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Soil quality — Sampling —

Part 202: Preliminary investigations

Qualité du sol — Échantillonnage —

Partie 202: Investigations préliminaires

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 190, *Soil quality*, Subcommittee SC 2, *Sampling*.

This first edition of ISO 18400-202, together with ISO 18400-104, ISO 18400-203 and ISO 18400-205, cancels and replaces the first editions of ISO 10381-4:2003 and ISO 10381-5:2005, which have been technically and structurally revised.

The new ISO 18400 series is based on a modular structure and cannot be compared to the ISO 10381 series clause by clause.

A list of all parts in the ISO 18400 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

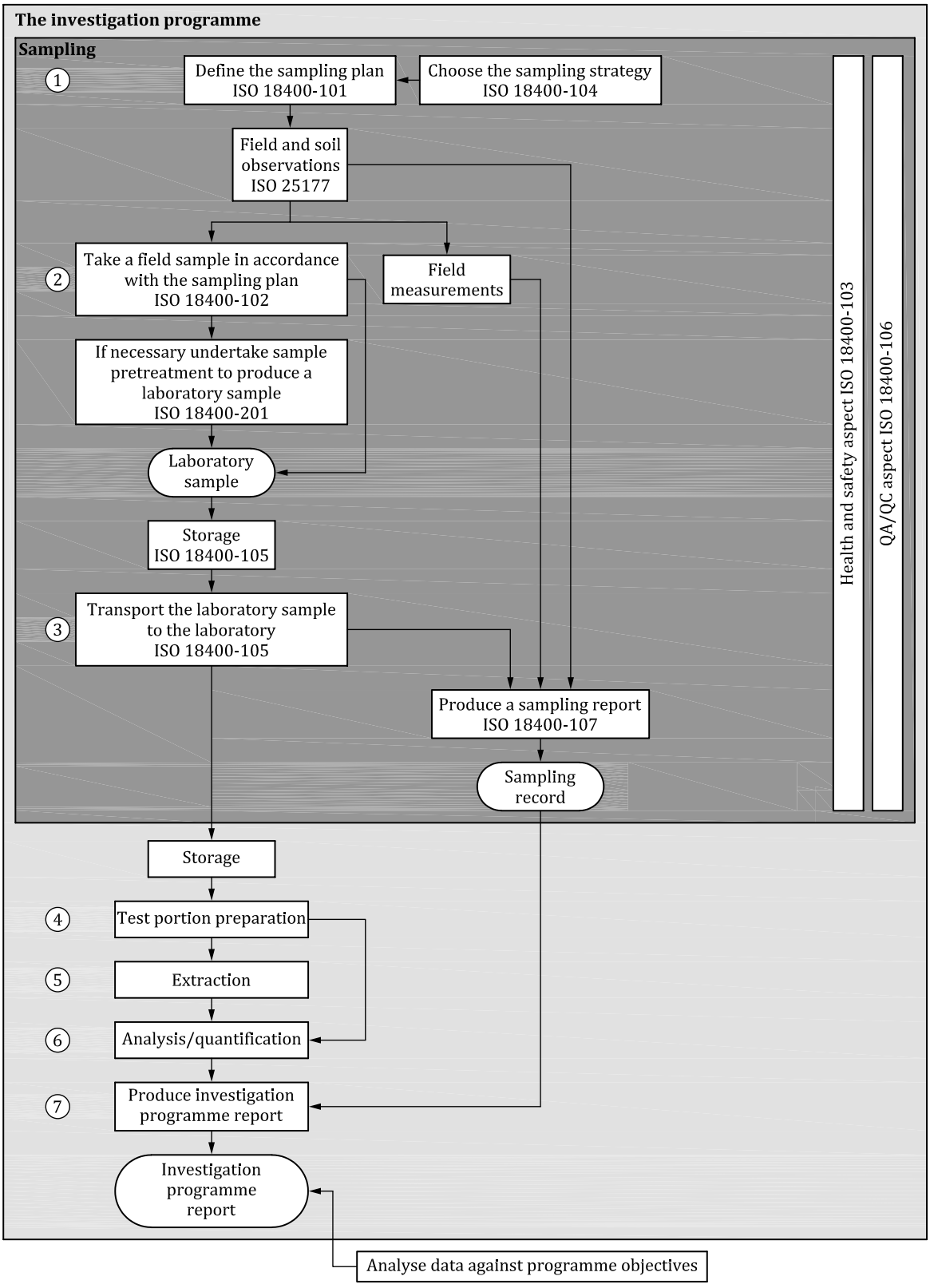
All investigation programmes to gather information about soil quality need some basic information about the subject site and its environmental setting to allow appropriate planning of the field work. To collect this information, a preliminary investigation is carried out comprising desk studies, retrieval of data from archives and databases, interviews and a site reconnaissance. From the information gathered, and the observations made, a conceptual site model can be developed including hypotheses about soil characteristics and their possible spatial distribution.

It is for the user of this document to decide the extent and nature of information required in any particular case taking into account the nature of the site and the objectives of the overall investigation: however, some preliminary information will always be needed. Detailed guidance is provided in the document based mainly on the need to obtain detailed information on many aspects of a site in the more complex cases, e.g. a potentially contaminated site, but the guidance is intended to be helpful when preparing to investigate all types of site.

The sources of information available for use in preliminary investigations will vary from country to country and jurisdiction to jurisdiction and, thus, the guidance given about sources of information in this document is of necessity generic in character. The user will find it useful to prepare detailed information about local sources for their own use. National standards providing guidance on the design and execution of geotechnical investigations often contain a requirement that a desk study and site reconnaissance should be carried out and thus could provide useful guidance about potential sources of information. Similarly, standards covering the demolition and dismantling of old buildings and industrial plant could provide useful information and guidance.

This document deals only with the investigation of the ground. It should be recognized that there could be derelict buildings and/or industrial plants awaiting demolition, dismantling or refurbishment on old urban and industrial sites, but that buildings in a poor state and containing potentially hazardous materials could also be present on farms and similar sites. Failure to investigate these buildings before demolition could put the safety of workers at risk or lead to the spread of contamination on and around the site[7][8]. The investigation of derelict buildings or remnant foundations is outside the scope of this document.

This document is part of a series on sampling standards for soil. The role/position of the standards within the total investigation programme is shown in Figure 1.



NOTE 1 The numbers in circles in Figure 1 define the key elements (1 to 7) of the investigation programme.

NOTE 2 Figure 1 displays a generic process which can be amended when necessary.

Figure 1 — Links between the essential elements of an investigation programme

INTERNATIONAL STANDARD **ISO 18400-202:2018(E)**

Soil quality — Sampling —

Part 202: Preliminary investigations

1 Scope

This document provides guidance on the design and execution of preliminary investigations comprising desk studies and site reconnaissance, and where appropriate, preliminary risk assessment. It is applicable whenever sampling exercises or investigations are to be carried out to determine soil quality.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 11074, *Soil quality — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 11074 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
conceptual site model
synthesis (mental representation) of all information about a site relevant to the task at hand including interpretation of the information as necessary, and recognition of uncertainties in the information including identification of what is known to be unknown

Note 1 to entry: A conceptual site model can be presented in narrative, tabular and/or diagrammatic form.

3.2
conceptual site model
<potentially contaminated site> synthesis (mental representation) of all information about a site relevant to the task at hand with interpretation as necessary and recognition of uncertainties in the information, including, as appropriate, information regarding the ground, groundwater, surface water, soil quality, and surrounding environment, and if the occurrence of contamination is likely, the nature and potential sources of hazardous substances that could be present including soil gases and volatile organic compounds (VOCs), potential migration pathways, and potential receptors, taking into account, when appropriate, planned changes of use and anticipated changes in the environmental setting such as in groundwater levels or propensity to flood

Note 1 to entry: A conceptual site model can be presented in narrative, tabular and/or diagrammatic form.

Note 2 to entry: The future use or uses will not always be known and could also be the subject of client confidentiality.

4 General/principle

A preliminary investigation (Phase I investigation) should always be carried out prior to any intrusive sampling exercise or site investigation. It should be a two-step process involving data collection followed by interpretation and reporting. Data collection should always comprise

— a desk study (including when appropriate consultations), and

— a site reconnaissance (walk-over survey, site inspection).

The assessor should decide the extent and nature of information required in any particular case taking into account the nature of the site, the purpose and the objectives of the overall investigation, the availability of existing information, the size and complexity of the site, known or projected future land uses and other relevant site-specific factors: the investigation needs to be no more detailed than the task at hand requires. However, some preliminary information will always be needed.

It will often be appropriate for a site investigation to be iterative with several stages of investigation within each phase. The objectives should be reconsidered at each stage, and the requirements for further investigation reviewed as the investigatory and assessment processes are developed.

When an investigation is carried out in a number of phases or stages, the preliminary investigation would ordinarily only be undertaken prior to the initial phase or stage. However, the results should be reviewed on completion of the first stage or phase, and after each subsequent stage or phase to determine whether the conclusions, including any preliminary risk assessment require amendment.

The results of the preliminary investigation enable a preliminary conceptual site model to be developed (see Clause 8).

In the case of potentially contaminated sites, the possibility of contamination can be deduced, and hypotheses can be formulated on the nature, location and distribution of the contamination (8.2). These hypotheses form part of the overall preliminary conceptual site model that should be developed, encompassing not only the contamination aspects but also the geology, pedology, hydrogeology, geotechnical properties and the environmental setting. The current and planned site uses are also important aspects of the conceptual site model.

NOTE Although the conceptual site model is usually first formally prepared following a preliminary investigation, it first comes into existence the moment the question is asked whether the site needs to be investigated. At that stage, for example, it could be recognized that the site is agricultural land or is industrial land and the assessor will immediately form an initial picture about what the site might be like and act accordingly. Thus, it is this initial conceptual site model and the purpose of the overall investigation that guide decisions about the scope and depth of the preliminary investigation required.

5 Phases of investigation

A phased approach as described in ISO 18400-104:2018, Clause 4 should always be taken to site investigation. The principal phases are

— preliminary investigation (this document),

— exploratory investigation, and

— detailed site investigation.

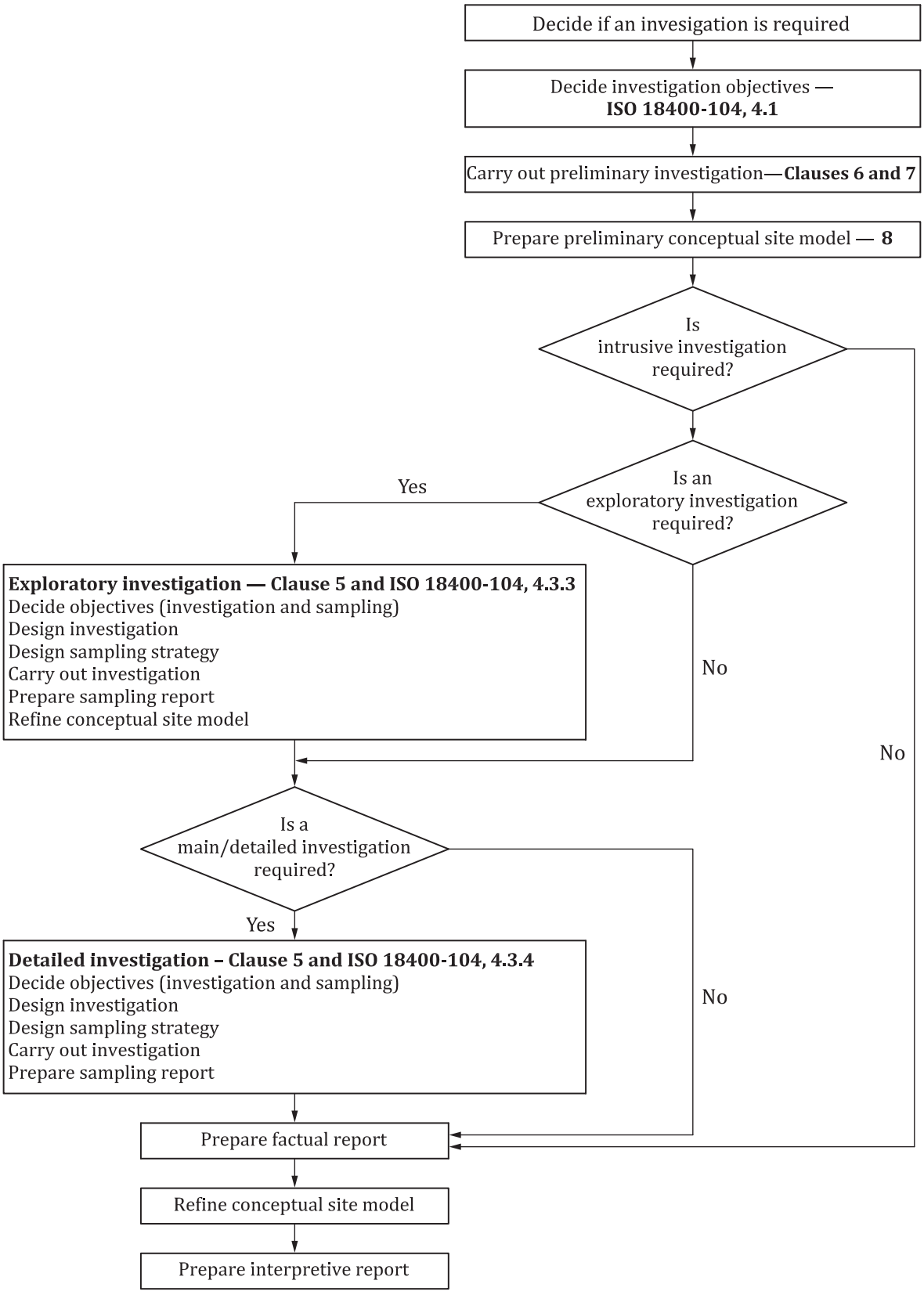


Figure 2 — Flow-chart of phases of site investigation for a potentially contaminated site

NOTE A preliminary investigation is always required but whether intrusive investigation is required, and if so, whether both an exploratory investigation and a detailed (main) investigation are required, will depend on the context and the findings of the preliminary investigation (see ISO 18400-104 for further guidance).

Supplementary investigations could be required subsequent to the detailed site investigation in order to

— fill information gaps, and

— design works and, in the case of a contaminated site, select remedial methods, or design remediation or construction works.

The relationship between these phases for a potentially contaminated site is illustrated in Figure 2.

Before embarking on any phase or stage of investigation including a preliminary investigation, it is important to set data quality objectives in terms of the type, quantity and quality (e.g. analytical quality) of the data and other information that is to be collected. These data quality objectives will depend in part on the nature of the decisions to be made on the basis of the investigation, and the confidence required in those decisions. Failure to set data quality objectives at the outset can lead to significantly higher costs, if, for example, the data collected are not suitable or sufficient for a reliable risk assessment, or leave too many uncertainties in the "conceptual site model" (see 8.1).

6 Objectives of preliminary investigations

The objectives of the preliminary investigation should be set out formally before the investigation is started to ensure that the scope (e.g. sources of information searched) is appropriate.

The preliminary investigation should always provide sufficient information to:

— enable a sampling programme including preparation of a sampling plan if deemed necessary to be designed that is both technically effective and economically acceptable;

— identify measures required to protect the health and safety of the investigating personnel;

— identify measures necessary to protect the environment during any subsequent intrusive investigation;

— identify any aspect of the site requiring immediate attention for reasons of health and safety or protection of the environment (e.g. insecure fences, hazardous substances accessible to trespassers or likely to be dispersed by wind or water) so that those in control of the site (e.g. owner or occupier) can be made aware of potential liabilities.

Other information relevant to the conduct of the sampling programme should also be gathered, e.g. means of access for equipment, locations for site facilities (e.g. laboratories, stores, equipment decontamination), availability and location of power and water, etc., and whether warfare or other military activities might have affected the site (including, for example, whether unexploded ordnance might be present).

NOTE In some jurisdictions, detailed information on the location of WWII bomb hits and, hence, possible unexploded ordnance is available.

Depending on the nature of the site and the objectives of the overall investigation, specific objectives could include:

— providing information on past and current uses of the site and surrounding area and the nature of any hazards and physical constraints;

— providing information on the geology, geomorphology, geochemistry, soil, hydrogeology and hydrology of the site and surrounding area;

— identifying potentially different sub-areas (zones) of a site, based on differing ground conditions; potential contamination; and past, present and future uses;

— identifying areas where informed decisions are to be made using specialist assessment techniques or advisors, e.g. if there are ecological, unexploded ordnance (UXO) or archaeological considerations;

— identifying the need to involve regulatory bodies prior to intrusive investigation;

— determining whether there is a need to inform the neighbourhood.

And in the case of potentially contaminated sites, specifically to obtain information:

— assessing the likelihood of contamination, its nature and its extent;

— evaluating the environmental setting of the site;

— identifying current and likely future receptors, potential sources of contamination and likely pathways and any features of immediate concern, including those that could be introduced in the future;

— providing information from which likely source-pathway-receptor relationships can be identified, and which can then be used to formulate a conceptual site model to enable the design of a field investigation (if required);

— producing a preliminary conceptual model for the site as a whole and/or for zones within the site;

— providing information for the preliminary risk assessment (see 8.4).

7 Scope of preliminary investigations

7.1 General/strategy

The preliminary investigation should consist of:

— a desk study, including consultations (see 7.3) with those who might have relevant information about the site, in which information on the history and other relevant aspects of the site, is collected and critically reviewed (see 7.2);

— a site reconnaissance (site inspection, walk-over survey) (see 7.4);

— development of a conceptual site model (see Clause 8), which in the case of potentially contaminated sites should include:

  — formulation of hypotheses on the possible type(s) and amount of contamination, migration pathways (on- and off-site), and spatial and temporal distribution; together with hypotheses regarding other aspects of the site, such as the hydrogeology;

— drawing conclusions with regard to the need for and scope of further investigations (see 8.4);

— identification of any need for immediate actions to protect humans or the environment (e.g. fencing, removal of superficial deposits).

In most cases, it should be possible to make a preliminary qualitative assessment of (potential) risks to humans and other receptors (see 8.3).

The minimum information that should be collected in the preliminary investigation is set out in 7.2 and 7.3 and the procedures on how the information can be obtained are provided in 7.2.3. Guidance on reporting the results of the preliminary investigation is provided in Clause 9.

The objectives of the preliminary investigation might not require all the elements recommended in 7.2, 7.3 and 7.4, in which case the strategy should identify what elements of the preliminary investigation are essential and those that do not need to be addressed. Some examples of information that could be required relating to stockpiles are listed in Table 1, to agricultural sites in Table 2 and wooded sites in Table 3. Much of the guidance in Table 1 is also applicable to other site types.

Where elements of a preliminary investigation described in 7.2 to 7.4 are not to be included, these should be documented in the report, and any limitations on the final assessment arising from the omissions should be clearly understood by all parties involved and stated in the report.

The strategy should provide for a review of the information obtained at the conclusion of the preliminary investigation to determine if the objectives have been achieved (and are still appropriate) and whether there is a need to carry out an exploratory investigation and/or detailed investigation (see Clause 5).

The site should be divided into zones if necessary or advantageous if this has not already been done (guidance on site zoning is provided in ISO 18400-104). Separate conceptual models should be developed for each zone that is identified.

NOTE It is likely that there will be different requirements for further investigation of each zone.

Care should be taken that a focus on separate zones does not obscure the overall picture and that the potential interactions between zones are not overlooked.

The output from the preliminary investigation should include the preliminary conceptual site model (see Clause 8) and, in the case of potentially contaminated sites, a preliminary risk assessment (see 8.3) based on the information available.

Table 1 — Examples of information requirements for stockpiles

General	Site details	History of the stockpile	Material type and dimensions
Background information on a stockpile will often be essential in order to get (general) information on the material to be sampled. The effort that should be put into obtaining prior information depends on the purpose for sampling in combination with the sampling strategy that is used to fulfil this purpose. Prior information can also be essential for assessing the safety aspects of sampling the particular stockpile.	The project manager should establish details of the site location and access, including any perceived hazards relating, for example, to high stockpiles, non-consolidated stockpiles or difficult access. In some situations, there could be a difference between the owner of the site where the stockpile is situated and the client for whom the stockpile is sampled. If so, the project manager should contact the site owner in order to get access to the stockpile and be informed about any site specific health and safety regulations to comply with.	The project manager should establish a history of the stockpile in order to determine the potential environmental risks involved. The history should include the period before the soil or other material was placed in the stockpile. The history of the stockpile should be based on the location(s) where the material in the stockpile originated from and the processes that occurred on that site. It should also include the process in which the stockpile was formed (e.g. placement in layers, placement by end-tipping, "single" or mixed materials) as this can give prior information on the spatial variability of material within the stockpile.	The project manager should establish the material characteristics (e.g. soil type, water content, particle size distribution, maximum particle size) and dimensions of the stockpile to be sampled.

Table 2 — Background Information requirements for investigation of agricultural sites

— Owner and occupiers.
— Relevant requirements in lease/rental agreements.
— Soil type(s).
— Whether the land to be investigated is used for raising crops or animals and the history of these activities (e.g. what crops or animals and when).
— Whether the farm is “organic” or conventional.
— Whether genetically modified crops are grown.
— Use of pesticides, soil amendment materials, and fertilizers, and how these have been applied.
— If organic wastes (e.g. farmyard manure, sewage sludge) has been spread the time period that has elapsed since this was done (important for safety in respect of the possible presence of pathogens).
— Current or past presence of plant or animal pathogens (7.2.4).
— Presence of ground-nesting birds.
— Whether irrigation is used and if so in what form.
— Presence of areas of stressed vegetation.
— Location of areas of wet ground and/or ground liable to flooding.
— Location used for servicing farm machinery.
— Location of waste deposits (slurry ponds, dung heaps, etc.).
— Location of animal burial pits and filled ponds.
— Location of natural water courses and artificial drainage ditches.
— Location of any in-ground drainage system (e.g. presence of land-drains).
— Location of any old redundant or little used machinery (could be a hazard, impede investigation or be a source of contamination).
— Presence of fuel tanks.
— Presence of underground fuel or gas pipelines (hazardous and there could be severe restrictions of excavation over wide zone).
— Presence of overhead cables.
— Presence of public rights of way (footpaths, bridle paths, etc.) or a “right to roam” (e.g. public access subject to some restrictions).
— Non-farming activities in buildings (e.g. vehicle maintenance, workshops, storage).
— Presence of ecologically sensitive areas or features within or close to the site (farm buildings often house protected birds and bats).
— Presence of archaeological remains.

Table 3 — Examples of background information requirements for wooded sites

— Ownership and occupiers.
— Soil type.
— Type of wood (e.g. deciduous, conifer, mixed, natural or planted, managed or unmanaged, coppiced, ancient woodland).
— Other plants present and whether these can be trafficked (and if so when).
— Wildlife present.
— Domesticated animals or birds present.
— Presence of public rights of way (footpaths, bridle paths, etc.) or a "right to roam" (e.g. public access subject to some restrictions).
— Presence of ecologically sensitive areas or features within or close to the site.
— Presence of archaeological remains.

7.2 Desk study

7.2.1 General

A desk study should include collection of all relevant information on the site, e.g. references to the location, infrastructure, utilization, historical information. It should comprise a combination of documentary research (see 7.2.1) and consultations (see 7.3). The search radius around the site for which information is to be gathered should be specified at the outset of the investigation.

The site location and site boundaries should be accurately established before any investigatory work is commenced.

The desk study should include, as appropriate, the following topics, amongst others (see also Tables 1 to 3):

a) ownership and occupier(s);

b) the history of the site and adjoining areas, with particular attention to the nature of any industrial processes and other activities that could have been potentially contaminative or could have modified the ground structure to create potential migration pathways;

c) review of any previous desk study or investigation of the site;

d) the geological, geomorphological, geochemical, hydrogeological, hydrological, topographical, archaeological and ecological setting of the site and surrounding area;

e) potential receptors of contamination (for example, trespassers, current and intended users, construction workers, surface waters, ground waters or nearby water abstractions, ecological receptors, property);

f) the proximity of waste disposal sites or other sources of contamination that could have an impact on the site;

g) on- and off-site incidents that could have had an impact on the site such as fires or spills, etc.;

h) the existence of naturally occurring harmful materials, such as radon, or naturally elevated concentrations of harmful substances;

i) the presence of any mining activities;

j) proximity to ecological sensitive sites or water protection areas;

k) any constraints on an intrusive site investigation (access or height limitations, underground and overhead services or obstructions, noise, working hours, etc.);

l) the potential for the site to contain or have been affected by unexploded ordnance (UXO)[9];

m) review of developers' designs and plans where the site is to have a change of use, with details recorded of the future use/characteristics of the site;

n) any foreseeable events or changes (e.g. flooding, rising groundwater, planned or likely changes of use of neighbouring sites) that could have an impact on the assessment.

Sources of information that it could be useful to consult are publications, maps (check the accuracy of any map used and check whether there is a reproducible graphic scale), aerial photographs, satellite imagery, and records held by official bodies (see Table 4). Particularly important is information on the physical and chemical properties and the possible spatial distribution of the soil parameter under investigation; special attention should be paid to geological features such as stratigraphy and hydrogeology.

The sources of information available for use in preliminary investigations will vary from country to country and jurisdiction to jurisdiction and thus the guidance given about sources of information in this document is of necessity generic in character. The user will find it useful to prepare detailed information about local sources for their own use. National standards providing guidance on the design and execution of geotechnical investigations often contain a requirement that a desk study and site reconnaissance should be carried out and thus might provide useful guidance about potential sources of information.

Table 4 — Examples of documentary sources of information

— Detailed maps of good quality: for example, regional maps at scale 1:25 000, local maps at scale 1:200 to 1:2 500 on which provisions such as utility lines are indicated, historical maps, soil maps, hydrogeological maps.
— Where structures are present, detailed plans — preferably in the form of “as-built” drawings rather than “as-planned” drawings.
— Maps and databases relating to the geology, pedology, hydrogeology and hydrology of the site and the area.
— Aerial photographs (black and white, colour and infrared).
— Archives of: current or previous licenses, owners or users, current or previous development plans, information obtainable from offices of land registry (for example, municipalities, provinces, public utility companies) with respect to both the site under consideration and adjacent sites.
— Trade and street directories to establish former users of the site and the potential activities.
— Satellite imagery.
— Records of land surveyor's offices, geological surveys, water management boards, industrial inspection boards, mining boards, mining companies, geotechnical institutions, regional and local city archives, agricultural and forestry authorities and building supervisory boards.
— Documentary records, particularly any previous desk study or investigation reports held by the current (and former) owners of the land, trade directories, the local government records and local libraries.
— Registers of regulatory permits, decisions, and interventions by regulatory authorities.

7.2.2 Information on past and present use

The rapid growth of urban areas has resulted both in the absorption of areas which were formerly rural and in the change of use of existing urban land. Contamination within urban areas is therefore frequently the result of some historic industrial process that has occurred on the site, or nearby, and information to be collected for both urban and industrial sites is very similar.

It is important to recognize that an agricultural site or a wooded site could be a potentially contaminated site, not only because of activities carried out on the site but because they were developed in the past on potentially contaminated land, for example an old refuse disposal site (landfill) or mining waste. This could have significance for agricultural performance of a site and the health and safety of investigator; hence the need for a good site history to be developed.

Data gathered on historic and current use of a site should, where relevant, provide information on the following (subject to any agreed limitations within the objectives):

— any development, building or other activity that has taken place on the site and its immediate surroundings;

— any specific actions that were taken in the past, and any materials that were used (including chemical composition when available), in connection with industrial, building or other activities on the site;

— industrial or other activities which have been (or are currently) potential causes of soil contamination [production processes, storage facilities, materials transport facilities including underground railways with an indication (as precise as possible) of the location(s)];

— details with regard to cables, conduits, areas of soft landscape and areas of hard landscape, areas of made ground and areas of tipped material, effluent treatment, sludge disposal, surface drainage, chemical storage, underground tanks, waste materials, building rubble, etc.;

— information on adjacent land use (present and intended) which could affect the site under investigation;

— any incidents such as spills or detected leakages of potentially harmful liquids from tanks, pipes and drains on the surface or underground;

— deposition or burial of industrial, agricultural or domestic waste or temporary stockpiling of leachable materials (for example, road salt);

— presence of wind or water dispersable dust;

— demolition of industrial structures and dispersal or burial of contaminated rubble and other materials;

— importation of potentially contaminated fill material onto the land.

In addition, it should be determined whether unexploded ordnance (UXO) is likely to be present[9].

Any available plans of the previous or current layout of different usages on the site should be inspected, as well as any plans of site drainage or underground services. Other information sources that should be consulted, as appropriate, are listed in Table 4.

The level of historical research undertaken should be compatible with the objectives of the investigation. The extent of research into the history of the site should take into account factors such as the complexity of past potentially contaminative uses on and adjacent to the site, the vulnerability of the site geology and local water environment, and the degree of confidence required by the client and/or regulator. The methods and extent of research should be agreed with the client (and regulator when required) in advance and modified as necessary according to the findings of the preliminary investigation.

NOTE Information with regard to similar sites elsewhere can be used for comparison. Examples of some land uses that can give rise to contamination are listed in Annex A. This provides guidance on contaminants of potential concern and the receptors that might be impacted (Tables A.1 and Table A.2) and on the association of potential contaminants with particular industrial uses of land (Tables A.3 and A.4). Published sources of guidance on the characteristics of sites operated by particular industries include a series of industry profiles published in the UK[10] and best practice guidance notes produced in connection with integrated pollution control[11]. The UK industry profiles (listed in Annex A) provide developers, local authorities and anyone else interested in contaminated land with information on the processes, materials and wastes associated with individual industries. Among other organizations publishing useful guidance on particular industrial sectors is the US Environmental Protection Agency (see for example References [15] to [17]).

The UK industry profiles provide information on the processes, materials and wastes associated with individual industries together with information on possible contamination, factors that affect the likely presence of contamination, the effect of mobility of contaminants and guidance on the characteristics potential contaminants. They are not definitive studies, but introduce some of the technical considerations that need to be in mind at the start of an investigation for possible contamination. They do not record much anecdotal information that those that have worked in an industry can provide, for example, industry specific information about what was common or bad practice regarding waste disposal. Site specific knowledge can be even more valuable as explained below (see 7.3)

7.2.3 Information on geology, pedology, geomorphology, hydrology and hydrogeology

Information should be collected on the geology and pedology of the area and the hydrological and hydrogeological situation as far as available. The scale at which this information should be collected, and the degree of detail that is required, depends on the defined objectives of the investigation.

The collected information should include:

— anticipated soil profile (natural and anthropogenic);

— obvious soil components (native or introduced) and their distribution regarding a statement on the homogeneity of the material;

— geomorphology including indications of artificial changes in topographic levels and landform;

— the nature of the underlying ground and the thicknesses of the underlying strata;

— presence of aquifers (number and type) and thicknesses;

— whether impermeable strata overlie an aquifer;

— tidal and seasonal variations in groundwater levels;

— groundwater flow direction(s), both on a regional and a local scale and variation with time (if possible);

— drainage patterns and the position of surface water courses, even if they are filled in at present and any continuity with groundwater;

— the presence of groundwater springs and wells and other abstraction points and any groundwater and soil gas monitoring installations;

— results of previous soil investigations at the site or its immediate surroundings, like boreholes or other forms of (geotechnical) investigations, in connection with, for example, building activities, and results of any chemical investigations;

— information on background geochemical aspects of soils and groundwater;

— properties of the contamination which could be relevant with respect to the local soil structure or profile (for example, humus in the ground could absorb contaminating organic compounds).

NOTE Observing the land surface could provide important information about the development of natural and/or anthropogenic (made or filled) ground, and will assist the assessment of drainage patterns.

7.2.4 Ecology and archaeology

The preliminary investigation should determine whether the site (or its immediate environs) has been designated as an area of ecological or archaeological significance.

NOTE 1 If it has been so designated, it is likely that there will be constraints on the methods of ground investigation that can be used. It is also likely that ecological and/or archaeological surveys and desk studies will need to be undertaken before any contamination-related or other intrusive field investigations.

The preliminary investigation should also determine by enquiry whether it is known that there are species (e.g. bats, nesting birds, water voles, bats) or habitats present subject to legal protection.

NOTE 2 The presence of these species or habitats could restrict the timing or method of investigation. The species, etc. subject to protection are likely to vary between jurisdictions.

NOTE 3 The preliminary investigation might indicate that there are possibly previously unidentified species (e.g. bats, nesting birds) or habitats of importance present that might be subject to legal protection, in which case the report might recommend that an appropriate ecological survey is carried out.

The presence of invasive plant species, such as Japanese knotweed (*Fallopia japonica*) and giant hogweed (*Heracleum mantegazzianum*), or infective agents such as those responsible for foot/hoof and mouth disease (*Aphatae epizooticae*), and Rhizomania [*Benyvirus*; beet necrotic yellow vein virus (BNYVV)] or Ash dieback disease (*Chalara fraxinea*) should also be determined. Care should be taken during the site reconnaissance not to do anything that could lead to the spread of any such organisms.

Similarly subsequent ground investigations should be designed to avoid any spread of these species or infections.

NOTE 4 The listing of invasive and noxious plants above is not exhaustive.

NOTE 5 The presence of Japanese knotweed can add to waste disposal costs and other remediation costs.

7.3 Consultations

Relevant parties should be consulted, normally in parallel with the documentary research. This should include, when appropriate, consultation with authorities about the current use of the site including environmental and operational permits and discharge consents (i.e. permits to discharge water to sewers or water courses).

Among those officials or organizations that could be consulted are those responsible for

— management of contaminated sites on behalf of governments or local governments,

— management of groundwater and surface water resources,

— physical planning,

— controlling environmental impacts such as noise and air pollution,

— ecologically sensitive sites,

— storage of petroleum and other hazardous substances,

— sites protected because of their scientific values (in some jurisdictions these can include valued geological exposures), and

— archaeological and other heritage sites.

Client approval should be obtained before entering consultations with third parties and regulators, in case of confidentiality issues.

Where possible, and appropriate, interviews should take place with current or former owners and workers, current or former neighbours, neighbouring businesses, environmental groups, groundwater exploration companies, water companies, water quality inspectors, etc., to obtain for example, further information on, or enhance knowledge of, suspect locations or features, underground services, etc. The accuracy of such anecdotal evidence should be treated with caution unless the information can be confirmed by an independent source. Such consultations can be combined with the site reconnaissance (see 7.4).

7.4 Site reconnaissance

A reconnaissance of the site, neighbouring land (i.e. adjacent to the site) and the surrounding area should be made after available historical information and other relevant information has been obtained and collated. The area around the site for which information is to be gathered should be specified before the site reconnaissance is carried out.

Arrangements for the reconnaissance visit, including access, should be agreed with the client and the site owner and/or occupier, as appropriate, before being undertaken.

When appropriate, a request should be made for personnel visiting the site to be accompanied by someone familiar with the site, such as a plant manager, person in charge of maintenance or safety officer in the case of an industrial site.

A health and safety risk assessment should be carried out before the visit. This assessment should be based on the results of the desk study, but should be refined once the preliminary investigation is completed. The assessment should be kept under review as the investigation proceeds, but where there is any doubt as to the presence or degree of contamination then protective equipment should be used. Personnel undertaking the visit should be briefed on any hazards (e.g. physical, chemical, biological) that could be encountered and any precautions to be taken. Old buildings, etc. could be structurally unsound and should only ever be entered after an assessment of the potential risk of doing so (for further guidance on safety, see ISO 18400-103).

NOTE 1 Assessment of the condition of a building might require advice from appropriately qualified expert.

A strategy for the visit should be decided in advance and suitable plans, checklists and reference documentation prepared.

The principal objectives of the visit should be to:

a) verify information on the site collated during the desk study;

b) collect additional information about the site and its environs and, in the case of potentially contaminated sites, any potential contaminants, pathways and receptors;

c) record observations of aspects of the site and its environs not revealed by the desk study, including the presence of invasive plant species;

d) collect information that will assist in the planning of any subsequent phases of field investigation (for example any constraints to access).

Care should be taken during the site reconnaissance not to do anything that could lead to the spread of potentially harmful organisms (see 7.2.4).

Typical observations to be made during a site visit are:

— current usage and state of the site;

— site access and ease of movement on-site, and conditions which could prohibit sampling at specific locations (e.g. buildings or other structures);

— conditions at boundaries to the site and surrounding land usage;

— proximity of sensitive developments and habitats;

— potential site risks (e.g. overhead power cables, live services and voids);

— presence of hazardous materials;

— evidence that topographic levels (altitudes) have changed (both increases and decreases) as a result of human activity or natural processes;

— indications of contamination or other adverse conditions (e.g. vegetation stress or lack of plant growth, presence of visual staining or fibrous materials);

— visual evidence of contamination on or entering or emitting from the site or the presence of odours;

— condition of any surface waters;

— evidence of water abstraction points;

— existence of any ground water or soil gas monitoring wells;

— surface and, where there are existing monitoring wells, groundwater levels.

The topography of the site should be observed and compared to topographic levels (altitude) anticipated from the desk study. Raised ground and artificial slopes could be indicative of made or filled ground (anthropogenic ground).

If buildings still remain in which potentially contaminating processes could have taken place, the past and present usage should be reviewed and the buildings inspected for evidence of actual and potential contamination[7]. However, care should be taken to ensure that it is safe to enter any building before doing so.

A photographic record should be made illustrating the site as a whole, and particular features of relevance to the investigation, subject to any restrictions forbidding photographs to be taken (in which case this should be noted in the report of the investigation).

If during the site reconnaissance anything is seen that is considered likely to pose an immediate threat to human health and safety or the environment, this should be reported immediately to whoever is in control of the site and to regulatory authorities or fire and police authorities when appropriate so that any essential urgent action can be taken.

NOTE 2 Detailed guidance on the field inspection of buildings prior to decommissioning or demolition is provided in CIRIA, SP102[7].

NOTE 3 Sampling is not usually undertaken during a site reconnaissance. However, it could be appropriate to do so where materials are identified during the visit that could potentially present an immediate hazard to vulnerable receptors. This ought only to be undertaken if it can be done safely using appropriate containers and protective equipment. If not, an urgent exploratory investigation could be planned where the objective is to determine whether an immediate risk is present from the identified site materials.

8 Development of the preliminary conceptual site model

8.1 Overall conceptual site model

The information from the desk study, site reconnaissance visit and consultations should be collated and evaluated to formulate a preliminary conceptual site model embracing all relevant information, including, when appropriate, contamination-related and other hypotheses. This requires some interpretation of the available information and explicit recognition of uncertainties in the available information including identified information gaps.

The scope of, and level of detail in, the conceptual site model should take into account the objectives of the investigation and requires judgement on the part of the person preparing the model.

NOTE 1 The development of a conceptual site model can aid greatly in the understanding of the site and the risks it could present to human and other receptors as well as the design of future stages of investigation. It also aids decisions on how remediation (if required) could be achieved and other works carried out.

NOTE 2 Detailed guidance on formulating an initial conceptual site model is outside the scope of this document. ASTM E1689-95[6] and National Groundwater and Contaminated Land Centre report NC19913812[12] give guidance on formulating a conceptual site model. In addition, various other International Standards (e.g. References [1] to [5]) give guidance on the characterization of soil and soil materials for particular purposes and consequently provide information on what parameters and characteristics could be relevant in particular situations.

The preliminary conceptual site model should identify as appropriate, and possible:

a) potential types, depths and extent of soil, groundwater and soil gas contamination present in different zones of the site;

b) the likely vertical and horizontal stratification of natural and man-made layers beneath the site;

c) strata variability (occurrence and thickness) in different areas of the site and their relative permeability, both vertically and horizontally;

d) potential migration routes (including airborne dispersion);

e) the presence of physical features such as service trenches, drainage runs, soakaways, underground storage tanks, power lines and former foundations that could influence the occurrence or migration of contamination or provide a constraint to investigation;

f) the occurrence of any biological, chemical or physical processes that could affect contaminant concentrations and migration;

g) the characteristics of groundwater bodies beneath the site, including groundwater levels and flow directions;

h) the presence of surface water bodies on, or adjacent to, the site;

i) the presence and planned (or potential) presence of human receptors;

j) presence of other actual or potential receptors;

k) presence of noxious organisms;

l) presence of legally protected species or ecological systems, other environmental features (e.g. nesting birds, geological exposures) and archaeological features;

m) any foreseeable event, for example rising groundwater, variable sea water levels or nearby construction, that might affect any of the above.

The preliminary conceptual site model should also include hypotheses about the presence of made ground, underground obstructions, buried river channels, the expected directions of groundwater flow, number of aquifers and details of groundwater recharge, permeability of the ground, the physical and chemical properties of the expected contaminants, their possible degradation products, the location and form of the contaminant source, duration, etc.

In the case of a potentially contaminated site, the conceptual site model should provide a description and/or representation of the site, incorporating what is known about the ground and groundwater conditions, the actual and potential contamination, the physical conditions and environmental setting, the current and past uses of the site, the receptors, and potential pathway linkages between contamination sources and receptors, foreseeable events such as flooding, changes in groundwater level, global warming, extreme weather conditions, the closure of mines, etc.; in fact, all information relevant to the task in hand. Depending upon the objectives of the investigation, it could be relevant to consider new future receptors associated with the construction and completion of a new development, as well as existing receptors. The conceptual site model leads, for example, to the formulation of contamination-related hypotheses (see 8.3 and ISO 18400-203), which the investigation process examines through the collection of relevant data.

In the case of other types of site (e.g. agriculture or woodland) and soil characteristics (e.g. biological, fertility, physical) it could similarly be helpful to prepare formal hypotheses that can be tested during the subsequent sampling or other intrusive investigation.

When further investigations are carried out the additional information should then be used to refine the conceptual site model.

Where there are data gaps or uncertainty in the initial conceptual site model, these should be highlighted.

8.2 Characteristic distributions of the physico-chemical properties

Soil materials are inherently variable in composition. A key element of sampling programme design (see ISO 18400-104) is an understanding of the main components of variability in the soil being sampled (the population).

Two distinctive types of variability can be distinguished

— at small scale, that of soil particles, i.e. fundamental variability, and

— at large scale, i.e. spatial variability.

NOTE 1 Scale is an important concept, as heterogeneity is a scale-dependent characteristic: soil properties show less heterogeneity with large-scale measurements than with small-scale measurements. Variability can occur at all scales from that of sample increments to that of large volumes or even the whole site of interest. Two scales of sampling are usually considered: the scale of the sample and the scale of the assessment. These rarely coincide.

NOTE 2 Scale in the context of determining background values is discussed in ISO 19258:2005, Annex A.

NOTE 3 When developing the conceptual site model, the substance of concern might:

— occur predominantly in solution in the pore water and that consequently care should be taken to capture and retain the water during sampling;

— be present as, or occur in, a non-aqueous phase;

— be concentrated in plant roots having been taken-up or adsorbed from the soil.

The anticipated variability at varying scales should be considered when developing the preliminary conceptual site model and the subsequent investigation should include among its objectives an aim to "disclose" this variability. When temporal effects are expected based on the process by which the stockpile or other deposit was formed (see NOTE 4), these effects should be taken into account.

NOTE 4 One cause of spatial variability can be temporal variability in the nature and composition of the soil or soil materials making up the soil volume (population that is to be sampled). Examples of when this might be the case include:

— when materials have been deposited in stockpiles or otherwise on the ground surface over a period of time (e.g. by end tipping or controlled placement in layers);

— when there have been a number of flooding events;

— when there have been a number of land slips or similar events.

Hypotheses about variability developed as part the preliminary conceptual site model could, for example, include:

— the population can be considered homogeneous (within the limits of interest) and only the level of the properties of interest need to be determined;

— the population is suspected to have varying characteristics with different spatial gradients;

— the properties under investigation are not homogeneously distributed in space and the average value of the characterizing property is of interest;

— the properties under investigation are not homogeneously distributed in space and the spatial variability of the properties is of interest;

— there is one or more areas of considerable deviation in characteristics from the rest (i.e. hot spots) that should be delineated in subsequent investigations.

8.3 Formulation of contamination-related hypotheses

Based on the results of the preliminary investigation, hypotheses should be formulated in relation to the probable nature, variation and spatial distribution of contaminating substances that are anticipated on the site.

In arriving at appropriate hypotheses it will be frequently necessary to identify different zones of a site to which different hypotheses are applicable. This will normally be essential for a large site but is also frequently appropriate for small sites.

Hypotheses relating to individual substances that can then be incorporated into a conceptual site model should be developed, taking into account all the information available, and translating the information into the most likely overall scenario with respect to the contamination status of a zone. The conceptual models for individual zones can be combined into a conceptual site model for the site as a whole. This site-wide conceptual site model is used to design the sampling strategy to be employed in the next stage of investigation.

However, before deciding on the sampling strategy, it is first essential to determine for each zone (and for the site as a whole) from the information available, whether it is reasonable to expect the zone or site to be contaminated or not, i.e. whether the zone (or site) should be categorized as "probably uncontaminated" or as "probably contaminated". Some possible formal hypotheses that can be tested during the intrusive phases of investigation are (a detailed description of each is provided in ISO 18400-203:2018, Annex A):

— hypothesis of "probably uncontaminated" site or zone;

— hypothesis of "probably contaminated" site or zone;

— hypotheses relating to spatial distribution of contamination, e.g. heterogeneous, homogeneous.

8.4 Preliminary qualitative risk assessment for potentially contaminated sites

A preliminary qualitative risk assessment should be undertaken once the initial conceptual site model has been formulated and the potential source-pathway-receptor linkages identified. Where adequate site investigation information has been obtained during the preliminary investigation, a semiquantitative, risk assessment can sometimes be undertaken (see Note 1). Information from previous investigative works should be either verified or used with caution.

However, where little or no previous investigation has been undertaken, only a qualitative assessment can be made. The effects of uncertainties in the information available on the outcome of a risk assessment should be identified and recorded.

NOTE 1 When pre-existing data about the concentrations of potentially hazardous substances, etc. have been collected during the desk study and these data are sufficient in terms of quantity, type and quality, it could sometimes be possible to use this data to prepare a preliminary semi-quantitative risk assessment based on comparisons of the data with generic assessment criteria. If this is done, it is important to describe the limitations of the available data.

NOTE 2 Guidance on carrying out a formal risk assessment is outside the scope of this document. Risk assessment covers:

a) identification of contaminants, pathways and receptors;

b) estimation of the likelihood, nature and extent of exposure to a hazard, and the risk of adverse effects;

c) assessment of the likely pollutant linkages and the degree of risk;

d) evaluation of the need for controlling the identified risk. Site investigation provides baseline information for stage a) of the process.

NOTE 3 A conclusion of the preliminary risk assessment could be that no further investigation is required.

NOTE 4 The preliminary risk assessment might identify soil properties such as particle size distributions and organic matter content that need to be determined in subsequent phases of investigation to enable the potential impact of contaminants to be properly assessed.

8.5 Further investigations

The findings of the preliminary investigation should form the basis upon which the requirement for the scopes and phasing of subsequent exploratory or detailed investigations are decided.

The risk assessment and the objectives of the investigation should be reviewed and the need for further investigation considered (see Figure 2), based upon the quantity and quality of previous site investigation information available, the level of confidence required in the characterization of ground conditions and hazards, and the results of the risk assessment.

9 Reporting the preliminary investigation and the conceptual site model

The preliminary investigation should be reported in such a way that the initial formulation of the conceptual site model and individual hypotheses will stand out as a clearly recognizable, identifiable, section of the report.

A report should be prepared documenting the sources of information and summarizing the factual findings of the preliminary investigations, and stating the conclusions (or hypotheses) drawn concerning the anticipated site conditions (e.g. geology, hydrology, possible contamination) which are relevant to the design of the sampling programme, and recommendations for further research and/or ground investigation.

Table 5 provides a detailed list of the information that should be included in the report as appropriate.

Where elements in 7.2 to 7.4 are not included, this should be documented in the report and any resulting limitations on the final assessment arising from the omissions should be clearly stated.

The report should follow a formalized structure and the contents should include

— table of contents,

— summary,

— introduction,

— objectives,

— details of the research (including sources of information which can be given in an appendix for convenience),

— details of the site (including gathered information and the results of the site visit),

— discussion and formulation of hypotheses,

— conclusions,

— recommendations (e.g. further investigation), and

— appendices (containing as much of the documentary evidence, etc. as is practicable).

The report should include detailed site maps and sections showing all relevant information (e.g. identified sources of pollution, groundwater flow direction).

Table 5 — Information to include in the report of a preliminary investigation

1	Information collected on past and present uses of the site together with details on geology, pedology and hydrogeology: — all aspects mentioned in 7.2 and 7.3 should be discussed, and details should be provided of all the sources that have been consulted; — indications should also be given about where there are possible gaps in the information that has been obtained, and any other constraints or limitations of the survey; — a record of where a source of information has been accessed, but no specific information was available.
2	A record of the site reconnaissance and the observations made during the site reconnaissance including: — a plan showing the location of observations together with photographs where necessary (the direction from which the photographs were taken should be shown on the plan); — photographs showing the general condition and layout of the site.
3	A record of anecdotal evidence which has been obtained, together with: — the name of the persons interviewed; — the date of the interview; — the relationship of the interviewee with the site (i.e. their function and the period during which that relationship existed, as this can be useful for assessing the reliability and relevance of the information).
4	A full discussion and a full description of the development of the conceptual site model, including: — the hypotheses which have been formulated; — the conclusions relating to the presence or absence (and the type and nature) of the contamination; — the spatial distribution, and details of delineation into zones for which the different hypotheses have been formulated.
5	In the case of a “probably uncontaminated” site, the arguments supporting this conclusion should be included.
6	In the case of a “potentially contaminated” site, the following elements should all be discussed where relevant: — the nature of the source(s) of contamination and the manner in which the contaminants were introduced into the soil; — a list of possible contaminants (and if applicable their chemical specification); — the spatial distribution that is anticipated and the expected distribution and location of the contamination in the soil, surface and ground water, and soil gas.

Annex A
(informative)

Contaminants of potential concern and industry/contaminant matrix

Guidance on why particular substances could be of concern and the receptors to which they could be hazardous is provided in Tables A.1 and A.2 which are derived from Reference [14].

Tables A.3 and A.4 which are based on guidance published in the United Kingdom[14] provide examples of the association of important potential contaminants with industrial uses of land. More detailed reviews of such substances are provided in the industry profiles in Reference [10] corresponding to each of the industries listed in the tables.

The information provided in Tables A.3 and A.4 is not entirely comprehensive. The selection of contaminants of potential concern on individual sites needs to be based on a detailed evaluation of the past uses of the land in question - substances might be present that are not listed in the tables.

Table A.1 — Potential inorganic contaminants for the assessment of industrial land and their receptors[14]

Contaminants[a]	Receptors			
	Humans	Water	Vegetation and ecosystem	Construction materials
Metals				
Barium	—	X	—	—
Beryllium	X	X	X	—
Cadmium	X	X	X	—
Chromium	X	X	—	—
Copper	—	X	X	—
Lead	X	X	X	—
Mercury	X	X	X	—
Nickel	X	X	X	—
Vanadium	X	X	—	—
Zinc	—	X	X	—
Semi-metals and non-metals				
Arsenic	X	X	—	—
Boron	—	X	X	—
Selenium	X	X	X	—
lnorganic chemicals				
Sulfur	X	—	X	X
Cyanide (complex)	X	X	X	X
Cyanide (free)[b]	X	X	X	—

[a] The list should not be regarded as a comprehensive list that should be taken into account in any particular site investigation. Some contaminants will be of no importance on certain types of site, while some sites may be contaminated by elevated concentrations of particular substances, which may not be listed because of their infrequent occurrence generally.

[b] Free cyanide is broadly equivalent to “easily liberatable cyanide”, which covers compounds that can release hydrogen cyanide at pH 4 and 100 °C.

Table A.1 *(continued)*

Contaminants[a]	Receptors			
	Humans	Water	Vegetation and ecosystem	Construction materials
Nitrate	—	X	—	—
Sulfate	—	X	X	X
Sulphide	—	X	X	X
Other				
Asbestos	X	—	—	—
pH (acidity/alkalinity)	X	X	X	X

[a] The list should not be regarded as a comprehensive list that should be taken into account in any particular site investigation. Some contaminants will be of no importance on certain types of site, while some sites may be contaminated by elevated concentrations of particular substances, which may not be listed because of their infrequent occurrence generally.

[b] Free cyanide is broadly equivalent to "easily liberatable cyanide", which covers compounds that can release hydrogen cyanide at pH 4 and 100 °C.

Table A.2 — Potential organic contaminants for the assessment of industrial land and their receptors[14]

Contaminants[a]	Receptors			
	Humans	Water	Vegetation and ecosystem	Construction materials
Acetone	X	X	—	—
Oil/fuel hydrocarbons	X	X	X	X[b]
Aromatic hydrocarbons				
Benzene	X	X	X	X[b]
Chlorophenols	X	X	X	X[b]
Ethylbenzene	X	X	X	X[b]
Phenol	X	X	X	X[b]
Toluene	X	X	X	X[b]
o-Xylene	X	X	X	X[b]
m,p-Xylene	X	X	X	X[b]
Polycyclic aromatic hydrocarbons	X	X	—	—
Chlorinated aliphatic hydrocarbons[c]				
Chloroform	X	X	X	—
Carbon tetrachloride	X	X	X	X[b]

[a] The list should not be regarded as a comprehensive list that should be taken into account in any particular site investigation. Some contaminants will be of no importance on certain types of site, while some sites may be contaminated by elevated concentrations of particular substances, which may not be selected because of their infrequent occurrence generally.

[b] The impact of chlorinated hydrocarbons and other organic substances is probably limited to concentrations in the free phase.

[c] Some chlorinated aliphatic hydrocarbons are considered to be of secondary importance and are therefore excluded because they are less toxic, highly volatile or have limited industrial use. However, some highly volatile substances may be significant due to their solubility and are not excluded on grounds of volatility alone.

[d] There are 209 polychlorinated biphenyl (PCB) congeners, the significance of which can be expressed using toxic equivalency factors (TEFs) relative to the best-characterized member of the group

[e] There are 210 possible isomers of chlorinated dioxins and furans, of which the most studied and most toxic representative of the group is 2, 3, 7, 8-tetrachlorodibenzo-p-dioxin (2, 3, 7, 8-TCDD). Other dioxins and furans could be expressed in terms of TEFs relative to 2, 3, 7, 8-TCDD.

Table A.2 *(continued)*

Contaminants[a]	Receptors			
	Humans	**Water**	**Vegetation and ecosystem**	**Construction materials**
Vinyl chloride	X	X	—	—
1,2-Dichloroethane	X	X	X	X[b]
1,1,1-Trichloroethane	X	X	X	X[b]
Trichloroethene	X	X	X	X[b]
Tetrachloroethene	X	X	X	X[b]
Hexachlorobuta-1,3-diene	X	X	X	—
Hexachlorocyclohexanes	X	X	X	—
Dieldrin	X	X	X	—
Chlorinated aromatic hydrocarbons				
Chlorobenzenes	X	X	X	—
Chlorotelomeres	X	X	X	—
Pentachlorophenol	X	X	X	—
Polychlorinated biphenyls[d]	X	X	X	—
Dioxins and furans[e]	X	X	X	—
Organometallics				
Organolead compounds	X	—	X	—
Organotin compounds	X	X	—	—

[a] The list should not be regarded as a comprehensive list that should be taken into account in any particular site investigation. Some contaminants will be of no importance on certain types of site, while some sites may be contaminated by elevated concentrations of particular substances, which may not be selected because of their infrequent occurrence generally.

[b] The impact of chlorinated hydrocarbons and other organic substances is probably limited to concentrations in the free phase.

[c] Some chlorinated aliphatic hydrocarbons are considered to be of secondary importance and are therefore excluded because they are less toxic, highly volatile or have limited industrial use. However, some highly volatile substances may be significant due to their solubility and are not excluded on grounds of volatility alone.

[d] There are 209 polychlorinated biphenyl (PCB) congeners, the significance of which can be expressed using toxic equivalency factors (TEFs) relative to the best-characterized member of the group

[e] There are 210 possible isomers of chlorinated dioxins and furans, of which the most studied and most toxic representative of the group is 2, 3, 7, 8-tetrachlorodibenzo-p-dioxin (2, 3, 7, 8-TCDD). Other dioxins and furans could be expressed in terms of TEFs relative to 2, 3, 7, 8-TCDD.

Table A.3 — Examples of association of important contaminants with industrial uses of land — Metals, semi-metals, non-metals, inorganic chemicals and others[14]

Industry	Key contaminants[a]																				
	Metals										Semi-metals and non-metals				Inorganic chemicals					Others	
	Ba	Be	Cd	Cr	Cu	Pb	Hg	Ni	V	Zn	As	B	Se	S_o	Complex CN^-	Free CN^-	NO_3	SO_4^{2-}	S^{2-}	Asbestos	pH
Airports				X	X										X					X	X
Animal and animal products processing works			X	X							X							X	X		
Asbestos manufacturing works			X	X		X												X		X	
Ceramics, cement and asphalt manufacturing works			X	X	X	X	X	X		X	X								X	X	X
Charcoal works			X	X	X	X	X			X	X		X			X	X	X		X	X
Chemical works: coatings (paints and printing inks) manufacturing works	X		X	X	X	X		X		X				X				X		X	X
Chemical works: cosmetics and toiletries manufacturing works				X						X									X	X	X
Chemical works: disinfectants manufacturing works	X				X		X	X		X								X			X
Chemical works: explosives, propellants and pyrotechnics manufacturing works	X			X	X	X	X	X		X	X	X					X	X		X	X
Chemical works: fertiliser manufacturing works			X	X	X	X		X		X										X	X
Chemical works: fine chemicals manufacturing works			X	X		X	X		X		X						X	X		X	
Chemical works: inorganic chemicals manufacturing works	X		X	X	X	X	X	X	X	X	X	X	X			X	X	X	X	X	X
Chemical works: linoleum, vinyl and bitumen-based floor covering manufacturing works			X			X				X	X							X		X	X
Chemical works: mastics, sealants, adhesives and roofing felt manufacturing works	X			X	X	X	X			X	X							X		X	X
Chemical works: organic chemicals manufacturing works				X	X	X		X	X	X	X					X		X		X	X
Chemical works: pesticides manufacturing works				X	X	X	X			X	X									X	X
Chemical works: pharmaceuticals manufacturing works				X	X		X			X	X									X	X

[a] The information in this table is not comprehensive. The selection of contaminants for assessment of individual sites should be based on a detailed evaluation of the past uses of the land in question. Individual sites may be contaminated by substances that pose significant hazards but which do not meet the overriding criteria for inclusion in this report or the above table. More detailed reviews of such substances appear in Reference [10] corresponding to each of the industries listed in this table.

Table A.3 *(continued)*

Industry	Key contaminants[a]																				
	Metals										Semi-metals and non-metals				Inorganic chemicals					Others	
	Ba	Be	Cd	Cr	Cu	Pb	Hg	Ni	V	Zn	As	B	Se	S_o	Complex CN^-	Free CN^-	NO_3	SO_4^{2-}	S^{2-}	Asbestos	pH
Chemical works: rubber processing works (including works manufacturing tyres and other rubber products)										X				X					X		
Chemical works: soap and detergent manufacturing works																					X
Dockyards and dockland			X	X	X	X	X	X		X	X							X	X	X	
Dry cleaners			X	X	X	X	X			X	X		X			X	X	X		X	X
Engineering works: aircraft, manufacturing works			X	X	X	X				X						X	X	X		X	X
Engineering works: electrical and electronic equipment manufacturing works including works manufacturing equipment containing PCBs			X	X	X	X	X	X		X	X	X					X	X	X	X	X
Engineering works: mechanical engineering and ordnance works		X	X	X	X	X	X	X	X	X	X	X				X	X	X		X	X
Engineering works: railway engineering works			X	X	X	X		X		X	X			X					X	X	X
Engineering works: shipbuilding repair and shipbreaking (including naval shipyards)				X	X	X		X		X	X					X				X	X
Engineering works: vehicle manufacturing works			X	X	X	X				X			X			X	X	X	X	X	X
Fibreglass and fibreglass resin manufacturing works			X	X	X	X	X	X		X	X		X			X	X	X		X	X
Gasworks, coke works and other coal carbonisation plants			X	X	X	X	X		X	X	X			X	X	X		X	X	X	X
Glass manufacturing works			X	X	X	X	X	X		X	X	X				X	X	X		X	X
Metal manufacturing, refining and finishing works: electroplating and other metal finishing works			X	X	X	X				X		X				X	X	X	X	X	X
Metal manufacturing, refining and finishing works: iron- and steelworks				X		X		X	X	X	X			X		X		X	X	X	X
Metal manufacturing, refining and finishing works: lead works			X	X	X	X		X		X	X							X	X	X	X

[a] The information in this table is not comprehensive. The selection of contaminants for assessment of individual sites should be based on a detailed evaluation of the past uses of the land in question. Individual sites may be contaminated by substances that pose significant hazards but which do not meet the overriding criteria for inclusion in this report or the above table. More detailed reviews of such substances appear in Reference [10] corresponding to each of the industries listed in this table.

Table A.3 *(continued)*

Industry	Key contaminants[a]																				
	Metals										Semi-metals and non-metals				Inorganic chemicals					Others	
	Ba	Be	Cd	Cr	Cu	Pb	Hg	Ni	V	Zn	As	B	Se	S_o	Complex CN^-	Free CN^-	NO_3	SO_4^{2-}	S^{2-}	Asbestos	pH
Metal manufacturing, refining and finishing works: non-ferrous metals (excluding lead works)			X	X	X	X	X	X	X			X							X	X	
Metal manufacturing, refining and finishing works: precious metal recovery works			X	X	X	X	X			X	X						X	X	X	X	X
Oil refineries and bulk storage of crude oil and petroleum products					X	X		X								X			X	X	X
Photographic processing industry			X	X	X	X	X			X	X		X			X	X	X		X	X
Fibreglass and fibreglass resin manufacturing works			X	X	X	X	X	X		X	X		X			X	X	X		X	X
Gasworks, coke works and other coal carbonisation plants			X	X	X	X	X		X	X	X			X	X	X		X	X	X	X
Glass manufacturing works			X	X	X	X	X	X		X	X	X				X	X	X		X	X
Metal manufacturing, refining and finishing works: electroplating and other metal finishing works			X	X	X	X				X		X				X	X	X	X	X	X
Metal manufacturing, refining and finishing works: iron- and steelworks				X		X		X	X	X	X			X		X		X	X	X	X
Metal manufacturing, refining and finishing works: lead works			X	X	X	X		X		X	X							X	X	X	X
Metal manufacturing, refining and finishing works: non-ferrous metals (excluding lead works)			X	X	X	X	X	X	X			X							X	X	
Metal manufacturing, refining and finishing works: precious metal recovery works			X	X	X	X	X			X	X						X	X	X	X	X
Oil refineries and bulk storage of crude oil and petroleum products					X	X		X								X			X	X	X
Photographic processing industry			X	X	X	X	X			X	X		X			X	X	X		X	X
Power stations (excluding nuclear power stations)	X	X	X	X	X	X	X	X	X	X	X		X					X	X	X	X
Printing and bookbinding works			X	X	X	X	X			X	X		X			X	X	X		X	X
Pulp and paper manufacturing works			X	X														X		X	X
Railway land			X	X	X	X		X	X									X		X	

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Table A.3 *(continued)*

Industry	Key contaminants[a]																				
	Metals										Semi-metals and non-metals				Inorganic chemicals					Others	
	Ba	Be	Cd	Cr	Cu	Pb	Hg	Ni	V	Zn	As	B	Se	S_o	Complex CN^-	Free CN^-	NO_3	SO_4^{2-}	S^{2-}	Asbestos	pH
Road vehicle servicing and repair: garages and filling stations				X	X	X				X										X	X
Road vehicle servicing and repair: transport and haulage centres				X	X	X			X	X				X						X	X
Sewage works and sewage farms			X	X	X	X	X	X		X	X					X	X	X	X	X	X
Textile works and dye works			X	X	X		X					X					X	X		X	X
Timber products manufacturing works			X		X	X				X	X	X						X			
Timber treatment works				X	X					X	X	X						X		X	X
Waste recycling, treatment and disposal sites: drum and tank cleaning and recycling plants																		X		X	
Waste recycling, treatment and disposal sites: hazardous waste treatment plants	X		X	X	X	X	X	X	X	X	X		X				X			X	X
Waste recycling, treatment and disposal sites: landfills and other waste treatment or waste disposal sites			X	X	X	X		X		X	X								X	X	X
Waste recycling, treatment and disposal sites: solvent recovery works			X	X	X	X		X		X											X
Waste recycling, treatment and disposal sites: metal recycling sites	X		X	X	X	X	X	X		X	X					X		X	X	X	X

[a] The information in this table is not comprehensive. The selection of contaminants for assessment of individual sites should be based on a detailed evaluation of the past uses of the land in question. Individual sites may be contaminated by substances that pose significant hazards but which do not meet the overriding criteria for inclusion in this report or the above table. More detailed reviews of such substances appear in Reference [10] corresponding to each of the industries listed in this table.

Table A.4 — Examples of association of important contaminants with industrial uses of land — Organic chemicals[14]

Industry	Key contaminants[a]													
	Phenol	Acetone	Chloro-phenols	Oil/fuel hydro-carbons[b,c]	Aromatic hydro-carbons	PAHs	Chlorinated aliphatic hydro-carbons	α, β and γ hexachloro-cyclohexane	Dieldrin	Chlorinated aromatic hydro-carbons	PCBs[d]	Dioxins and furans	Organolead compounds	Organotin compounds
Airports		X		X	X		X				X			
Animal and animal products processing works	X				X	X	X		X					
Asbestos manu-facturing works					X	X	X				X			
Ceramics, cement and asphalt manu-facturing works		X		X		X					X			
Charcoal works		X			X		X				X			
Chemical works: coatings (paints and printing inks) manufac-turing works	X				X	X	X							X
Chemical works: cosmetics and toiletries manu-facturing works		X			X	X	X							
Chemical works: disinfectants manufacturing works	X		X		X	X				X	X	X		
Chemical works: explosives, propellants and pyrotechnics manufacturing works	X	X		X	X		X				X			
Chemical works: fertiliser manu-facturing works				X		X					X			

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[b] Oil/fuel hydrocarbons are often found on sites where they were used as fuel, e.g. in oil-fired boilers or auxiliary power generators. Thus, they could be found on virtually any industrial site of significant size. Irrespective of the industrial use itself.

[c] Oil/fuel hydrocarbons are often determined analytically as "total petroleum hydrocarbons (TPH)".

[d] PCBs can be found on sites where they were used as dielectric fluids in capacitors in electricity substations. Thus, they could be found on virtually any industrial site of significant size, irrespective of the industrial use itself.

Table A.4 *(continued)*

Industry	Key contaminants[a]													
	Phenol	Acetone	Chloro-phenols	Oil/fuel hydro-carbons[b,c]	Aromatic hydro-carbons	PAHs	Chlorinated aliphatic hydro-carbons	α, β and γ hexachloro-cyclohexane	Dieldrin	Chlorinated aromatic hydro-carbons	PCBs[d]	Dioxins and furans	Organolead compounds	Organotin compounds
Chemical works: fine chemicals manufacturing works	X	X			X	X					X	X		
Chemical works: inorganic chemicals manufacturing works						X								
Chemical works: linoleum, vinyl and bitumen-based floor covering manufacturing works	X			X	X	X	X			X	X			X
Chemical works: mastics, sealants, adhesives and roofing felt manufacturing works	X			X	X	X	X							
Chemical works: organic chemicals manufacturing works	X	X			X					X				
Chemical works: pesticides manufacturing works	X		X		X		X	X	X		X	X		X
Chemical works: pharmaceuticals manufacturing works				X	X	X	X			X	X			

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Table A.4 *(continued)*

Industry	Key contaminants[a]													
	Phenol	**Acetone**	**Chloro-phenols**	**Oil/fuel hydro-carbons[b,c]**	**Aromatic hydro-carbons**	**PAHs**	**Chlorinated aliphatic hydro-carbons**	**α, β and γ hexachloro-cyclohexane**	**Dieldrin**	**Chlorinated aromatic hydro-carbons**	**PCBs[d]**	**Dioxins and furans**	**Organolead compounds**	**Organotin compounds**
Chemical works: rubber processing works (including works manu-facturing tyres and other rubber products)	X				X		X				X			
Chemical works: soap and deter-gent manufactur-ing works		X			X	X								
Dockyards and dockland	X			X		X	X	X		X	X			
Dry cleaners					X		X				X			
Engineering works: aircraft, manufacturing works		X			X		X				X			
Engineering works: electrical and electronic equipment manu-facturing works including works manufacturing equipment con-taining PCBs					X		X				X			
Engineering works: mechani-cal engineering and ordnance works	X	X			X	X	X				X			

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Engineering works: railway engineering works					X	X	X				X			
Engineering works: shipbuilding repair and shipbreaking (including naval shipyards)		X		X	X		X							X
Engineering works: vehicle manufacturing works		X		X	X	X	X				X			
Fibreglass and fibreglass resin manufacturing works	X	X			X		X				X			
Gasworks, coke works and other coal carbonisation plants	X				X	X								
Glass manufacturing works		X			X		X				X			
Metal manufacturing, refining and finishing works: electroplating and other metal finishing works	X				X		X							

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	Phenol	**Acetone**	**Chloro-phenols**	**Oil/fuel hydro-carbons[b,c]**	**Aromatic hydro-carbons**	**PAHs**	**Chlorinated aliphatic hydro-carbons**	**α, β and γ hexachloro-cyclohexane**	**Dieldrin**	**Chlorinated aromatic hydro-carbons**	**PCBs[d]**	**Dioxins and furans**	**Organolead compounds**	**Organotin compounds**
Metal manufacturing, refining and finishing works: iron- and steelworks	X			X	X	X					X			
Metal manufacturing, refining and finishing works: lead works				X		X					X			
Metal manufacturing, refining and finishing works: non-ferrous metals (excluding lead works)				X	X	X					X			
Metal manufacturing, refining and finishing works: precious metal recovery works				X			X				X			
Oil refineries and bulk storage of crude oil and petroleum products	X	X		X	X						X		X	
Photographic processing industry		X			X		X				X			
Power stations (excluding nuclear power stations)				X		X	X				X			

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Printing and bookbinding works		X			X		X				X			
Pulp and papers manufacturing works				X			X	X		X	X	X		
Railway land						X	X				X			
Road vehicle servicing and repair: garages and filling stations				X	X	X	X						X	
Road vehicle servicing and repair: transport and haulage centres		X			X	X	X						X	
Sewage works and sewage farms				X			X			X	X			
Textile works and dye works	X	X		X	X		X		X		X			
Timber products manufacturing works	X	X			X	X								
Timber treatment works	X		X	X		X	X	X	X					X
Waste recycling, treatment and disposal sites: drum and tank cleaning and recycling plants		X			X						X			

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Waste recycling, treatment and disposal sites: hazardous waste treatment plants	X						X	X	X	X	X			
Waste recycling, treatment and disposal sites: landfills and other waste treatment or waste disposal sites				X		X	X			X	X	X		
Waste recycling, treatment and disposal sites: solvent recovery works							X			X				
Waste recycling, treatment and disposal sites: metal recycling sites				X			X				X			

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