: ....altitude: ....national monitoring map no.: ....

13 Contacts

❑ **cf. accompanying *Sampling* monitoring form (11)**

❑ **Owner: ....**

❑ **Farmer: ....**

2 General operational data

21 Production type

❑ organic ❑ integrated ❑ conventional

22 Zoning

❑ arable zone ❑ extended transitional zone ❑ transitional zone ❑ hill zone

❑ mountain zone 1 2 3 4 (mark as applicable)

23 Laboured areas (ha)

agricultural cultivation: .... fertilisable area: .... arable area: ....

24 Farmer

on the farm since (year): .... previous farmer: ....

3 Land use

31 Permanent grassland/pasture

❑ mown meadow ❑ pasture ❑ mown pasture

32 Arable farming / crop rotation

crops: .... year:

....

....

....

....

....

....

....

....

....

33 Orchards

❑ apples ❑ pears ❑ damsons ❑ cherries

❑ others: ....

34 Horticulture

❑ fresh vegetables ❑ vegetables for tin production

crops: ....

....

35 Viniculture

Duration (years): ....age of vineyard (years): ....

4 Present livestock / manure produced on farm

41 Cattle manure unit (number of CMU)

Total CMU:.. pigs (fattening pigs FPU; or else pig-CMU):...................................

42 Present livestock (number)

pigs: ....cattle: .... horses: ....

ruminants: ....poultry: .... others: ....

43 Farmyard manure contracts

type: .... quantity/year: .... supply/delivery: ....

....

5 Bought-in manure

51 Mineral fertilisers containing phosphor

❑ superphosphate ❑ triple superphosphate ❑ raw phosphate ❑ slag phosphate

❑ others (product/manufacturer):...

....

52 Recycling fertilisers

❑ compost: quantity/year:.. origin: ....

❑ sewage sludge: quantity/year:.. origin: ....

❑ others:..quantity/year:....................................... origin: ....

53 Additional information

6 Use of pesticides

61 Type, quantity, origin

Product name (quantity/year):

....

....

....

....

....

....

....

7 Date and signature

Bold type: minimum data set

71 Date and signature

Date: .... **signature:** ....

Forestry additional monitoring form — Annex 5-6

1 Identification

Bold type: minimum data set

11 Project

Project: .... site/plot: ....

Person responsible for recording .... date: ....

12 Place

❑ **cf. accompanying *Sampling* monitoring form (11)**

❑ **Location/municipality: .... canton: ....**

Name of field: .... land register no.: ....

Coordinates: ....altitude: .... national monitoring map no.: ....

13 Contacts

❑ **cf. accompanying *Sampling* monitoring form (11)**

❑ **Owner: ....**

❑ **Farmer: ....**

❑ **Forester: ....**

2 Operational data

21 Forest type

❑ high forest ❑ medium forest ❑ coppice

22 Type of forestry

❑ group felling ❑ strip felling ❑ clear felling ❑ selective felling

3 Stand data

31 Type of stand mixture

❑ **coniferous (91–100 % conifers)** ❑ **mixed coniferous (51–90 % conifers)**

❑ **mixed deciduous (11–50 % conifers)** ❑ **deciduous (0–10 % conifers)**

32 Stand cover

Ratio of crown projection area to total area (%): ....

33 Development stage

Chest-height diameter of 100 thickest trees per ha (d_{dom}): ....cm

❑ recruitment (d_{dom}<12 cm) ❑ pole wood (d_{dom} = 12–30 cm)

❑ small diameter roundwood (d_{dom} = 31–40 cm) ❑ medium diameter roundwood (d_{dom} = 41–50 cm)

❑ large diameter roundwood (d_{dom}>50 cm) ❑ mixture (no predominant development stage)

34 Stand structure

❑ single level ❑ stepped

❑ multi-level (give height of each level):

....

....

....

35 Top height

Average height of 100 thickest trees per ha (h_{dom}): ....

36 Stand age

Average age of stand (years): ....

37 Additional information

4 Date and signature

Bold type: minimum data set

41 Date and signature

Date: .... signature: ....