Federal Soil Protection and Contaminated Sites Ordinance (BBodSchV)

dated 12 July 1999

On the basis of §§ 6, 8 paragraphs 1 and 2 and § 13 paragraph 1 sentence 2 Federal Soil Protection Law of 17 March 1998 (Federal Law Gazette I p. 502), the Federal Government, after hearing the parties concerned, decrees the following:

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Part One

General Provisions

§ 1
Scope of Application

This Ordinance shall be applied to

(1) the investigation and evaluation of suspected sites, suspected contaminated sites, harmful soil changes and contaminated sites as well as to the requirements in respect of sampling, analysis and quality assurance pursuant to § 8 paragraph 3 and § 9 Federal Soil Protection Law,

(2) requirements in respect of warding off danger by way of decontamination and stabilizing measures well as other protective and restrictive measures pursuant to § 4 paragraphs 2 to 5, § 8 paragraph 1 sentence 2 No. 3 Federal Soil Protection Law,

(3) supplementary requirements in respect of investigations and plans for remediation in case of specific contaminated sites pursuant to § 13 paragraph 1 Federal Soil Protection Law,

(4) requirements in respect of the precaution against the development of harmful soil changes pursuant to § 7 Federal Soil Protection Law including the requirements in respect of the application and introduction of materials pursuant to § 6 Federal Soil Protection Law,

(5) the determination of trigger and action values as well as of precaution values including the admissible additional pollution load pursuant to § 8 paragraph 1 sentence 2 Nos. 1 and 2 and paragraph 2 Nos. 1 and 2 Federal Soil Protection Law.

§ 2
Definitions

For the purposes of this Ordinance,

(1) soil material

shall be material from soils as defined by § 2 paragraph 1 Federal Soil Protection Law and their initial substrates, to include topsoil, which is excavated, moved or treated in connection with construction works or other changes to the crust of the earth;

(2) area of impact

shall be an area where impacts on resources to be protected can be expected that originate from a real property within the meaning of § 2 paragraphs 3 to 6 Federal Soil Protection Law or where impacts on the soil cause concern about the development of harmful soil changes;

(3) exploratory investigation

shall be on-site examinations, in particular measurements, on the basis of the results of a survey in order to determine whether the suspicion of a harmful soil change or contaminated site can be ruled out or whether there is reasonable suspicion within the meaning of § 9 paragraph 2 sentence 1 Federal Soil Protection Law;

(4) detail investigation

shall be the comprehensive further examination for the final hazard assessment which particularly serves the determination of amount and spatial distribution of pollutants, their mobile or mobilizable components, possibilities for their spreading in soil, water and air, as well as the possibility of their intake by human beings, animals and plants;

(5) leachate prognosis

shall be the estimation of the pollutants reaching the groundwater with the leachate and originating, or to be expected in the foreseeable future, from a suspected site, a suspected contaminated site, a harmful soil change or a contaminated site, in consideration of pollutant concentrations and loads and related to the area of transition from the unsaturated zone to the water-saturated zone;

(6) pollutants

shall be the substances and preparations which, due to their harmfulness for health, their longevity or bio-availability in the soil or due to other characteristic features and their concentration, are suited to harm the functions of the soil or to provoke other dangers;

(7) exposure conditions

shall be the way, influenced by the local conditions and the use of a real property in a particular case, in which the resources to be protected may be exposed to the effect of pollutants;

(8) pathway

shall be the route of a pollutant from the source of pollution to the place of potential effect on a resource to be protected;

(9) background content

shall be the pollutant content of a soil which is made up of the geogenic (natural) basic content of a soil and the ubiquitous substance distribution as a consequence of diffuse inputs into the soil;

(10) erosion area

shall be the area from which the soil material is washed away with surface run-off;

(11) root-permeable soil layer

shall be the soil layer which can be penetrated by the roots of plants in dependence of the natural site conditions.

Part Two

Requirements in Respect of the Investigation and Evaluation of Suspected Sites and Suspected Contaminated Sites

§ 3

Investigation

(1) Indications for the existence of a contaminated site at a former industrial site are given especially when harmful substances were handled on real properties over an extended period of time or in considerable amounts and the respective method of operation, management or procedure or disturbances of operation in accordance with regulations give reason to suspect considerable inputs of such substances into the soil. At former waste deposits, such indications exist especially in cases where the type of operation or the time of closure give reason to suspect that the waste was not treated, stored or deposited properly.

(2) Paragraph 1 sentence 1 shall be applied analogously to harmful soil changes. Indications for the existence of a harmful soil change are given, in addition to paragraph 1, particularly in the form of general or specific clues to

a. the input of pollutants over an extended period of time or in a considerable amount through the air or a body of water or through the application of considerable loads of waste or waste waters onto soils

b. a considerable release of naturally increased pollutant contents in soils

c. increased pollutant contents in food or fodder plants at the site

d. water with considerable loads of pollutants coming out of soils or former waste deposits

e. considerable erosion and deposition of soil by water or wind.

To be included hereby shall be the findings from general investigations or empirical values from comparable situations, in particular with respect to the spreading of harmful substances.

(3) In the event of indications described in paragraphs 1 or 2, the suspected site or suspected contaminated site shall, after their identification, be subjected to an exploratory investigation first.

(4) Specific indications which give sufficient grounds for the suspicion of a harmful soil change or contaminated site (§ 9 paragraph 2 sentence 1 Federal Soil Protection Law) as a rule exist when examinations reveal an exceeding of trigger values or when, based on an evaluation pursuant to § 4 paragraph 3, an exceeding of trigger values is to be expected. In case there is reasonable suspicion as per sentence 1 or based on other ascertainments, a detail investigation shall be conducted.

(5) In the course of detail investigations, it shall also be established whether hazards result from spatially limited accumulations of pollutants within a suspected site or suspected contaminated site and whether and how a delimitation of unpolluted areas is necessary. A detail investigation can be done without in cases where the hazards, considerable disadvantages or considerable nuisances emanating from harmful soil changes or contaminated sites can be warded off or otherwise eliminated with simple means, according to the determination by the competent authority.

(6) As far as, due to the local conditions or based on the results of soil gas examinations, there are indications for the spreading of volatile pollutants from a suspected site or a suspected contaminated site into buildings, the indoor air shall be examined; the duties and powers of other authorities remain unaffected.

(7) Within the framework of directions for investigation pursuant to § 9 paragraph 2 sentence 1 Federal Soil Protection Law, also recurrent investigations of the pollutant spreading and the relevant circumstances come into consideration.

(8) As for the rest, the requirements in respect of the investigation of soils, soil material and other materials, as well as of soil gas, landfill gas and leachate are governed by Annex 1.

§ 4
Evaluation

(1) The results of the exploratory investigations shall, pursuant to this Ordinance, be evaluated in consideration of the circumstances of the particular case, above all also on the basis of trigger values.

(2) In cases where the content or the concentration of a pollutant is below the respective trigger value indicated in Annex 2, the suspicion of a harmful soil change or contaminated site is eliminated in this respect. When a trigger value pursuant to Annex 2 No. 3 is exceeded at the sampling site, it shall be ascertained in the particular case whether the pollutant concentration in the leachate exceeds the trigger value at the site of assessment. Measures specified in § 2

paragraphs 7 or 8 Federal Soil Protection Law can already become necessary when, in a particular case, all unfavorable circumstances assumed in the derivation of a trigger value pursuant to Annex 2 coincide and the content or concentration of a pollutant is slightly above the respective trigger value in Annex 2.

(3) For the evaluation of the groundwater hazards emanating from suspected sites or suspected contaminated sites, a leachate prognosis shall be made. In cases where a leachate prognosis is based on investigations pursuant to Annex 1 No. 3.3, it shall be estimated and evaluated in the particular case first of all to what extent the pollutant concentration in the leachate can be expected to exceed the trigger value at the site of assessment. Site of assessment is the area of transition from the unsaturated zone to the saturated zone.

(4) The results of the detail investigation shall, pursuant to this Ordinance, be evaluated in consideration of the circumstances of the particular case, especially also on the basis of action values, to determine the extent in which measures pursuant to § 2 paragraphs 7 or 8 Federal Soil Protection Law are required.

(5) As far as this Ordinance does not establish any trigger or action values for a pollutant, the methods and standards applied in Annex 2 for the derivation of such values shall be considered for the evaluation. They are published in Federal Gazette No. 161a dated 28 August 1999.

(6) In the event of a use on sections of a suspected site or a suspected contaminated site which deviates from and is more sensitive than the prevailing use, these sections shall be evaluated in accordance with the standards established for their use.

(7) In cases where information is available from groundwater examinations in a particular case, these shall be considered in the evaluation regarding pollutant inputs into the groundwater. In cases where increased pollutant concentrations in the leachate or other pollutant discharges give reason to expect, in the long run, only small pollutant loads and only locally increased pollutant concentrations in waters, these facts shall be considered when looking into the proportionality of investigation and remediation measures. Water law provisions remain unaffected.

(8) A harmful soil change shall not be considered to exist in soils with naturally increased pollutant contents solely on the basis of these contents, unless these substances were or are released in a considerable extent as a result of impacts on the soil. In case of soils with large-area, settlement-related increases in pollutant contents, a comparison of these contents with the pollutant contents ascertained in a particular case can be included in the risk assessment.

Part Three
Requirements in Respect of the Remediation of Harmful Soil Changes and of Contaminated Sites

§ 5
Remediation Measures, Protective and Restrictive Measures

(1) Decontamination measures are suited for remediation when they are based on technically and economically feasible procedures which make their practical suitability for the environmentally safe elimination or reduction of pollutants appear certain. In this connection, also the consequences of the interference, in particular for soils and waters, must be considered. Upon completion of the decontamination measure, proof shall be furnished to the competent authority that the remediation goal was achieved.

(2) In cases where pollutants shall be eliminated pursuant to § 4 paragraph 5 Federal Soil Protection Law and a previous pollution load exists, the responsible party shall in principle be asked to do everything he would have had to do without the previous pollution load. The real property shall be restored to allow uses that were possible before.

(3) Stabilizing measures are suited for remediation provided they guarantee that the pollutants remaining in the soil or in contaminated sites will, in the long run, not bring about any dangers, considerable disadvantages or considerable nuisances for the individual or the general public. The hazard potential of the pollutants remaining in the soil and their conversion products must be considered hereby. A subsequent restoration of the stabilizing effect within the meaning of sentence 1 must be possible. The effectiveness of stabilizing measures must be proven to the competent authority and must be monitored permanently.

(4) Also a suitable covering of soils that underwent a harmful change or of contaminated sites by means of a soil layer or sealing can be taken into consideration as stabilizing measure.

(5) In case of harmful soil changes or contaminated sites on areas used for agricultural and forestry purposes, especially protective and restrictive measures through adjustment of use and management of soils as well as changes in the quality of the soil come into consideration. Records shall be kept on any protective and restrictive measures taken. Agreement shall be reached with the competent agricultural technical authority. § 17 paragraph 3 Federal Soil Protection Law remains unaffected.

(6) In cases where moved, excavated or treated material shall be applied or introduced again or moved around within the scope of remediation in the area of the same harmful soil change or contaminated site or within the area of a compulsory remediation plan, the requirements of § 4 paragraph 3 Federal Soil Protection Law shall be fulfilled.

Part Four
Supplementary Provisions for Contaminated Sites

§ 6
Investigation and Planning for Remediation

(1) In the course of remediation investigations, it shall be studied in particular which measures are suited to achieve a remediation within the meaning of § 4 paragraph 3 Federal Soil Protection

Law, to what extent changes to the soil will remain after the accomplished remediation, and which legal, organizational and financial circumstances are of significance for the performance of the measures.

(2) When establishing a remediation plan, the measures specified in § 13 paragraph 1 sentence 1 No. 3 Federal Soil Protection Law shall be represented completely both in text and drawings. It shall be shown in the remediation plan that the scheduled measures are suited to permanently avoid dangers, considerable disadvantages or considerable nuisances for the individual or the general public. To be represented are further the impacts of the measures on the environment and the expected costs as well as required licenses, also as far as a compulsory remediation plan pursuant to § 13 paragraph 6 Federal Soil Protection Law cannot include these.

(3) As for the rest, the requirements in respect of a remediation investigation and a remediation plan are governed by Annex 3.

Part Five
Exceptions

§ 7
Exceptions

§ 6 shall not be applied to harmful soil changes and contaminated sites in case of which, according to determination by the competent authority, hazards, considerable disadvantages or considerable nuisances can be warded off or otherwise eliminated with simple means.

Part Six
Supplementary Provisions for Warding off the Danger of Harmful Soil Changes Resulting from Soil Erosion by Water

§ 8
Warding off the Danger of Harmful Soil Changes Resulting from Soil Erosion by Water

(1) The existence of a harmful soil change resulting from soil erosion by water can be assumed especially in cases where

a. considerable amounts of soil material were washed out of an erosion area by the surface runoff and

b. further soil erosion according to No. 1 can be expected.

(2) Indications for the existence of a harmful soil change resulting from soil erosion by water are given especially when areas located outside the supposed erosion area were loaded with washed off soil material.

(3) In case of indications mentioned in paragraph 2, it shall be ascertained whether a harmful soil change is the result of soil erosion by water. When it can be established from which erosion area the washed-off soil originates and that considerable amounts of soil material were washed off from this area, it shall be examined whether the prerequisites of paragraph 1 No. 2 are fulfilled.

(4) The evaluation of the results of the investigations will be related to a particular case, in consideration of the peculiarities of the site. Further soil erosion is to be expected in cases where

a. considerable amounts of soil material were already washed out of the same erosion area on various occasions in the past years or

b. the site data and the data on long-term precipitations in the area reveal that, within a period of ten years, another occurrence of soil erosion according to paragraph 1 No. 1 can be expected with reasonable probability.

(5) Further requirements in respect of the investigation and evaluation of areas where there is suspicion of a harmful soil change resulting from soil erosion by water are laid down in Annex 4.

(6) In cases where the erosion area is used for agricultural purposes, the competent advisory agency referred to in § 17 Federal Soil Protection Law shall be given an opportunity within the framework of consultations to recommend suitable erosion-reducing measures to allow the use of the erosion area. In the event of directives, agreement shall be reached with the competent agricultural technical authority.

Part Seven

Precautions against the Development of Harmful Soil Changes

§ 9

Concern about Harmful Soil Changes

(1) As a rule, there is reason for concern about the development of harmful soil changes pursuant to § 7 Federal Soil Protection Law when

1. pollutant concentrations are measured in the soil that exceed the precaution values indicated in Annex 2 No. 4 or

2. a considerable accumulation of other pollutants occurs which, because of their properties of causing cancer, changing hereditary factors or endangering reproduction or because of toxic characteristics, are especially suited to cause harmful soil changes.

§ 17 paragraph 1 Federal Soil Protection Law remains unaffected.

(2) In case of soils with naturally increased pollutant contents, the exceeding of precaution values pursuant to Annex 2 No. 4 only gives reason for concern about the development of harmful soil changes if a considerable release of pollutants or additional inputs by the parties obligated under § 7 sentence 1 Federal Soil Protection Law can be expected to have adverse impacts on the soil functions.

(3) Paragraph 2 applies mutatis mutandis to soils with large-area, settlement-related increases in pollutant concentrations.

§ 10

Precaution Requirements

(1) In cases where the prerequisites of § 9 paragraph 1 sentence 1 No., paragraphs 2 or 3 are fulfilled, the party obligated under § 7 Federal Soil Protection Law must take precautions in order

to avoid or effectively reduce further pollutant inputs caused by him on the real property and its area of impact, as far as this is proportional also with regard to the designated use of the real property. This includes technical precautions on facilities or procedures as well as measures for the examination and monitoring of soils. As regards the examination, Annex 1 applies accordingly.

(2) Pollutant inputs within the meaning of § 9 paragraph 1 sentence 1 No. 2 for which no precaution values are established shall be limited according to paragraph 1, as far as this is technically feasible and economically justifiable. This applies in particular to substances that are classified in § 4a paragraph 1 Hazardous Materials Ordinance as substances causing cancer, changing hereditary factors or endangering reproduction.

§ 11
Admissible Additional Pollution Load

(1) In cases where the precaution values established in Annex 2 No. 4.1 are exceeded for a pollutant, an additional load up to the amount of the annual pollutant loads established in Annex 2 No. 5 is admissible. To be observed hereby are the impacts on the soil through air and waters as well as by direct inputs.

(2) As far as the admissible additional load established in Annex 2 No. 5 is exceeded for a pollutant, the geogenic or large-area, settlement-related previous loads shall be considered in a particular case.

(3) The loads established in Annex 2 No. 5 do not determine, in the sense of § 3 paragraph 3 sentence 2 Federal Soil Protection Law, which additional loads resulting from the operation of a facility are not to be regarded as causal contribution to the development of harmful soil changes.

§ 12
Requirements in Respect of the Application and Introduction of Materials onto or into the Soil

(1) To provide a root-permeable soil layer, only soil material as well as excavated earth according to DIN 19731 (edition 5/98) and mixtures of soil material and waste that satisfies the substance quality requirements set forth in the ordinances issued pursuant to § 8 Closed-Cycle Materials Management and Waste Law as well as the Sewage Sludge Ordinance may be applied or introduced onto or into soils.

(2) The application and introduction of materials onto or into a root-permeable soil layer or to provide a root-permeable soil layer within the scope of recultivation projects, including restoration for utilization, is admissible when

a. especially the kind, amount, pollutant contents and physical attributes of the materials as well as the the pollutant concentents of the soils at the site of application or introduction do not give reason for concern about the development of harmful soil changes pursuant to § 7 sentence 2 Federal Soil Protection Law and § 9 of this Ordinance and

b. at least one of the soil functions mentioned in § 2 paragraph 2 Nos. 1 and 3 letters b and c Federal Soil Protection Law is permanently secured or restored.

The intermediate storage and the moving around of soil material on real properties in connection with the establishment or modification of structural and operational facilities are not subject to the provisions of this section when the soil material is used again at the place of origin.

(3) Before the application and introduction of materials, the parties obligated under § 7 Federal Soil Protection Law must perform or arrange for performance of the necessary examinations of the materials in compliance with Annex 1. The competent authority pursuant to § 10 paragraph 1 Federal Soil Protection Law may order further investigations in regard to the properties of site and soil in cases where the development of a harmful soil change must be feared; the requirements of DIN 19731 (edition 5/98) shall be observed hereby.

(4) In the event of an agricultural follow-on use, the pollutant contents in the developed root-permeable soil layer shall, with respect to future unavoidable pollutant inputs as a result of management measures or atmospheric pollutant inputs, not exceed 70 percent of the precaution values indicated in Annex 2 No. 4.

(5) When applying soil material onto agricultural soils, including soils used for horticultural purposes, their yield capacity shall be secured or restored for a long time and must not be permanently reduced.

(6) When providing a root-permeable soil layer for agricultural follow-on use within the framework of recultivation projects, including restoration for utilization, soil material shall be applied or introduced that is suitable by kind, amount and pollutant content.

(7) The nutrient supply in connection with the application and introduction of materials onto and into the soil shall be adapted, by amount and availability, to the demand of the plants of subsequent vegetation in order to avoid to the largest extent possible especially nutrient inputs into waters. DIN 18919 (edition 09/90) shall be observed.

(8) Soils that satisfy to a special degree the soil functions specified in § 2 paragraph 2 Nos. 1 and 2 Federal Soil Protection Law shall be excluded from the application and introduction of materials. This also applies to soils in forests, in water protection zones pursuant to § 19 paragraph 1 Federal Water Law, in sites and parts of nature and landscape legally declared protected areas pursuant to §§ 13, 14, 14a, 17, 18, 19b and 20c Federal Nature Conservation Law, as well as to the soils of the core zones of major nature conservation projects of the Federal Government that are of significance for the entire country. The competent technical authorities may admit deviations herefrom when the application or introduction is necessary from a forest or nature conservation point of view or for reasons of groundwater protection.

(9) When applying and introducing materials onto or into the soil, compaction, waterlogging and other unfavorable soil changes shall be avoided by suitable technical measures as well as taking into consideration amount and time of application. After materials of a thickness of more than 20 centimeters are applied, an effort must be made to secure or build up a solid soil structure. DIN 19731 (edition 5/98) shall be observed.

(10) In areas with increased pollutant concentrations in soils, it is admissible to move the soil material around within the area provided this does not constitute an additional impairment for the soil functions mentioned in § 2 paragraph 2 Nos. 1 and 3 letters b and c Federal Soil Protection Law and, in particular, this does not have a negative effect on the pollution situation at the site of application. Areas of increased pollutant concentrations can be determined by the competent authority. The competent authority can thereby also admit deviations from paragraphs 3 and 4.

(11) § 5 paragraph 6 remains unaffected.

(12) Paragraph 3 does not govern the application and introduction of soil material onto and into the agriculturally useful area after locally limited erosion occurrences or to return soil material from the cleaning of harvested agricultural products.

Part Eight
Final Provisions

§ 13
Accessibility of Technical Regulations and Standard Specifications

(1) Technical regulations and standard specifications to which reference is made in this Ordinance are deposited for safe custody with the archives of the German Patent Office. Sources of supply are listed in Annex 1 No. 6.2

(2) References to drafts of technical standards in the annexes always relate to the version published at the time indicated in the reference.

§ 14
Entry into Force

This Ordinance enters into force on the day following its promulgation.

The Bundesrat has granted its consent.

Bonn, 12 July 1999

The Federal Chancellor
Gerhard Schröder

The Federal Minister of Environment, Nature Conservation and Nuclear Safety
Jürgen Trittin

Investigation Methods, Sampling, Analysis

Annex 1

Requirements in Respect of Sampling, Analytical Procedures and Quality Assurance during the Investigation

This Annex shall be applied to the investigation of soils, soil materials and other materials that occur in the soil or on the soils of suspected sites or suspected contaminated sites or are scheduled for application or introduction, as well as of soil gas.

In case of former waste deposits suspected of being contaminated, the scope of the investigation and the taking of samples, in particular in regard to testing for landfill gas, high-volatile pollutants, deposited waste and the transition of pollutants into the groundwater, depend on the requirements of the individual case.

For the purpose of this Annex, state of the art of procedures and methods means the level of development of advanced procedures and methods that makes their practical suitability for the aforementioned investigations appear safe. The knowledge of such procedures and methods and of their application are compiled by a selected group of experts at Federal and Länder level as well as the affected parties in consultation with the Länder; this group is convened by the Federal Ministry of Environment, Nature Conservation and Nuclear Safety.

I. Scope of the Investigation and Required Knowledge

The investigations pursuant to § 3 of this Ordinance relate to pathways for which the information that is available in a particular case gives reason to suspect a danger. The determination of the scope of investigation shall be made by taking into consideration the results of the survey, especially the knowledge or justified assumptions of the occurrence of certain pollutants and their distribution, the present use and the use pursuant to § 4 paragraph 4 Federal Soil Protection Law and the protection requirements resulting therefrom, as well as other local circumstances of significance for the assessment. E DIN ISO 10381-3:03.96 shall be observed. In regard to industrial safety, reference is made to ZH 1/183:04.97.

For investigations regarding the pathway *soil - human being*, the uses

I. playgrounds
II. residential areas
III. parks and recreational facilities
IV. industrial and commercial real properties shall be distinguished; for investigations regarding the pathway *soil - useful plant*, the uses
V. agriculture, vegetable garden
VI. grassland

shall be distinguished.

For investigations regarding the pathway *soil - groundwater*, no distinction shall be made by the kind of soil use involved.

1.1 Exploratory Investigation

Exploratory investigations of suspected sites and former industrial sites suspected of being contaminated shall aim particularly at the identification and the estimation of the size of partial areas with varying pollutant contents.

In case of former waste deposits suspected of being contaminated, investigations shall, as a rule, be conducted with respect to landfill gas and high-volatile pollutants and in particular also in regard to the transition of pollutants into the groundwater.

In cases where the groundwater or surface water must be examined on suspected sites or suspected contaminated sites at the request of the competent authority, this shall be considered when determining scope and course of the exploratory investigation for soil or leachate examinations.

In cases where there are no soil mapping documents that could be consulted or there is no suitable soil-related information on suspected sites, a pedological mapping or descriptive soil characterization shall be made at the sampling site within the framework of the exploratory investigation, in the extent necessary for risk assessment, on the basis of the Pedological Mapping Guide, 4th edition, corrected reprint 1996.

The instructions for the investigation of soils and soil materials shall be applied mutatis mutandis to §§ 9, 10 and 12.

1.2 Detail Investigation

In the detail investigation, the circumstances mentioned in § 3 paragraphs 5 and 6 of this Ordinance shall be clarified in addition to the exposure conditions relevant for the pathways, in particular the mobile or mobilizable portions of pollutant contents that are of significance for the various pathways. It shall further be determined whether hazards result from spatially limited accumulations of pollutants within a suspected site or suspected contaminated site and whether and how a delineation of uncontaminated areas is necessary.

2. Sampling

The sampling approach depends in particular on the pathways affected in the individual case, the size of the area, the vertical and horizontal pollutant distribution assumed based on survey results, as well as the present use, the use admissible under planning law, and the previous use. To be observed hereby shall be the requirements listed under Nos. 2.1 to 2.3. The sampling approach shall be justified and documented. The requirements of industrial safety must be complied with.

Areas to be investigated shall be divided into suitable sections for sampling. The breakdown shall be made on the basis of a varying hazard suspicion, a varying soil use, the shape of the terrain or the quality of the soil, as well as peculiarities like, e.g., varying vegetation development, or based on established facts from the survey.

2.1 Planning the sampling for soil investigations - determination of sampling points and sampling depths

In cases where the spatial distribution of pollutants shall be ascertained, the area or partial area to be examined shall in principle be sampled representatively with the aid of a grid. As far as a hypothesis on the spatial distribution of pollutants can be derived from previous knowledge - in case of former industrial sites suspected of being contaminated especially by the results of the survey -, this shall be considered when determining the sampling points and the grid. The results of a suitable on-site analysis may also be considered for the determination of sampling sites.

Suspected pollutant accumulations shall be sampled selectively. Sampling shall be made, especially in regard to number and spatial arrangement of the sampling points, in such a way that the hazard suspicion can be clarified, a potential hazard evaluated, and a spatial delimitation of pollutant accumulations effected.

For the determination of sampling depths for pathways *soil - human being* and *soil - useful plant,* the sampling depths listed in Table 1 shall be taken as a basis when testing for inorganic and nonvolatile organic pollutants.

Table 1

Use-oriented sampling depth in investigations concerning pathways *soil - human being* and *soil - useful plant*

pathway	use	sampling depth
soil - human being	playground, residential area	0-10 cm 1) 10-35 cm 2)
	park and recreational facility	0-10 cm 1)
	industrial and commercial real properties	0-10 cm 1)
soil - useful plant	agriculture, vegetable garden	0-30 cm 3) 30-60 cm
	grassland	0-10 cm 4) 10-30 cm

1) contact area for oral and dermal pollutant intake, additional 0-2 cm in case of relevance of the intake path through inhalation
2) 0-35 cm: average thickness of applied soil layers; at the same time, maximum depth that can be reached by children
3) working horizon
4) main root depth

Soils shall be sampled, as far as possible, by horizon. Basis for the ascertainment of the sequence of the horizons is the Pedological Mapping Guide of the Geological State Offices (AG Bodenkunde, 4th edition 1994). Soils that are faulty down to the subsoil shall be sampled in layers (see Table 1). The thickness of layers or horizons which can be represented by sample drawing is generally 30 cm. Horizons or layers of greater thickness shall be subdivided, as required. In addition to Table 1, that sampling depth must be considered for which special precautions must be taken for a use to be taken into account pursuant to § 4 paragraph 4 Federal Soil Protection Law. The reasons for different sampling depths shall be documented.

During sampling, the following shall be observed in regard to the pathways:

2.1.1 Pathway *soil - human being*

In connection with the determination of sampling points and sampling depth, ascertainments shall also be made regarding the exposure conditions existing in a particular case, especially

- the actual use of the area (kind, frequency, duration)

- the accessibility of the area

- the sealing of the area as well as upgrowth

- the possibility of intake of soil particles through inhalation

- the relevance of further pathways

For the assessment of hazards resulting from the intake of soil particles through inhalation, the uppermost two centimeters of the soil are relevant. Those pollutants are of significance in terms of inhalation for which, according to the derivation standards provided in § 4 paragraph 5 of this Ordinance, the inhalation pathway has proved to be decisive for the establishment of the trigger value. It shall be ensured by means of reserve samples that the pollutant content in the fine-grain fraction up to 63 µm which is relevant for dust development can be analyzed separately, as required.

When it can be assumed, based on available findings, that the pollutants in the soil layer of relevance for the assessment are distributed over an area almost evenly, one mixed sample may be taken on areas up to 10,000 m^2 in size for every 1000 m^2, however at least from 3 partial areas. The mixed sample shall be obtained from 15 to 25 individual samples taken at the same sampling depth. In case of areas smaller than 500 m^2, as well as in back gardens or other gardens of similar use, a subdivision does not have to be made. For areas larger than 10,000 m^2, however, samples shall be taken from at least 10 partial areas.

2.1.2 Pathway *soil - useful plant*

In case of soils used for agricultural - including horticultural - purposes with almost even soil quality and pollutant distribution, one mixed sample shall be taken on areas up to 10 hectares in size as a rule for 1 hectare each, however at least from 3 partial areas, in correspondence with the sampling depths. In case of areas smaller than 5,000 m^2, a subdivision does not have to be made. For areas larger than 10 hectares, however, samples shall be taken from at least 10 partial areas. Sampling shall be made in accordance with the rules for sampling on agricultural soils (E DIN ISO 10381-1: 02.96, E DIN ISO 10381-4: 02.96) by means of 15 to 25 hand-bore samples per partial area which are combined to one mixed sample each.

In vegetable gardens, sampling will as a rule be made by drawing one property-related mixed sample for every sampling depth and, for the rest, in accordance with the rules for sampling on agricultural areas.

The suitability of sampling devices is governed by E DIN ISO 10381-2: 02.96.

2.1.3 Pathway *soil - groundwater*

In case of pathway *soil - groundwater*, samples shall be taken from the unsaturated soil zone as far as below a presumed pollutant accumulation or a conspicuous soil body to allow the ascertainment of vertical pollutant distribution. Sampling shall be made by horizons or layers. In the subsoil, samples may be taken from depth intervals up to 1 m at the most. In justified cases, the consolidation of narrow soil horizons or layers up to a maximum depth interval of 1 m is admissible. Peculiarities shall be evaluated and, if applicable, subjected to separate sampling. The sampling depth shall be reduced when it becomes apparent that a groundwater contamination must be feared as a result of the piercing through water-bearing strata in the subsoil. In cases where the piercing through water-bearing layers is necessary, special safeguarding measures must be taken. The suitability of sampling devices is governed by DIN 4021:10.90.

2.2 Planning the sampling for soil gas

Sampling shall be made in compliance with VDI-guideline 3865, sheets 1 and 2.

2.3 Planning the sampling of moved and excavated soil material

Sampling shall be made in accordance with DIN 52101: 03.88 or DIN EN 932-1: 11.96.

2.4 Drawing of samples

2.4.1 Soils, soil material and other materials

According to DIN 18123: 11.96, the required sample amount depends on the biggest grain size and must be enough to guarantee - after the correct pretreatment of the sample - the laboratory test as well as, if applicable, the holding available of reserve samples. Coordination with the investigating agency should take place.

Coarse materials (materials > 2 mm) and foreign materials that may contain pollutants or to which pollutants may adhere, shall be taken out of the total sample amount and routed to the laboratory test separately. Their mass proportion in the sampled soil horizon or layer unit shall be ascertained and documented.

For the withdrawal of soil, soil material and other materials, procedures shall be applied which are listed in DIN 4021: 10.90 and E DIN ISO 10381-2: 02.96. For the selection of procedures, the required sample amount and the structure of the subsoil must be considered in addition to the information contained in the standard.

2.4.2 Soil gas

The drawing of soil gas samples is governed by VDI-guideline 3865, sheet 2.

2.5 Preservation, transport and storage of samples

For the selection of sample containers as well as for the preservation, transport and storage of samples, the relevant provisions contained in the regulations on investigations pursuant to No. 3.1.3, Tables 3 thru 7, shall be complied with. Where such provisions do not exist, E DIN ISO 10381-1: 02.86 and DIN EN ISO 5667-3: 04.96 shall be observed.

The transport of soil samples for testing for organic pollutants as well as their storage are governed by E DIN ISO 14507: 02.96.

3. Investigation procedures

3.1 Investigation procedures for soils, soil material and other materials

3.1.1 Selection and pretreatment of samples

In case of investigations in stages, a decision must be made for the particular case in which sequence samples obtained in the field are to be analyzed, and, if applicable, whether the consolidation of several samples is expedient. The decision and the reasons for it shall be documented.

The pretreatment of samples, including drying the sample material, shall be made to allow the determination of physico-chemical properties (No. 3.1.3 Table 3) and the determination of inorganic pollutants (No. 3.1.3 Table 4) pursuant to DIN ISO 11464: 12.96. For organic pollutants, E DIN ISO 14507: 02.96 shall be applied.

In cases where a division into coarse and fine grain sizes must be made for soils, soil material and other materials (in particular slags and construction debris), this shall be done with a screen of 2 mm mesh width into size fractions of ≤ 2 mm (fine share) and
> 2 mm (coarse share) grain diameter. Agglomerations shall be crushed, whereby aggregates of low stability (e.g. carbonate, iron-concretions, pumice) should not be broken, however, as far as this is possible. Both size fractions shall be weighed, described and documented; their dry weight share shall be determined. The fine share shall be homogenized and examined. In case of indications for an increased pollutant content of size fraction > 2 mm, this fraction shall be obtained and, after crushing and homogenization, also be examined. Foreign matter contained in the sample material shall be examined separately, as required, and considered in the evaluation.

Representative portions of the samples taken in the field shall be kept as reserve samples. Kind and scope of sample reserving shall be agreed upon based on the requirements of the particular case.

3.1.2 Extraction, elution

Aqua regia-extract

The content of inorganic pollutants for comparing the pollutant intake through pathway *soil - human being* with the values indicated in Annex 2 No. 1 except for cyanides, for pathway *soil - useful plant* on agricultural areas and in vegetable gardens regarding arsenic and mercury according to Annex 2 No. 2.2 and for pathway *soil - useful plant* on grassland according to Annex 2 No. 2.3, as well as in regard to the precaution values indicated in Annex 2 No. 4.1 shall be determined from ground samples (grain size < 150 µm) by way of the aqua regia-extract according to DIN ISO 11466: 06.97.

Ammonium-nitrate extraction

The ammonium-nitrate extract according to DIN 19730: 06.97 shall be used to ascertain the contents of inorganic pollutants for evaluation of the pollutants on pathway *soil - useful plant* on agricultural areas and in vegetable gardens with respect to the plant quality relating to cadmium, lead and thallium pursuant to Annex 2 No. 2.2 as well as on agricultural areas with regard to growth impairments of cultivated plants pursuant to Annex 2 No. 2.4 and can be used for the estimation of inorganic pollutant concentrations in the leachate pursuant to No. 3.3 of this Annex.

Extraction of organic pollutants

The determination of the content of organic pollutants for comparing the pollutant intake through pathway *soil - human being* with the values pursuant to Annex 2 No. 1.2 as well as in regard to the precaution values pursuant to Annex 2 No. 4.2 follows from the soil extracts indicated in No. 3.1.3, Table 5. In case other procedures are to be applied, this shall be justified and proof furnished that the results of these procedures are equivalent or comparable to the results of the procedures indicated above.

Elution with water

For the preparation of eluates with water for estimation of pollutant concentrations in the leachate pursuant to No. 3.3 of this Annex, the procedures indicated in Table 2 shall be applied.

Table 2

Procedures for the preparation of eluates with water

procedure	procedural directions	method
inorganic substances		
soil saturation extract	procedure see (1)	
elution with water	- sample mass in consideration of the dry weight according to DIN 38414-2: 11.85 or DIN ISO 11 465: 12.96 - filtration see (2)	DIN 38414-4: 10.84
organic substances		
column or lysimeter test	To be noted is the speed with which the substance-specific equilibrium concentration sets in	

(1) Obtaining the soil saturation extract:

As preparation, enough bidistilled water is slowly added to the soil sample in a polyethylene receptacle that it is moistened completely. The amount of water needed for pre-moistening depends on the type of soil involved and should correspond approximately to the field capacity. In case of sandy samples, approx. 25 % of the weighed portion of air-dried soil is taken as a basis, for loamy/silty samples approx. 35 %, and for clayey samples approx. 40 %. The amount of water added is determined gravimetrically and recorded. The sample is mixed well and allowed to stand 24 hours at 5ºC under evaporation protection.

To prepare the soil saturation extract, the pre-moistened soil material is placed in centrifuge beakers. Bidistilled water is slowly added under constant stirring until the flow limit is reached (forming a glossy surface and deliquescing of a spatula groove). In case of clayey samples, 15 minutes must have passed until the swelling is finished and, if necessary, water must be added. The amount of water added is determined gravimetrically and the soil paste mixed up with a glass rod. The soil paste shall be kept in the refrigerator or cooling room for 24 hours at 5ºC under evaporation protection for establishment of the equilibrium.

From the weighed portion of air-dried soil and two additions of water, the soil/water ratio is calculated. The water content of the air-dried sample shall thereby be determined separately by an aliquot (drying at 105ºC to constant weight) and considered in the calculation.

To obtain the equilibrium soil solution, centrifugation is made in a refrigerated centrifuge for 30 minutes. The supernatant solution is decanted and filtered through membrane to separate suspended particles into a pre-weighed polyethylene wide-neck bottles under reduced pressure. The filtrate amount shall be determined gravimetrically. The solutions shall be stabilized by adding 10 volume shares of nitric acid (c = 5 mol/l), whereby the addition of acid must be considered in the evaluation of measuring results and the production of calibrating solutions.

(2) Filtration:

A pressure filtration unit for membrane filters is used (142 mm diameter, media-carrying parts of PTFE) with a membrane filter with 0.45 µm pore size. In case different devices are used, the volume to be filtered shall be changed according to the filter surface; the ratio of filtering volume and filter surface shall be adhered to.

After shaking, the suspension shall be allowed to stand approx. 15 minutes to allow sedimentation of the coarse particles. The supernatant liquid shall be decanted as far as possible into the centrifuge beaker.

Centrifugation shall be made for 30 minutes with 2000 g. After that, almost complete decanting of the supernatant liquid in the membrane pressure filtration apparatus. After 5 minutes of filtration without pressure, a pressure of 1 bar is applied to accelerate filtration. In case less than two thirds of the eluate passed the filter after 15 minutes, pressure is raised to 2 bar. If necessary, pressure is increased to 3.5 bar after another 30 minutes. Filtration shall be continued until the entire supernatant liquid of the centrifugation has passed the filter. In case filtration is still not completed after 120 minutes, it is discontinued and work continued with the incomplete filtrate.

3.1.3 Analytical Procedures

Soils, soil material and other materials

The analysis of soils, soil material and, if applicable, other materials shall be performed in accordance with the investigation procedures specified in Tables 3 to 5.

In cases where other procedures are to be used, for which the reasons are indicated, it shall be proven and documented that the results of these procedures are equivalent or comparable to the results of the procedures indicated in Tables 3 to 5.. It shall be examined in a particular case to what extent individual procedures can be applied also under the aspects mentioned in No. 4.2. The pollutant contents shall be related to the dry weight (105ºC). They must be indicated in the same unit as the respective trigger, action and precaution values in Annex 2.

Table 3
Analysis of physico-chemical properties

investigation parameter	procedural directions	method
determination of the dry weight	soil samples fresh from the field or air-dried	DIN ISO 11465: 12.96
organic carbon and total carbon after dry combustion	air-dried soil samples	DIN ISO 10694: 08.96
pH-value ($CaCl_2$)	suspension of the soil sample fresh from the field or air-dried in $CaCl_2$-solution; c($CaCl_2$): 0.01 mol/l	DIN ISO 10390: 05.97
grain-size distribution	1) “finger test” in the field *	Pedological Mapping Guide, 4th edition, 1994; DIN 19682-2: 04.97
	2) screening, dispersion, pipette-analysis *	E DIN ISO 11277: 06.94 DIN 19683-2: 04.97
	3) screening, dispersion, areometer method	DIN 18123: 11.96 E DIN ISO 11277: 06.94
bulk density	drying of a soil sample taken in the proper volume at 105ºC, back weighing	E DIN ISO 11272: 01.94 DIN 19683-12: 04.73

* recommended methods

Table 4
Analysis of inorganic pollutant contents

investigation parameter	procedural directions	method
Cd, Cr, Cu, Ni, Pb, Tl, Zn	AAS	E DIN ISO 11047: 06.95
As, Cd, Cr, Cu, Ni, Pb, Tl, Zn	ICP-AES (ICP-MS possible) must consider spectral disturbances in case of great matrix concentrations	DIN EN ISO 11885: 04.98
arsenic (As)	ET-AAS hydride-AAS	in analogy to E DIN ISO 11047: 06.95 DIN EN ISO 11969: 11.96
mercury (Hg)	AAS-vapor compression technique During sample pretreatment, the drying temperature must not exceed 40ºC	DIN EN 1483: 08.97 reduction with tin(II)-chloride or NaBH4
chromium (VI)	1) extraction with phosphate-buffered aluminum sulphate solution 2) elution with water, separation of Cr(III), determination of soluble Cr(VI) in soils	spectrophotometry DIN 18734: 01.99 DIN 38405-24: 05.87
cyanides		E DIN ISO 11262: 06.94

Table 5
Analysis of organic pollutant contents

investigation parameter	procedural directions	method
polycyclic aromatic hydrocarbons (PAH): 16 PAH (EPA) benzo(a)pyrene	1) Soxhlet-extraction with toluene, chromatographic clean-up; quantification by means of GC-MS* 2) extraction with tetrahydrofuran or acetonitrile; quantification by means of HPLC-UV/DAD/F* 3) extraction with acetone, adding petroleum ether, removal of acetone, chromatographic clean-up of the petroleum ether extract, take-up in acetonitrile; quantification by means of HPLC-UV/DAD/F 4) extraction with a water/ acetone/petroleum ether-mix in the presence of NaCl; quantification by means of GC-MS or HPLC-UV/DAD/F	pamphlet No. 1 of LUA-NRW, 1994* pamphlet No. 1 1 of LUA-NRW, 1994* E DIN ISO 13877: 06.95 VDLUFA-book of methods, vol. VII; manual Contaminated Sites vol. 7 LfU HE

investigation parameter	procedural directions	method
hexachlorobenzene	extraction with acetone/cyclohexane-mix or acetone/petroleum ether, if applicable chromatographic clean-up after removal of the acetone; quantification by means of GC-ECD or GC-MS	E DIN ISO 10382: 02.98
pentachlorophenol	Soxhlet-extraction with heptane or acetone/heptane (50:50); derivatization with acetic anhydride; quantification by means of GC-ECD or GC-MS	E DIN ISO 14154: 10.97
aldrin, DDT, HCH-mix	1) extraction with petroleum ether or acetone/petroleum ether-mix, chromatographic clean-up; quantification by means of GC-ECD or GC-MS*	E DIN ISO 10382: 02.98*
	2) extraction with water/acetone/ petroleum ether-mix, quantification by means of GC-ECD or GC-MS	VDLUFA-book of methods, vol. VII
polychlorinated biphenyls (PCB): 6 PCB-congeners (No. 28, 52, 101, 138, 153, 180 according to Ballschmiter)	1) extraction with heptane or acetone/petroleum ether, chromatographic clean-up, quantification by means of GC-ECD (GC-MS possible)	E DIN ISO 10382: 02.98*
	2) Soxhlet-extraction with heptane, hexane or pentane, chromatographic clean-up on $AgNO_3$/silicic acid; quantification by means of GC-ECD (GC-MS possible)	DIN 38414-20: 01.96
	3) extraction with a water/ acetone/petroleum ether-mix in the presence of NaCl; quantification by means of GC-ECD (GC-MS possible)	VDLUFA-book of methods, vol. VII
polychlorinated dibenzodioxins and dibenzofurans	Soxhlet-extraction of freeze-dried samples with toluene, chromatographic clean-up; quantification by means of GC-MS	according to the Sewage Sludge Ordinance in consideration of DIN 38414-24: 04.98, VDI-guideline 3499, sheet 1: 03.90

* recommended method

Eluates and leachate

The analytical determination of inorganic substance concentrations in eluates and leachate shall be made in accordance with the analytical procedures listed in Table 6, the determination of organic substance concentrations in the leachate shall be made in accordance with the methods mentioned in Table 7.

In case other procedures are to be applied, for which reasons are indicated, proof shall be furnished that the results of these procedures are equivalent to or comparable with the results of the procedures indicated in Tables 6 and 7.

Table 6

Determination of the concentration of inorganic pollutants in eluates and leachate

investigation parameter	procedural directions	method
As, Cd, Cr, Co, Cu, Mo, Ni, Pb, Sö, Se, Sn, Tl, Zn	ICP-AES (ICP-MS possible)	on the basis of DIN EN ISO 11885: 04.98*
arsenic (As), antimony (Sb)	hydride-AAS	DIN EN ISO 11969: 11.96
lead (Pb)	AAS	DIN 38406-6: 07.98
cadmium (Cd)	AAS	DIN EN ISO 5961: 05.95
chromium (Cr), total	AAS	DIN EN 1233: 08.96
chromium (Cr VI)	spectrophotometry ion chromatography	DIN 38405-24: 05.87 DIN EN ISO 10304: 11.97
cobalt (Co)	AAS	DIN 38406-24: 03.93
copper (Cu)	AAS	DIN 38406-7: 09.91
nickel (Ni)	AAS	DIN 38406-11: 09.91
mercury (Hg)	AAS vapor-compression technique	DIN EN 1483: 08.97
selenium (Se)	AAS	DIN 38405-23: 10.94
zinc (Zn)	AAS	DIN 38406-8: 10.80
cyanide (CN-), total	spectrophotometry	DIN 38405-13: 02.81 E DIN EN ISO 14403: 05.98
cyanide (CN-) easily set free	spectrophotometry	DIN 38405-13: 02.81
fluoride (F-)	fluoride-sensitive electrode ion-chromatography	DIN 38405-4: 07.85 DIN EN ISO 10304-1: 04.95

*The determination limit shall be adapted to the examination target by suitable measures or suitable technical equipment

Table 7
Determination of the concentration of organic pollutants in the soil leachate

investigation parameter	notes for the procedure	method
benzene	GC-FID	DIN 38407-9: 05.91*
BTEX	GC-FID matrix load must be observed	DIN 38407-9: 05.91
high-volatile halogenated hydrocarbons	GC-ECD	DIN EN ISO 10301: 08.97
aldrin	GC-ECD (GC-MS possible)	DIN 38407-2: 02.93
DDT	GC-ECD (GC-MS possible)	DIN 38407-2: 02.93
phenols	GC-ECD	ISO/DIS 8165-2: 01.97
chlorophenols	GC-ECD or GC-MS	ISO/DIS 8165-2: 01.97
chlorobenzenes	GC-ECD (GC-MS possible)	DIN 38407-2: 02.93
PCB, total	GC-ECD	DIN EN ISO 6468: 02.97 DIN 51527-1: 05.87
	GC-ECD or GC-MS	DIN 38407-2: 07.98
PAH, total	HPLC-F	DIN 38407-8: 10.95
naphthalene	GC-FID or GC-MS	DIN 38407-9: 05.91
mineral oil hydrocarbons	extraction with petroleum ether, gas chromatographic quantification	according to ISO/TR 11046: 06.94

* determination limit must be adapted

3.2 Investigation of soil gas

The investigation of soil gas shall be made according to VDI-guideline 3865, sheets 2 and 3.

3.3 Procedures for the assessment of substance input from suspected sites or suspected contaminated sites into the groundwater

The substance concentrations and substance loads in the leachate and the pollutant input into the groundwater in the transition area from the unsaturated to the water-saturated soil zone (site of assessment) can be estimated unless favorable circumstances allow representative sampling of leachate at the site of assessment.

This estimation can also be made approximately by use of mass transport models

I. through conclusions or back calculations from investigations in the groundwater downflow in consideration of the substance concentration in the incoming groundwater flow, dilution, the pollutant behavior in the unsaturated and saturated soil zone, as well as the pollutant stock in the soil

II. on the basis of in-situ investigations or

III. on the basis of material testing in the laboratory (elution, extraction), in case of inorganic substances in particular the elution with water, according to Table 2.

At the site of sampling, the substance concentration in the leachate can be

IV. equated approximately with the results of the soil saturation extract for inorganic pollutants; estimations in consideration of analytical results from Table 6 and other elution procedures (e.g. DIN 19730 or DIN 38414-4) are admissible provided the equivalence of the results is ensured in particular through reference of these results to the soil saturation extract; results according to DIN 38414-4: 10.84 can only be used when filtration was made in accordance with No. 3.1.2 of this Ordinance;

V. ascertained. with procedures listed in Table 7, for organic substances from column tests of the drawn samples in consideration of the local conditions at the site of sampling, in particular in regard to the time of contact.

The analytical results of the investigation of leachate, groundwater, extracts and eluates, as well as of soil samples shall be indicated together with the respective investigation procedure. The estimation of leachate quality and leachate loads for the transition area from the unsaturated to the water-saturated zone which is based thereon shall be explained in detail and justified.

For the estimation, especially those procedures shall be applied which have been used successfully in practical cases. Expert comments shall be provided here in the particular case.

The following directions for application shall be observed in addition:

In the event that, in a particular case of a harmful soil change or a contaminated site, the access of acid leachates, the access of dissolving agents or a change in the redox potential is to be expected, suitable additional extraction procedures shall be applied.

When estimating the pollutant input in the transition area from the unsaturated to the water-saturated zone, the degradation and retention effect of the unsaturated zone must be considered in particular. The following criteria are of special significance here:

VI. depth of groundwater table
VII. soil type
VIII. content of organic substance (humus content)
IX. pH-value
X. rate of natural groundwater recharge /leachate rate
XI. mobility and degradability of the substances.

The influence of these factors on substance retention in the unsaturated zone is estimated on the basis of generally available scientific knowledge and experience for the respective location. Also the use of mass transport models may be expedient.

In case of direct sampling and investigation of leachate, the dynamics of the measured substance concentrations conditioned by the weather must be considered in the evaluation.

4. Quality assurance

4.1 Sampling and storage of samples

The determination of sampling places and sampling depths as well as the drawing of samples shall be handled by qualified personnel.

Sampling, transport and storage of samples must be made in such a way that an influence of working procedures and/or working materials as well as storage conditions on the chemical, physical and biological quality of the sample material is precluded as far as possible.

Sampling shall be documented. The documentation shall contain all the information relevant for the laboratory test and the evaluation of the examination results, in particular information on

I. date of sampling, person drawing the sample
II. location of the examined area and sampling points
III. designation of the area
IV. sampling depth
V. soil horizons, according to Pedological Mapping Guide, 4th edition, corrected reprint 1996
VI. index of layers
VII. withdrawal procedure
VIII. former and present use of the area, previous knowledge of contaminations.

Existing standards, regulations of the Länder and technical rules concerning quality assurance must be observed.

4.2 Pretreatment and analysis of samples

Suitable internal and external quality assurance measures, in particular with respect to reproducibility (precision) and correctness of the investigation results shall be carried out, monitored and documented.

Internal quality assurance measures are in particular:

IX. the performance of independent multiple determinations
X. the calibration of measuring and testing instruments
XI. the use of certified and/or lab-internal reference materials for quality control of reproducibility and correctness
XII. credibility control of the investigation results.

External quality assurance measures are in particular:

XIII. the successful participation in investigations of comparison, in particular ring tests
XIV. confirmation of competence according to DIN EN 45001:05.90.

The detection and determination limits pursuant to DIN 32645:05.94 shall be indicated for the investigation procedures applied. The determination procedure shall be selected so that, based on the determination limit, the exceeding and staying below the respective trigger, action and precaution values provided in Annex 2 can be evaluated for certain. The determination procedures applied shall be documented.

An uncertainty of measurement pursuant to DIN 1319-3: 05.96 and/or DIN 1319-4: 12.85 shall be indicated for the analytical result.

5. Index of abbreviations

5.1 Units of measure

1 ng (nanogram) = 10^{-9}g = 0.000 000 001 gram

1 µg (microgram) = 10^{-6}g = 0.000 001 gram

1 mg (milligram) = 10^{-3}g = 0.001 gram

1 kg (kilogram) = 10^{3}g = 1,000 gram

1 µm (micrometer) = 10^{-6}m = 0.000 001 meter

1 mm (millimeter) = 10^{-3}m = 0.001 meter

1 cm (centimeter) = 10^{-2}m = 0.01 meter

1 ha (Hektar) = 10^{4}m^{2} = 10,000 square meters

ºC - degree Celsius

5.2 Instrumental analysis

AAS - atomic absorption spectrometry

ET AAS - atomic absorption spectrometry with electrothermal excitation

ICP-AES - atomic emission spectrometry with inductively coupled plasma

GC - gas chromatography

HPLC - high-power liquid chromatography

Detectors (GC, HPLC)

DAD - diode-array-detector

ECD - electron capture detector

FID - flame ionization detector

F - fluorescence detector

UV - ultraviolet detector

MS - mass spectrometer

5.3 Other abbreviations

TM - dry weight

I-TEq - international toxicity equivalents

PTFE - polytetrafluoroethylene

6 PCB-congeners (PCB$_6$) according to Ballschmiter:

Nr. 28:	2,4,4’	trichlorobiphenyl
Nr. 52:	2,2’,5,5’	tetrachlorobiphenyl
Nr. 101:	2,2’4,5,5’	pentachlorobiphenyl
Nr. 138:	2,2’,3,4,4’,5’	hexachlorobiphenyl
Nr. 153:	2,2’,4,4’,5,5’	hexachlorobiphenyl
Nr. 180:	2,2’,3,4,4’,5,5’	trichlorobiphenyl

16 PAH (EPA):

naphthalene
acenaphthylene
acenaphthene
fluorene
phenanthrene
anthracene
fluoranthene
pyrene
benz(a)anthracene
chrysene
benzo(b)fluoranthene
benzo(k)fluoranthene
benzo(a)pyrene
dibenz(a,h)anthracene
Indeno(1,2,3-cd)pyrene
benzo(g,h,iperylene

6. Standards, technical regulations and other methods, sources of supply

6.1 Standards, technical regulations and other methods

E DIN ISO 10381-1: 02.96
Soil quality - sampling - part 1: guidance for the development of sampling programs (ISO/DIS 10381-1: 1995)

E DIN ISO 10381-2: 02.96
Soil quality - sampling - part 2: guidance for sampling procedures (ISO/DIS 10381-2: 1995)

E DIN ISO 10381-3: 02.96
Soil quality - sampling - part 3: guidance regarding safety (ISO/DIS 10381-3: 1995)

E DIN ISO 10381-4: 02.96
Soil quality - sampling - part 4: guidance for the proceeding in the investigation of natural, close-to-natural, and cultivated sites (ISO/DIS 10381-4: 1995)

E DIN ISO 10382: 02.98
Soil quality - gas chromatographic determination of the content of polychlorinated biphenyls (PCB) and organo-pesticides (OCP) (ISO/CD 10382: 1995)

DIN ISO 10390: 05.97
Soil quality - determination of the pH-value (ISO 10390: 1994)

DIN ISO 10694: 08.96
Soil quality - determination of organic carbon and total carbon after dry combustion (elementary analysis) (ISO 10694: 1995)

ISO/TR 11046: 06.94
Soil quality - determination of mineral oil content - by infrared spectrometry and gas chromatographic method

E DIN ISO 11047: 06.95
Soil quality - determination of cadmium, chromium, cobalt, copper, lead, manganese, nickel and zinc - by flame and electrothermal atomic absorption spectrometry method (ISO/DIS 11047)

E DIN ISO 11262: 06.94
Soil quality - determination of cyanides

E DIN ISO 11272: 01.94
Soil quality - determination of the dry bulk density (ISO/DIS 11272: 1992)

E DIN ISO 11277: 06.94
Soil quality - determination of the particle-size distribution in mineral soils - methods by screening and sedimentation after removal of soluble salts, organic substance and carbonates (ISO/DIS 11277: 1994)

DIN ISO 11464: 12.96
Soil quality - pretreatment of samples for physico-chemical examinations (ISO/DIS 11464: 1994)

DIN ISO 11465: 12.96
Soil quality - determination of the dry residue and the water content on the basis of the mass-gravimetric procedure (ISO 11465: 1993)

DIN ISO 11466: 06.97
Soil quality - extraction of trace elements soluble in aqua-regia (ISO/DIS 11466: 1995)

E DIN ISO 13877: 06.95
Soil quality - determination of polycyclic aromatic hydrocarbons (PAH) - high-power liquid chromatographic (HPLC) procedure (ISO/DIS 13877)

E DIN ISO 14154: 10.97
Soil quality - determination of selected chlorophenols in soils - gas chromatographic method (ISO/CD 14154: 1997)

E DIN ISO 14507: 02.96
Soil quality - pretreatment of samples for the determination of organic contaminations in soils (ISO/DIS 14507)

DIN 19730: 06.97
Soil quality - extraction of trace elements with ammonium nitrate solution

DIN 19731: 05.98
Soil quality - recovery of soil material

DIN 19734: 01.99
Soil quality - determination of chromium(VI) in phosphate-buffered solution

DIN 19682-2: 04.97
Soil investigation procedures in agricultural hydraulic engineering - field tests - part 2: determination of the soil type

DIN 19683-2: 04.97
Soil investigation procedures in agricultural hydraulic engineering - physical lab tests, determination of the grain size composition after pretreatment with sodium pyrophosphate

DIN 19683-12: 04.73
Soil investigation procedures in agricultural hydraulic engineering; physical lab tests, determination of the bulk density

DIN EN 1233: 08.96
Water quality - determination of chromium - by atomic absorption spectrometry method, German version, EN 1233: 1996

DIN EN ISO 5667-3: 04.96
Water quality - sampling - part 3: guidance for the preservation and handling of samples (ISO 5667-3: 1994); German version EN ISO 5667-3: 1995(A 21)

DIN EN ISO 5961: 05.95
Water quality - determination of cadmium by atomic absorption spectrometry method (ISO 5961: 1994); German version EN ISO 5961: 1995 (A 19)

DIN EN ISO 6468: 02.97
Water quality - determination of selected organo-insecticides, polychlorobiphenyls and chlorobenzenes; gas chromatographic method after liquid-liquid-extraction (ISO 6468: 1996); German version EN ISO 6468: 1996

ISO/DIS 8165-2: 01.97
Water quality - determination of selected monohydric phenols by derivatization and gas chromatography

DIN EN ISO 10301: 08.97
Water quality - determination of high-volatile halogenated hydrocarbons - gas chromatographic method (ISO10301: 1997); German version EN ISO 10301: 1997

DIN EN ISO 10304-1: 04.95
Water quality - determination of the dissolved anions fluoride, chloride, nitrite, orthophosphate, bromide, nitrate and sulphate by means of ion chromatography - part 1: procedure for slightly polluted waters (ISO 10304-1: 1992); German version EN ISO 10304-1: 1995 (D 19)

DIN EN ISO 10304-3: 11.97
Water quality - determination of the dissolved anions by means of ion chromatography - part 3: determination of chromate, iodide, sulphite, thiocyanate and thiosulphate (ISO 10304-3: 1997); German version EN ISO 10304-3: 1997 (D 22)

DIN EN ISO 11885: 04.98
Water quality - determination of 33 elements by inductively couples plasma-atom-emission spectrometry (ISO 11885: 1996); German version EN ISO 11885: 1997

DIN EN ISO 11969: 11.96
Water quality - determination of arsenic - atomic absorption spectrometry (hydride process)

E DIN EN ISO 14403: 05.98
Water quality - determination of total cyanide and free cyanide with the continuous flow analysis (ISO/DIS 14403: 1998); German version EN ISO 14403: 1998

DIN 38405-4: 07.85
German standard procedure for the investigation of water, wastewater and sludge - anions (group D); determination of fluoride (D 4)

DIN 38405-13: 02.81
German standard procedure for the investigation of water, wastewater and sludge - anions (group D); determination of cyanides (D 13)

DIN 38405-23: 10.94
German standard procedure for the investigation of water, wastewater and sludge - anions (group D) - part 23; determination of selenium by way of atomic absorption spectrometry (AAS) (D 23)

DIN 38405-24: 05.87
German standard procedure for the investigation of water, wastewater and sludge - anions (group D) - part 24: photometric determination of chromium(VI) by means of 1,5-diphenyl carbazide (D 24)

DIN 38406-6: 07.98
German standard procedure for the investigation of water, wastewater and sludge - cations (group E) - determination of lead by way of atomic absorption spectrometry (AAS)(E 6)

DIN 38406-7: 09.91
German standard procedure for the investigation of water, wastewater and sludge; cations (group E); determination of copper by way of atomic absorption spectrometry (AAS)(E 7)

DIN 38406-8: 10.80
German standard procedure for the investigation of water, wastewater and sludge; cations (group E); determination of zinc (E 8)

DIN 38406-11: 09.91
German standard procedure for the investigation of water, wastewater and sludge - cations (group E); determination of nickel by way of atomic absorption spectrometry (AAS)(E 11)

DIN 38406-24: 03.93
German standard procedure for the investigation of water, wastewater and sludge - cations (group E); determination of cobalt by way of atomic absorption spectrometry (AAS)(E 24)

DIN 38407-2: 02.93
German standard procedure for the investigation of water, wastewater and sludge; jointly detectable substance groups (group F); gas chromatographic determination of nonvolatile halogenated hydrocarbons (F 2)

DIN 38407-3: 07.98
German standard procedure for the investigation of water, wastewater and sludge; jointly detectable substance groups (group F); part 3: gas chromatographic determination of polychlorinated biphenyls (F 3)

DIN 38407-8: 10.95
German standard procedure for the investigation of water, wastewater and sludge; jointly detectable substance groups (group F); determination of 6 polycyclic aromatic hydrocarbons (PAH) in water by means of high-power liquid chromatography (HPLC) with fluorescence detection (F 8)

DIN 38407-9: 05.91
German standard procedure for the investigation of water, wastewater and sludge; jointly detectable substance groups (group F); determination of benzene and some derivates by means of gas chromatography (F 9)

DIN 38414-2: 11.85
German standard procedure for the investigation of water, wastewater and sludge; sludge and sediments (group S); determination of the water content and the dry residue or the dry weight (S 2)

DIN 38414-4: 10.84
German standard procedure for the investigation of water, wastewater and sludge; sludge and sediments (group S); determination of the elutability with water (S 4)

DIN 38414-20: 01.96
German standard procedure for the investigation of water, wastewater and sludge - sludge and sediments (group S)- part 20: determination of 6 polychlorinated biphenyls (PCB) (S 20)

DIN 38414-24: 04.98
German standard procedure for the investigation of water, wastewater and sludge - sludge and sediments (group S) - part 24: determination of polychlorinated dibenzodioxins (PCDD) and polychlorinated dibenzofurans (PCDF) (S 24)

DIN EN 1483: 08.97
Water analysis - determination of mercury; German version EN 1483: 1997 (E 12)

DIN 32645: 05.94
Chemical analysis - limit of detection and determination - assessment under repetitive conditions - definitions, procedures, evaluation

DIN 1319-3: 05.96
Fundamentals of measuring practice- part 3: evaluation of the measurements of one measured variable, uncertainty in measurement

DIN 13194: 12.85
Fundamentals of measuring practice: treatment or uncertainties in the evaluation of measurements

DIN EN 45001: 05.90
General criteria for the operation of test laboratories; identical with EN 45001: 1989

DIN 4021: 10.90
Foundation soil - exploration by way of digging and boring as well as withdrawal of samples

DIN 18123: 11.96
Foundation soil - examination of soil samples - determination of the grain size distribution

DIN EN 932-1: 11.96
Test procedure for general characteristics of rock grains - part 1: sampling procedure; German version EN 932-1: 1996

DIN 52101: 03.88
Testing natural stone and rock grains - sampling

DIN 51527-1: 05.87
Testing mineral oil products; determination of polychlorinated biphenyls (PCB) - liquid chromatographic pre-separation and determination of 6 selected PCB by means of gas chromatograph with electron-capture-detector (ECD)

ZH 1/183: 04.97
Safety and health protection rules for work in contaminated areas, Main Federation of Trade Cooperative Associations - Technical Committee Civil Engineering, edition April 1997

VDI-guideline 3865: Measuring organic soil contaminations

- sheet 1: Measuring high-volatile halogenated hydrocarbons, measurement plan for soil gas-testing procedures (Oct 1992)

- sheet 2: techniques for the active withdrawal of soil gas samples (January 1998)

- sheet 3: Measuring organic soil contaminations; gas chromatographic determination of low-boiling organic compounds in soil gas after enrichment on activated coal or XAD-4 and desorption with organic solvents (draft November 1996);

VDI-guideline 3499, sheet 1: Measuring emissions - measuring residual matters, measuring polychlorinated dibenzodioxins and -furans in clean and raw gas from firing plants with the dilution method, determination in filter dust, boiler ash and in slags. VDI-manual Air Pollution Control, vol. 5 (draft March 1990)

Working Group Pedology of the Geological Land Offices and the Federal Institute for Geosciences and Raw Materials (1994): Pedological Mapping Guide - 4th edition, corrected reprint Hannover 1996, E.Schweizerbart'sche Verlagsbuchhandlung Stuttgart

Land Office for Environmental Protection of North Rhine-Westphalia (LUA NRW): determination of polycyclic aromatic hydrocarbons (PAH) in soil samples, pamphlets LUA NRW No. 1, Essen 1994

Hessen Land Office for Environmental Protection (LfU HE): determination of polycyclic aromatic hydrocarbons (PAH) in solids from the contaminated sites sector. Manual Altlasten vol. 7, Wiesbaden 1998

Association of German Agricultural Testing and Research Institutions (VDLUFA): book of methods, vol. VII Environmental Analyses, VDLUFA-Verlag Darmstadt 1998

6.2 Sources of Supply

The standards, technical regulations and other provisions on methods can be purchased from:

I. DIN and ISO standards and draft standards, VDI-guidelines -
DIN- und ISO-Normen und Normenentwürfe, VDI-Richtlinien: Beuth-Verlag GmbH, 10772 Berlin

II. Pedological mapping guide -
Bodenkundliche Kartieranleitung: E. Schweizerbart'sche Verlagsbuchhandlung, 70176 Stuttgart

III. VDLUFA-book of methods (Methodenbuch): VDLUFA-Verlag, 64293 Darmstadt

IV. Pamphlet (Merkblatt) LUA NRW: Landesumweltamt NRW, 45023 Essen

V. Manual (Handbuch) Altlasten LfU HE: Hessische Landesanstalt für Umwelt, 65022 Wiesbaden

VI. ZH 1/183: Main Federation of Trade Cooperative Associations - Technical Committee Civil Engineering
Hauptverband der gewerblichen Berufsgenossenschaften, Fachausschuß Tiefbau, 81241 München

Annex 2

Action, Trigger and Precaution Values

1. Pathway soil - human being (direct contact)

1.1 Definition of uses

a) Playgrounds

Places for children that are generally used for playing, without the playing sand in sandboxes. Officially identified playgrounds shall, if applicable, be evaluated on the basis of the standards applied in the field of public health.

b) Residential areas

Areas serving housing purposes, including back gardens or other gardens of similar use, also as far as they are not represented or specified under planning law within the meaning of the Building Use Ordinance, except for parks and recreational facilities, playgrounds, as well as paved traffic surfaces.

c) Parks and recreational facilities

Facilities serving social, health and sports purposes, in particular public and private green areas as well as unpaved areas that are regularly accessible and used in a comparable way.

d) Industrial and commercial real properties

Unpaved areas of places of work and manufacturing plants that are used only during workhours.

1.2 Action values pursuant to § 8 paragraph 1 sentence 2 No. 2 Federal Soil Protection Law for the direct intake of dioxins/furanes at playgrounds, in residential areas, parks and recreational facilities, and industrial and commercial real properties (in ng/kg dry weight, fine soil, analysis according to Annex 1).

	action values [ng I-TEq/kg TM]*)			
substance	playgrounds	residential areas	parks and recreational facilities	industrial and commercial real properties
dioxins/furanes (PCDD/F)	100	1,000	1,000	10,000

*) sum of the 2,3,7,8-TCDD-toxicity equivalents (according to NATO/CCMS).

1.3 Application of the Action Values

In the event of dioxin-containing lye-residues from copper slate, the action values shall, due to the low resorption in the human organism, be applied not directly to protect human health but rather to ward off danger for a long time.

1.4 Trigger values pursuant to § 8 paragraph 1 sentence 2 No. 1 Federal Soil Protection Law for the direct intake of pollutants at playgrounds, in residential areas, parks and recreational facilities, and industrial and commercial real properties (in mg/kg dry weight, fine soil, analysis according to Annex 1)

trigger values [mg/kg TM]				
substance	playgrounds	residential areas	parks and recreational facilities	industrial and commercial real properties
arsenic	25	50	125	140
lead	200	400	1,000	2,000
cadmium	10 1)	20 1)	50	60
cyanide	50	50	50	100
chromium	200	400	1,000	1,000
nickel	70	140	350	900
mercury	10	20	50	80
aldrin	2	4	10	--
benzo(a)pyrene	2	4	10	12
DDT	40	80	200	--
hexachlorobenzene	4	8	20	200
hexachlorocyclohexane (HCH-mix or β-HCH)	5	10	25	400
pentachlorophenol	50	100	250	250
polychlorinated biphenyls (PCP$_6$)2))	0.4	0.8	2	40

1) in back gardens and small gardens where children stay and food plants are grown, trigger value 2.0 mg/kg TM shall be applied for cadmium.

2) as far as PCB-total contents are determined, the measured values shall be divided by a factor of 5.

2. Pathway soil – food plant

2.1 Definition of uses

a) Agriculture

areas for the cultivation of varying field crops, including vegetables and field food plants; this also includes areas used for commercial gardening

b) Vegetable garden

back garden, small garden and other garden areas used for growing food plants

c) Grassland

permanent green areas

2.2 Trigger and action values pursuant to § 8 paragraph 1 sentence 2 No. 1 Federal Soil Protection Law for the pollutant transition soil – food plant on agricultural areas and in vegetable gardens with regard to the plant quality (in mg/kg dry weight, fine soil, analysis according to Annex 1)

	agriculture, vegetable garden		
substance	method[1)]	trigger value	action value
arsenic	KW	200[2)]	--
cadmium	AN	--	0.04/0.1[3)]
lead	AN	0.1	--
mercury	KW	5	
thallium	AN	0.1	--
benzo(a)pyrene	--	1	--

1) extraction process for arsenic and heavy metals: AN - ammonium nitrate, KW = aqua regia (Königswasser)

2) In case of soils with occasionally decreasing conditions, a trigger value of 50 mg/kg dry weight shall be applied

3) On areas that are used for growing bread wheat or strongly cadmium-accumulating vegetables, an action value of 0.04 mg/kg dry weight shall be applied; otherwise, the action value is 0.1 mg/kg dry weight

2.3 Action values pursuant to § 8 paragraph 1 sentence 2 No. 2 Federal Soil Protection Law for the pollutant transition soil – food plant on grassland areas with regard to the plant quality (in mg/kg dry weight, fine soil, arsenic and heavy metals in aqua regia-extract, analysis according to Annex 1)

	grassland
substance	action value
arsenic	50
lead	1,200
cadmium	20
copper	1,300 [1)]
nickel	1,900
mercury	2
thallium	15
polychlorinated biphenyls (PCB_6)	0.2

1) In case sheep are kept on grassland, an action value of 200 mg/kg dry weight shall be applied.

2.4 Trigger values pursuant to § 8 paragraph 1 sentence 2 No. 1 Federal Soil Protection Law for the pollutant transition soil food plant on agricultural areas with regard to growth impairments of cultivated plants (in mg/kg dry weight, fine soil, in ammonium nitrate-extract, analysis according to Annex 1)

	agriculture
substance	trigger value
arsenic	0.4
copper	1
nickel	1.5
zinc	2

2.5 Application of the trigger and action values

The trigger and action values shall be applied in the assessment of pollutant contents at soil depths ranging from 0 to 30 cm for agricultural areas and in vegetable gardens, as well as soil depths ranging from 0 to 10 cm for grassland according to Annex 1 No. 2.1 table 1. For bigger soil depths mentioned in Annex 1 No. 2.1 table 1, the values must be multiplied by a factor of 1.5.

3. Pathway soil - groundwater

3.1 Trigger values for the assessment of the pathway soil - groundwater pursuant to § 8 paragraph 1 sentence 2 No. 1 Federal Soil Protection Law (in µg/l, analysis according to Annex 1)

inorganic substances	trigger value [µg/l]
antimony	10
arsenic	10
lead	25
cadmium	5
chromium, total	50
chromate	8
cobalt	50
copper	50
molybdenum	50
nickel	50
mercury	1
selenium	10
zinc	500
tin	40
cyanide, total	50
cyanide, easily set free	10
fluoride	750

organic substances	trigger value [µg/l]
mineral oil hydrocarbons [1)]	200
BTEX [2)]	20
benzene	1
high-volatile halogenated hydrocarbons [3)]	10
aldrin	0.1
DDT	0.1

phenols	20
PCB, total[4)]	0.05
PAH, total [5)]	0.20
naphthalene	2

1) n-alkanes (C10 C39), isoalkanes, cycloalkanes and aromatic hydrocarbons
2) high-volatile aromatic hydrocarbons (benzene, toluol, xylols, ethylbenzene, styrene, cumene)
3) high-volatile halogenated hydrocarbons (sum of the halogenated C1 and C2 hydrocarbons)
4) PCB, total: sum of the ploychlorinated biphenyls; as a rule, determination by way of the 6 congeners according to Ballschmiter pursuant to Used Oil Ordinance (DIN 51527) muliplied by a factor of 5; if applicable, for example in case of a known substance spectrum, simple formation of the sum of all relevant individual substances (DIN 38407-3-2 or 3-3).
5) PAH, total: sum of the polycyclic aromatic hydrocarbons without napththalene and methylnaphthalene; as a rule, determination by way of the sum of 15 individual substances according to the list of the US Environmental Protection Agency (EPA) without naphthalene; if applicable, in consideration of other relevant PAH (e.g. quinolene).

3.2 Application of the trigger values

- The trigger values shall be applied to the transition area from the unsaturated to the water-saturated soil zone (site of assessment). The site of soil sampling is not necessarily identical with the site of assessment for the groundwater.

- In the evaluation as to whether it can be expected that the trigger values for leachate are exceeded at the site of assessment, the changes in the pollutant concentrations in the leachate when passing through the unsaturated soil zone as well as the depths of the groundwater table and their variations shall be considered.

- In case of former waste deposits, it is generally not expedient to estimate the pollutant concentrations in the leachate by way of material tests because of inhomogeneities of the deposited wastes. This applies accordingly to former industrial sites with especially uneven pollutant distribution. In these cases, the pollutant concentrations in the leachate can be estimated by drawing conclusions or calculating back from downflow measurements in the groundwater by giving special consideration to the substance concentration in the oncoming flow.

- As far as the pollutant concentrations in the leachate can be measured directly, soil sampling shall, as far as possible, be made at the site of assessment for the groundwater.

- As far as harmful soil changes and contaminated sites are located in the water-saturated soil zone, they shall be evaluated with regard to a danger for the groundwater in accordance with the provisions of water law.

- The geogenic background situation of the respective groundwater region shall be considered when trigger values are applied.

4. **Precaution values for soils** pursuant to § 8 parargraph 2 No. 1 Federal Soil Protection Law (analysis according to Annex 1)

4.1 Precaution values for metals
(in mg/kg dry weight, fine soil, aqua regia-decomposition)

soils	cadmium	lead	chromium	copper	mercury	nickel	zinc
soil type clay	1.5	100	100	60	1	70	200
soil type loam/silt	1	70	60	40	0.5	50	150
soil type sand	0.4	40	30	20	0.1	15	60
soils with naturally increased and large-area settlement-related increased background contents	safe, as far as the release of pollutants or additional inputs pursuant to § 9 paragraphs 2 and 3 of ths Ordinance do not give reason to expect any adverse impacts on the soil functions						

4.2 Precaution values for organic substances
(in mg/kg dry weight, fine soil)

soils	polychlorinated biphenyls (PCB_6)	benzo(a)pyrene	polycyclic aromatic hydrocarbons (PAH_{16})
humus content > 8 %	0.1	1	10
humus content $\leq$ 8 %	0.05	0.3	3

4.3 Application of the precaution values

- The precaution values are differentiated by the main soil types pursuant to the Pedological Mapping Guide, 4th edition, corrected reprint 1996; they consider the precautionary protection of the soil functions in case of sensitive uses. Agricultural soil use is governed by § 17 parargraph 1 Federal Soil Protection Law.

- Highly silty sands shall be evaluated according to soil type loam/silt

- For the precaution values of table 4.1, the acid content of the soils shall be considered as follows:
  - for soils of soil type clay with a pH-value of < 6.0, the precaution values of soil type loam/silt shall be applied to cadmium, nickel and zinc.

  - for soils of soil type loam/silt with a pH-value of < 6.0, the precaution values of soil type sand shall be applied to cadmium, nickel and zinc. § 4 paragraph 8 sentence 2 of the Sewage Sludge Ordinance of 15 April 1992 (BGBl. I p. 912), last amended by the Ordinance of 6 March 1997 (BGBl. I p. 448) remains unaffected.

  - for soils with a pH-value of < 5.0, the precaution values for lead shall be reduced according to the first two points.

- The precaution values of table 4.1 shall not be applied to soils and soil horizons with a humus content exceeding 8 %. If applicable, the competent authorities can make region-specific determinations for these soils.

5. **Admissible additional annual pollutant loads through all pathways** pursuant to § 8 paragraph 2 No. 2 Federal Soil Protection Law (in gram per hectare)

element	load [g/ha a]
lead	400
cadmium	6
chromium	300
copper	360
nickel	100
mercury	1.5
zinc	1,200

Annex 3

Requirements in Respect of Investigations for Remediation and the Remediation Plan

1. Investigations for remediation

Investigations for remediation in case of contaminated sites serve to ascertain the measures that are suitable, necessary and appropriate for the fulfilment of duties specified in § 4 paragraph 3 Federal Soil Protection Law. Measures that qualify shall be represented, by taking into consideration combinations of measures and necessary accompanying measures.

The study shall include in particular

- the suitability of methods with respect to pollutant, soil, material and location
- the technical feasibility
- the time requirement
- the effectiveness with regard to the remediation objective
- a cost estimate as well as the proportion of costs and effectiveness
- the impacts on the parties concerned within the meaning of § 12 sentence 1 Federal Soil Protection Law and on the environment
- the requirement of licenses
- the generation, recovery and disposal of waste
- industrial safety
- duration of the effect of the measures and possibilities for monitoring them
- the requirements of aftercare and
- the possibilities for subsequent improvement.

The study shall be conducted by making use of available data, in particular from investigations pursuant to § 3 of this Ordinance, as well as on the basis of other reliable findings. As far as this information does not suffice, especially to allow the reliable definition of polluted areas or to assess the suitability of remediation methods in a particular case, supplementary investigations shall be conducted to verify the suitability of a method.

The results of the study and the concept of measures to be preferred in view of these results shall be presented.

2. Remediation Plan

A remediation plan shall contain the information listed below under Nos. 1 thru 5 as well as the information and documents necessary for declaring it binding pursuant to § 13 paragraph 6 Federal Soil Protection Law.

1. Statement of the initial situation, in particular with regard to

   - the local conditions (among others, geological, hydrogeological situation; current use admissible under planning law)
   - the hazard situation (summary of the investigations pursuant to § 3 of this Ordinance in regard to pollutant inventory by type, amount and distribution, affected pathways, resources and needs requiring protection)
   - the remediation objectives
   - the decisions taken by authorities and the public-law contracts entered into, in particular also in regard to the concept of measures which will have an effect on the fulfilment of obligations pursuant to § 4 Federal Soil Protection Law, and
   - the results of the investigations for remediation.

2. Description in text and drawing of the measures to be carried out and furnishing proof of their suitability, in particular with regard to

   - the area of impact of the contaminated site and the areas that will be needed for the planned measures
   - the area covered by the remediation plan
   - the elements and the course of the remediation with regard to
     - the construction schedule
     - earthwork (in particular excavation, separation, re-placing, moving around in the area of the remediation plan)
     - demolition work
     - intermediate storage of soil material and other materials
     - waste disposal in case facilities are in operation
     - the use of soils and the deposition of waste at landfills and
     - industrial safety and immission control measures
   - specific technical calculations regarding
     - on-site soil treatment facilities
     - in-situ measures
     - facilities for the collection and treatment of landfill gas or soil gas

    - groundwater treatment facilities
    - facilities and measures for the collection and treatment particularly of leachate
  - the amounts to be treated and the transport routes in case of soil treatment at off-site facilities
  - the technical planning of stabilizing measures and accompanying measures, in particular of
    - surface, vertical and base sealings
    - surface covering layers
    - intermediate storage and/or holding sites
    - accompanying passive pneumatic, hydraulic or other measures (e.g. drainage of the construction field, drainage of the excavated material, encasement, exhaust air interception and treatment) and
  - requirement of official licenses for the measures to be performed.

3. Description of the internal control measures to check the correct execution and effectiveness of the planned measures, in particular
   - the monitoring concept with regard to
     - soil management in case of excavation, separation and re-placing
     - soil and groundwater treatment, degassing or soil gas extraction
     - industrial safety and immission control
     - the accompanying sampling and analysis and
   - the investigation concept for materials and construction components in case of the building of structures.

4. Description of the internal control measures within the scope of aftercare including monitoring, in particular with regard to
   - the requirement and design of facilities or installations for the collection and treatment of groundwater, leachate, surface water, soil gas or landfill gas which shall be operated for a long period of time, as well as requirements in respect of their monitoring and maintenance
   - the measures of surveillance (e.g. measuring stations) and
   - function control with regard to the adherence to remediation requirements and maintenance of stabilizing structures or facilities

5. Description of time schedule and costs.

Annex 4

Requirements in Respect of the Investigation and Evaluation of Areas in Case of Which There is Suspicion of a Harmful Soil Change Resulting from Soil Erosion by Water

1. Application

This Annex shall be applied pursuant to § 8 when investigating areas in case of which there is suspicion of a harmful soil change resulting from soil erosion by water.

2. Investigation and evaluation

In case of indications for the existence of a harmful soil change resulting from soil erosion by water, it shall first be examined

a) whether considerable amounts of soil material were washed out of the erosion area
and

b) from which erosion areas the washed-off soil originates and what were the causes of the erosion.

Clues for identifying the erosion area are in particular clearly noticeable points of transition of soil material from the erosion area to areas located outside the erosion area and affected by the soil material. Further clues are the existence of clearly visible erosion forms on the erosion area. For the investigation according to letter a., it may be necessary to estimate the amount of soil washed off a suspected site during one erosion occurrence or as a consequence of erosion occurrences that took place at an interval of a few weeks at the most. This can be done by means of the „Mapping Guide for the Identification of Current Erosion Forms“ (DVWK 1996).

For the assessment of the probability of a re-occurrence of soil erosions pursuant to § 8 paragraph 1, the statistical evaluations of precipitation recordings taken by the German Weather Service in a specific area over many years shall be consulted in particular. Also erosion prognosis models may be resorted to, as far as it can be proven that they are suited to assess, with sufficient accuracy, the soil amounts washed off the erosion areas during specific erosion occurrences.

The prerequisites for the expectation of further soil erosion pursuant to § 8 paragraph 1 No. 2 are normally fulfilled when considerable amounts of soil material were washed out of the same erosion area at least on one other occasion during the past ten years.