BS ISO 18400-102:2017

BSI Standards Publication

Soil quality — Sampling

Part 102: Selection and application of sampling techniques

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National foreword

This British Standard is the UK implementation of ISO 18400-102:2017. It supersedes BS ISO 10381-2:2002 which is withdrawn. Together with BS ISO 18400-104, BS ISO 18400-105:2017 and BS ISO 18400-206 it supersedes BS ISO 10381-6:2009 which will be withdrawn upon publication of all remaining parts of the BS ISO 18400 series

BS ISO 18400-102:2017 is intended to be used in conjunction with BS 10175:2011+A1:2013 and other members of the BS ISO series of standards as appropriate. Where there are differences in the guidance given in this standard and that in BS 10175:2011+A1:2013, the guidance in this standard takes precedence. The UK committee notes that this standard covers a wide variety of situations in which investigations including sampling to determine soil quality might be carried out rather than being focused on potentially contaminated sites, as is the case in BS 10175:2011+A1:2013.

The UK participation in its preparation was entrusted to Technical Committee EH/4, Soil quality.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Published by BSI Standards Limited 2017

ISBN 978 0 580 80925 5

ICS 13.080.05

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 April 2017.

Amendments/corrigenda issued since publication

Date	Text affected

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INTERNATIONAL STANDARD

ISO 18400-102

First edition
2017-01

Soil quality — Sampling —

Part 102: Selection and application of sampling techniques

Qualité du sol — Échantillonnage —

Partie 102: Choix et application des techniques d'échantillonnage

Reference number
ISO 18400-102:2017(E)

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

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).

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For an explanation on 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 the following URL: 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 18400-102, together with ISO 18400-104, ISO 18400-105 and ISO 18400-206, cancels and replaces ISO 10381-2:2002 and ISO 10381-6:2009, which have been technically and structurally revised. The new ISO 18400 series is based on a modular structure and cannot be compared to ISO 10381-2 and ISO 10381-6 clause by clause.

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

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Introduction

This document is one of a group of International Standards intended to be used in conjunction with each other where necessary. It deals with various aspects of sampling for the purposes of soil investigation including agricultural, forestry, and contamination investigations, but is not applicable to investigations for geotechnical purposes. These are dealt with in the ISO 22475 series.

ISO 22475-1 specifies the technical principles for the execution of sampling and groundwater measurements for geotechnical purposes. It describes and provides guidance on the application of many of the sampling techniques included in this document albeit in a different context. Many contractors engaged to carry out work in connection with environmental studies will be familiar with its often prescriptive requirements. It includes detailed design information for some equipment. It is to be noted that the nomenclature used in this document may differ in places from that used in ISO 22475-1 because of the different contexts and traditions in the fields of geotechnical and geo-environmental investigation.

General principles to be applied in the design of sampling programmes for the purpose of characterization of soil and identification of sources and effects of contamination of soil and related material are given in ISO 18400-104[1]. ISO 18400-104[1] provides information about where to sample, the tests to be conducted, the type of sample, the depth of sampling and the required representativeness of the sampling system for sampling in respect of specific purposes.

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

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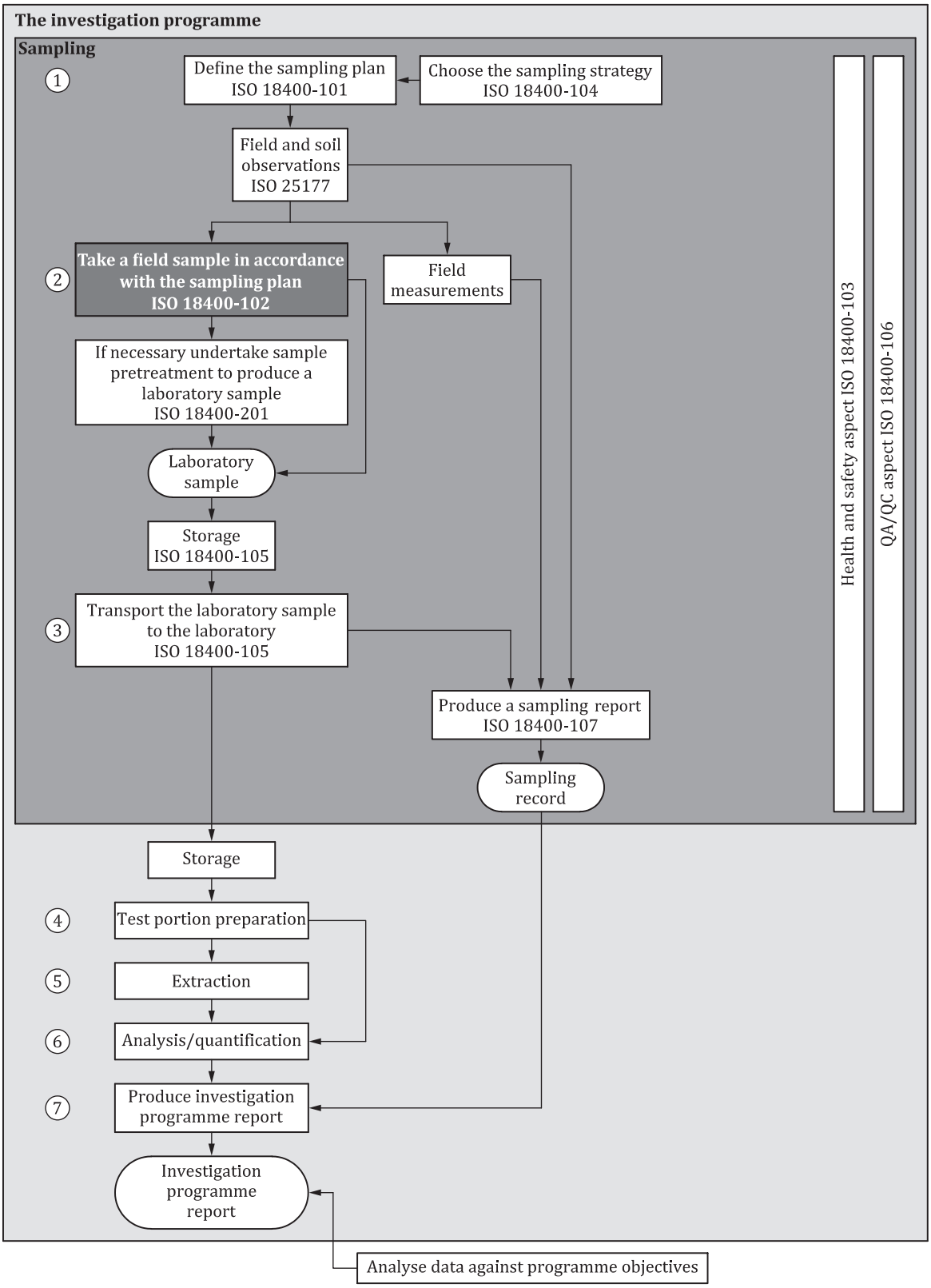

Figure 1 — Links between the essential elements of an investigation programme

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.

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Soil quality — Sampling —

Part 102: Selection and application of sampling techniques

1 Scope

This document gives guidelines for techniques for taking samples so that these can subsequently be examined for the purpose of providing information on soil quality. It gives information on equipment that is typically applicable in particular sampling situations to enable correct sampling procedures to be carried out and representative samples to be collected. Guidance is given on the selection of the equipment and the techniques to use to enable both disturbed and undisturbed samples to be correctly taken at different depths.

This document does not cover:

— investigations for geotechnical purposes, though where redevelopment of a site is envisaged, the soil quality investigation and the geotechnical investigation may sometimes be beneficially combined;

— sampling of hard strata such as bedrock;

— methods for the collection of information on soil quality without taking samples such as geophysical methods;

— collection of water samples (these are to be collected in accordance with appropriate International Standards on ground or surface water sampling; for further information, see the ISO 5667 series);

— investigations of soil gas about which guidance is provided in ISO 18400-204;

— investigation of radioactively contaminated sites.

NOTE 1 "Sampling technique" is defined in ISO 11074.

NOTE 2 Guidance on the investigation and assessment of radioactivity in soils is provided in the ISO 18589 series.

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 3551-1, *Rotary core diamond drilling equipment — System A — Part 1: Metric units*

ISO 3552-1, *Rotary core diamond drilling equipment — System B — Part 1: Metric units*

ISO 10097-1, *Wireline diamond core drilling equipment — System A — Part 1: Metric units*

ISO 11074, *Soil quality — Vocabulary*

ISO 18400-101, *Soil quality — Sampling — Part 101: Framework for the preparation and application of a sampling plan*

ISO 18400-103, *Soil quality — Sampling — Part 103: Safety*

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ISO 18400-104[2)], *Soil quality — Sampling — Part 104: Strategies and statistical evaluations*

ISO 18400-105, *Soil quality — Sampling — Part 105: Packaging, transport, storage and preservation of samples*

ISO 18400-201, *Soil quality — Sampling — Part 201: Physical pretreatment in the field*

ISO 18400-202[3)], *Soil quality — Sampling — Part 202: Preliminary investigations*

ISO 25177, *Soil quality — Field soil description*

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:

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

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

3.1
cluster sample
composite sample for which the increments are taken over a small area around a predefined sampling point

Note 1 to entry: Sampled area is typically about 0,5 m^2 to 1,0 m^2.

Note 2 to entry: Material sampled is taken from within the same stratum or from material with the same characteristics.

3.2
cutting cylinder
cylindrical device with removable top and base forced into the surface of exposed soil to obtain an *undisturbed sample* (3.7)

3.3
disturbed sample
sample obtained from the ground without any attempt to preserve the soil structure

EXAMPLE Sample obtained by using a hand auger.

[SOURCE: ISO 11074:2015, 4.4.8, modified — changed to read: …from the ground…]

3.4
Kubiëna tin
metal box with removable top and base which can be forced into the surface of exposed soil to obtain an *undisturbed sample* (3.7)

Note 1 to entry: Usually made to desired size from aluminium, galvanized steel, or stainless steel sheet. Size varies, but a typical example might have an area of about 55 mm × 75 mm with a depth of 40 mm. The sample, once obtained, can be used to determine bulk density or may be impregnated with resin prior to the production of thin sections for microscopic examination.

2) Under preparation. Stage at the time of publication: ISO/DIS 18400-104:2016.

3) Under preparation. Stage at the time of publication: ISO/DIS 18400-202:2016.

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3.5
spatial sample
composite sample formed from evenly spaced increments of the same size taken over a predetermined area which are then bulked together

Note 1 to entry: The increments may be located according to a regular grid, random, or other pattern. In agricultural/horticultural land investigations, "N", "S", "W", and "X" sampling patterns are commonly used.

Note 2 to entry: The general premise is that the distribution of soil constituents is relatively homogeneous. Along the outline of such a pattern, a number of samples or increments are taken which are bulked and mixed to provide one (composite) sample for analysis.

3.6
spot sample
sample from a discrete location made up of one or more contiguous increments

Note 1 to entry: May be a *disturbed* (3.3) or *undisturbed sample* (3.7).

3.7
undisturbed sample
sample obtained from the ground with soil structure unaltered during sampling procedure

Note 1 to entry: Special sampling equipment is used so that the soil particles and voids cannot change from the distribution which exists in the ground before sampling (these can provide volume-proportional or mass-proportional results).

4 Principle

Sampling technique should be chosen taking into account all the needs of the investigation including planned distribution of sampling locations, the depth(s) from which samples are to be taken, the size and type of sample(s) required, the nature of any potential contaminants, and the nature of the site including any problems the site poses to carrying out the investigation.

The sampling technique(s) should be selected to enable:

— the collection of samples of soil and soil materials that can be presented to the laboratory for examination or analysis to establish basic information on the pedology and distribution of naturally occurring or man-made soils, their chemical, mineralogical and biological composition, and their physical properties at selected locations, as appropriate, to meet the objectives of the investigation;

— examination and recording of *in situ* materials exposed by the investigation.

NOTE 1 Detailed guidance on general aspects of sampling relevant to the selection and application of sampling techniques are given in 5.1 to 5.4 and about available techniques in 5.5. Detailed guidance on the selection of sampling techniques is provided in Clause 6 and on their application in Clause 7.

Among the decisions to be made is whether to use manual methods or machinery. Sampling may be required at or near the ground surface at some depth below the ground surface, or from locations deep below the ground surface. Methods of achieving the desired depth for sampling include formation of excavations (e.g. trial pits), by driven probes, or by drilling (e.g. boreholes).

Depending on the purpose for which sampling is being carried out, either disturbed or undisturbed, samples may be taken (5.3). Undisturbed samples could be required, for example, for soil physical testing or for determination of volatile organic compounds (VOCs).

NOTE 2 What constitutes a sufficiently undisturbed sample depends on the purpose for which the sample is required and can be a matter of judgement. For example, some compression of the sample might be acceptable when VOCs are to be determined, but would not be acceptable when the bulk density is to be determined. The ISO 22475 series defines classes of sample suitable for geotechnical testing.

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Soil sampling techniques usually consists of the following two steps:

a) gaining access to the point of sampling (avoiding services, as well as removing any hard cover, etc., digging, or drilling a hole to reach the desired depth of sampling);

b) taking the soil sample.

These steps are interdependent and should both meet the requirements of the sampling principles.

NOTE 3 A distinction can also be made between:

— sampling by drilling (continuous sampling);

— sampling using samplers (sampling devices) to obtain disturbed or undisturbed samples as required once a borehole or excavation has been formed;

— block sampling (in which a large undisturbed sample is obtained).

Combinations of these sampling methods are possible and sometimes required due to the geological conditions and the purpose of the investigation.

5 General aspects

5.1 Health and safety

All necessary measures shall be taken when selecting and applying sampling techniques to protect the health and safety of those carrying out the work, anyone entering the site (with or without permission), and the general public (e.g. the occupants of neighbouring properties) and to avoid harm to the environment.

The guidance in ISO 18400-103 shall be followed.

ISO 18400-103 should be read in conjunction with relevant national and international legislation and regulations regarding health and safety at work and associated guidance produced by statutory bodies and trade associations.

5.2 Preliminary information

A preliminary investigation comprising a desk study and site reconnaissance (walk-over survey, site inspection) should be carried out as specified in ISO 18400-202 prior to undertaking any sampling.

The selection of the sampling technique, the sampling equipment to be used, and the method of taking soil samples depend upon the objectives of the sampling, the strata to be sampled, the nature of possible contamination, and the examination or analysis to be carried out on the samples.

Information should be compiled and assessed about the following:

a) the objectives of the sampling;

b) required accuracy of measurements;

c) planned locations for boreholes and excavations;

d) the anticipated depths from which samples are to be taken taking into consideration the future use of the site including depth of excavations or foundations (see ISO 18400-104);

e) potential risks to the health and safety of the site personnel;

f) potential risks to the environment from the investigation including the potential to pollute groundwater and to spread infective agents;

g) emergency arrangements;

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h) the size and topography of the area to be sampled;

i) accessibility for different types and sizes of equipment and factors such as the likely bearing capacity of the ground, see Reference [1];

j) the nature of the ground to be sampled;

k) possible lateral and vertical variations of soil type or strata;

l) the geology of the site and surrounding area;

m) the assumed depth to groundwater;

n) previous usage or treatment of the site;

o) the presence of buildings and obstructions such as foundations, buried tanks, and underground services (e.g. electricity, sewers, mains, cables, gas);

p) the presence of concrete or tarmac pathways, roadways, or hard-standings;

q) the growth of vegetation leading to extensive root development;

r) the presence of unexpected surface-water pools or water-saturated ground;

s) the presence of fences, walls, or earthworks designed to prevent access to the site;

t) the presence of tipped material above the general level of the site or material from the demolition of buildings;

u) the presence of artefacts of archaeological or heritage value;

v) possible presence of unexploded ordinance, see Reference [2];

w) the presence of protected species, ecosystems, and other features of scientific value;

x) the presence of invasive or noxious plant species (e.g. Japanese Knotweed – *Fallopia japonica*, Giant Hogweed – *Heracleum mantegazzianum*) or infective agents (these may affect humans, animals, or plants) (see also 7.2, last paragraph);

y) location of water bodies at risk from contamination including surface and ground water;

z) the planned flow of information.

NOTE For guidance on accessibility for light percussion drilling rigs, see Reference [1].

5.3 Sample types

The samples taken should be of appropriate type(s) to enable the objectives of the investigation to be achieved in accordance with the guidance provided in ISO 18400-104. Special consideration is required regarding the following:

— whether to take disturbed or undisturbed samples;

— whether to take spot samples or cluster samples or to employ a form of spatial composite sampling (see Table 1);

— how to comply with any statutory or authoritative guidance relating to judging whether guideline values (assessment criteria) have been exceeded;

— whether statistical analysis of the data obtained will be required;

— the expected distribution of contaminants or other substances of interest;

— how to reduce uncertainty in the results of the investigation.

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Composite samples should not be used when soil characteristics that may suffer changes during the composition process, such as concentrations of volatile compounds, are to be determined. They also should not be used if peak concentrations of any substance or variations of soil characteristics are to be determined.

The use of cluster samples can reduce sampling uncertainties. This method of sampling is particularly appropriate when using trial pits when surface samples (e.g. 0,0 mbgl to 0,10 mbgl) are being taken and when carrying out validation sampling of imported topsoil.

Where composite sampling is used to determine the characteristics of *in situ* soil, the sample should represent a single stratum.

NOTE Table 1 provides information on different types of sample and their application.

Table 1 — Types of sample

Type of sample[a]	Uses	Means of sampling
Disturbed sample See 3.3	Disturbed samples are suitable for most purposes except, e.g. for determination of volatile organic compounds (VOCs), some physical measurements, profile descriptions, and microbiological examinations for which undisturbed samples are required.	Samples can be collected using one of a variety of sampling techniques. Disturbed samples may be taken as single spot samples or as composite samples where this is appropriate for the objectives of the investigation.
Undisturbed sample See 3.7	Undisturbed samples are inherently spot samples, i.e. taken from a specific material at a specific location and depth.	Samples can be collected using one of a number of techniques designed to preserve the soil structure and/or to prevent the loss of volatiles. The initial undisturbed field sample may sometimes be taken over a depth range or of extended lateral extent (e.g. when a core is taken for later examination) and subsequently subsampled in the laboratory.
Spot sample See 3.6	Suitable for identifying distribution and concentration of particular elements or compounds in geological or contamination investigations.	Samples can be collected using one of a variety of sampling techniques. Where undisturbed samples are required, specific drilling methods or special equipment (see Clause 8) are used to collect the sample while maintaining the original ground structure.

[a] See ISO 18400-104 for detailed guidance.

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Table 1 *(continued)*

Type of sample[a]	Uses	Means of sampling
Cluster sample See 3.1	Suitable for identifying distribu-tion and concentration of particular elements or compounds in geological or contamination investigations involving disturbed samples.	Samples are typically collected using hand tools on exposed surfaces, but may also be taken from locations within a bucket of excavated material.
Spatial (composite) sample Spatial sample, see 3.5	Appropriate for assessing the overall quality or nature of the ground in an area, e.g. for agricultural purposes. Not normally recommended for investigations of land potentially affected by contamination How-ever, some jurisdictions specify the use of a form of composite sampling for the assessment of surface and near-surface soils.	Samples normally collected using auger, trowel, or similar imple-ment for speed and repeatability.
[a] See ISO 18400-104 for detailed guidance.		

5.4 Sample size

Instructions regarding the size of the samples to be sent to laboratories should be provided in the sampling plan (as specified in ISO 18400-101) in accordance with the guidance in ISO 18400-104 taking into account, among other things:

— the range of pedological, chemical, physical, and/or biological examinations and tests that are to be carried out;

— the particle size distribution of the material be sampled;

— the specific requirements of the laboratory(ies) carrying out the examinations and tests.

Any subsampling from the sample extracted by the equipment or measures to reduce the volume of material to be transported to the laboratory should be carried out in accordance with ISO 18400-201.

When potentially expansive slags are to be sampled for expansion tests, specialist advice should be sought. These tests commonly require samples of about 50 kg or more to be taken, see References [3] and [4].

NOTE Often, laboratories carrying out the chemical analyses will require more than one sample from a location with those for different tests being of an appropriate size and placed in an appropriate container (e.g. plastic tub, glass jar) rather than a single large sample that can be subdivided or subsampled in the laboratory.

5.5 Available techniques

Available techniques for accessing and obtaining samples are listed in Table 2 together with qualitative information about their advantages and disadvantages. Table 3 provides further detail on the applicability and characteristics of the techniques while Table 4 provides further information on practical aspects of their application, such as the operating footprint and access requirements.

The use of other methods which might be suitable in specific locations or other methods which are developed in the future are not precluded by this document (see Clause 7).

Extreme natural circumstances such as permafrost, laterization, calcretion, or other indurations might require techniques other than those listed in Tables 2 and 3, in order to obtain samples.

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Other situations where special procedures might be required include, for example:

— sampling water-saturated soil (influenced by groundwater) in order to avoid negative influences on structure and physical properties, as well as loss or displacement of substances of interest;

— sampling when asbestos or asbestos-containing materials are present in the ground (it is essential to comply with national regulations concerning asbestos in relation to protection of workers, preventing spread of the asbestos, and the disposal of asbestos-containing wastes) (see References [5] and [6]).

NOTE 1 ISO 22475-1 specifies the technical principles for the execution of sampling and groundwater measurements for geotechnical purposes. It describes and provides guidance on the application of many of the sampling techniques included in this document, albeit in a different context. Many contractors engaged to carry out work in connection with environmental studies will be familiar with its often prescriptive requirements.

NOTE 2 When sampling from a trial pit, samples may be taken using a trowel, or similar, or samplers with a cutting action may be used (9.1.1), or block samples recovered. In cohesive soils, block samples can be cut by hand.

Continuous sampling (sampling by drilling) allows the following:

— identification and description of the soil at the site penetrated by the borehole;

— the differentiation of distinct soil layers and changes of soil material;

— the sampling, as well as the investigation of samples from all strata and depths.

Sampling using samplers (sampling devices) can be used in conjunction with many drilling methods. The drilling diameter should be chosen so that the sampler can be lowered to the borehole bottom without hindrance.

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Table 2 — Principle techniques for taking samples

Methods	Advantages	Disadvantages
Table 2 should be read in conjunction with Table 3 which gives further information on the applicability of ground excavation, drilling, and sampling techniques.		
Thin diagnostic layer scraping Can be formed by scraping off a thin layer (10 mm to 50 mm) from the exposed surface using a small shovel, trowel, spatula, or similar tool. Increments may be taken in this way from a number (e.g. 5 to 10) of squares and combined in a composite sample.	Allows collection of loosely compacted layers, especially organic horizons and a thin A horizon in forest areas.	—
Digging trial pits and trenches Can be formed by hand digging vacuum excavation or using wheeled or tracked excavators depending on the requirements of the investigation. For health and safety reasons, trial pits cannot normally be entered, unless shored, see Reference [7]. A suitably wide bucket is chosen according to the depth to be excavated which allows a good view of the excavation, but minimizes the amount of material excavated.	Allows detailed examination of ground conditions (in three dimensions). Easy to obtain discrete samples (where entry is appropriate) and bulk samples. Rapid and inexpensive if dug by hand or machinery is available. Applicable to a wide range of ground conditions. Can be used for integrated contamination and geotechnical investigations. Excavations (including separate faces) and excavated material can be photographed. It is good practice to use an identifier board giving the trial pit reference and also a scale, e.g. surveyor's staff. Use of a board showing standard colours can also be helpful.	The investigation depth is limited by the size of the machine (generally, approximately 4,5 m) (see Table 3). There can be significant safety issues (see ISO 18400-103, A.1.3 and Reference [7]). Media are exposed to air and there is a risk of changes to contaminants and loss of volatile components. Not suitable for sampling below water and groundwater table. Greater potential for disruption of/ damage to the site than boreholes/ probe holes. Care is required to ensure that surrounding area is not affected by excavated spoil and that reinstatement does not leave contaminants exposed or result in settlement of trafficked surface. Can generate more waste for disposal than boreholes. There is more potential for escape of contaminants to air/water. Might be necessary to import clean material to site for backfilling (to ensure clean surface).
[a] See A.2.		

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Table 2 *(continued)*

Methods	Advantages	Disadvantages
Hand augering Many designs available for different soil types, conditions, and sampling requirements. Preferred forms take a core sample.	Allows examination of soil profile and collection of samples at pre-set depths. Easier to use in sandy soils, i.e. where there are no obstructions, such as stones. Portable and useful for locations with poor access. Limited operating expense.	Only limited depths can be achieved if obstructions present, e.g. stones. Ease of use very dependent on soil type. Can lead to cross-contamination from material falling down auger hole. This can be prevented by the use of plastic casing. Only small sample volumes obtainable. Equipment can be physically difficult to operate. Samples are heavily disturbed. Not recommended for sampling for volatiles.[a]
Forming power driven auger boreholes Rotary drilling using solid stem auger	Can achieve greater depths than hand augers. More rapid than hand augering for shallow investigations. Can be used to install water and ground gas monitoring wells if hole remains open after withdrawal of auger.	Greater risk of physical injury to operator due to lack of guards and potential for snagging (due to obstructions). There is a need to avoid cross-contamination of samples and contamination due to fuel/exhaust gases. Sampling is only possible when auger withdrawn and if borehole remains open. Not suitable for sampling for volatiles.

[a] See A.2.

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Table 2 *(continued)*

Methods	Advantages	Disadvantages
Forming hollow stem auger boreholes Uses a continuous flight auger with hollow central shaft. Withdrawing centre bit and plug allows access down the stem for sampling.	Forms a fully cased hole avoiding potential problems of cross-contamination arising with cable percussion techniques. Soil samples can be taken through hollow stem allowing accurate estimation of depth. Can be used for installation of water and ground gas monitoring wells. Usually more rapid than cable percussion. Good recovery possible of very coarse samples (e.g. river terrace gravels) compared to cable percussion.	Less amenable to visual inspection of strata than cable percussion boreholes. Less suitable for deeper boreholes than cable percussion, unless large rigs used. Not suitable for sampling for volatiles. Difficulties in measuring water strikes, particularly where water is used during drilling.
Driven tube sampling Consist of a hollow metal tube (possibly with a plastic sleeve) that is driven into the ground with a hydraulic or pneumatic hammer.	Continuous intact samples of the complete soil profile can be recovered. A variety of measuring devices can be installed once hole is formed. Less potential for adverse effects on health and safety and aboveground environment than trial pits and boreholes. Can be used either for shallow sampling or at depths down to 10 m with appropriately sized equipment. Substantially faster than cable percussion. Portable so can be used in poor and limited access areas. Enables groundwater samples to be collected since ground is not disturbed. Enables monitoring well installation by using a driven point slotted well screen.	Limited opportunity to inspect strata. Sample volumes can be relatively small depending upon the diameter of the driven tube. Cannot penetrate obstructions, e.g. brick. Can cause smearing of hole walls in some strata. Poor sample recovery in non-cohesive granular material. Causes compression of some strata, e.g. peat. Holes not cased and could open up migration pathways. Limited possibility of sampling for volatiles. Difficulties in measuring water strikes, particularly where water is used during drilling.

[a] See A.2.

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Table 2 *(continued)*

Methods	Advantages	Disadvantages
Dynamic sampling, window sampling, windowless sampling, closed piston sampling Cylindrical steel tubes are driven into the ground by a percussive hammer Steel tubes are often provided with disposable plastic liners. (Some dynamic sampling rigs are capable of rotary drilling also.)	Permits collection of continuous intact samples Can be used for installation of water and ground gas monitoring wells. Very compact rigs are available which can be used inside buildings or where space is limited. Does not require flush to be used minimizing the risk of cross-contamination and waste generated Effective at retaining volatiles, especially in cohesive soils where a plastic liner is used and because a relatively intact sample can be cut from the extruded core. Windowless sampling can be used to obtain samples for testing for volatiles. Casing can be inserted where the rig has adequate power and a removal system.	Generally, poor recovery in dense sands and gravels loose sands below the water table and certain types of made ground. Limited depth of penetration compared to other drilling methods, particularly for the smallest rigs. Where used, a percussive hammer is noisy. Could be unsuitable in certain locations where noise is an issue Cannot penetrate through hard rock or obstructions (except where the drilling rig has a dual percussive and rotary capability). Hammering and rod vibration can lead to compaction of sediments within the plastic liner during sampling. Difficulties in measuring water strikes, particularly where water is used during drilling.

[a] See A.2.

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Table 2 *(continued)*

Methods	Advantages	Disadvantages
Forming cable percussion boreholes Consists of a tripod derrick with a winch driven by a diesel engine. The cutting tool which forms the borehole by gravity percussion is attached to the winch via a steel cable. Steel casing can be used to support the borehole	Allows greater sampling depth than trial pits or hand augers. Enables installation of permanent sampling/monitoring wells. Can penetrate most soil types. Less potential for adverse effects on above-ground environment than trial pits (but note, there are potential risks to groundwater). Minimal surface disturbance. Allows the collection of intact samples. Allows integrated sampling for contamination, geotechnical and gas/water sampling, and the installation of groundwater and ground gas monitoring pipes. Allows use of clean drilling techniques for aquifer protection. Not usually suitable for sampling for volatiles, but large diameter cores can be sealed in the field and subsampled in the laboratory under controlled conditions.	More time-consuming than trial pits and hand augers. Less amenable to visual inspection than trial pits. Waste from boreholes requires disposal and can cause surface contamination where groundwater or liquid contamination is present. Limited access for discrete sampling purposes. Smaller sample volumes than for trial pits. Can cause disturbance of samples and therefore, loss of contaminants. Potential for contamination of underlying aquifers and groundwater flow between strata within an aquifer, unless properly cased (see 7.2). Samples from standing water can be subject to cross-contamination and are therefore, not representative of the groundwater (see B.2.7, Application). Difficulties in measuring water strikes, particularly where water is used during drilling.

[a] See A.2.

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Table 2 *(continued)*

Methods	Advantages	Disadvantages
Sonic/rota-sonic drilling Involves the use of high-frequency energy which shears and displaces the soil particles. Two types of rig are generally available: sonic and rota-sonic. Rota-sonic combines rotary and sonic drilling capabilities in the same rig	Permits at or near 100 % core recovery in the majority of ground conditions. Fast drilling is possible. Permits recovery of intact samples. The use of drilling flush is not always necessary. Rotary-sonic drilling can penetrate all soil types and also hard rock, concrete, and other obstructions (sonic drilling can be subject to refusal). Might permit sampling for volatiles from core.	Some rigs do not have the ability to insert casing, which could result in the creation of migration pathways. Dry drilling (without flush) can result in heat being generated by the drill rod, which causes loss of volatiles. This can be reduced by changing the drilling process. Sonic drilling in weak rock can result in drilling-induced fracturing of the intact samples, which could be of concern if an integrated investigation (see 7.2) is required. Dry soils can adversely affect progress of probing. Difficulties in measuring water strikes, particularly where water is used during drilling. Drilling flush requires containment and disposal.

[a] See A.2.

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Table 3 — Applicability of ground excavation, drilling, and sampling techniques

Designation	Method	Method of sample extraction	Normal area/ diameter	Soil profile detail	Suitability for ground type		Suitable below water table	Type of sampling possible	Typical depth of sampling[a]	Comments
				mm	Unsuitable for soil type	Suitable for soil type			m	
Manual methods										
Hand auger	Rotary	With auger	50 mm to 100 mm	50	Hard rock Non-cohesive gravel, stones, rubble, lumps of material Likely to be difficult in made ground	Clay, silt, cohesive sand and similar ground Granular-material subject to ground stability, grain size and degree of cohesion	No	Disturbed	0 to 2,0	Sampling to 5,0 m possible in cohesive sandy ground Some types of auger can be used below water table
Hand excavation	Digging	With sampling tool	1 m × 1 m	10	Solid concrete or similar obstruction	All types	No	Disturbed or undisturbed	0 to 1,5	In unstable ground, the sides may need support
Machine excavations										
Trial pit	Digging	With sampling tools	3 m to 4 m × 1 m	10	Hard rock Large solid obstructions	All soils and material including made ground subject to ground stability	No	Disturbed and undisturbed	0 to 6	
Power-driven sampling holes										
Power driven auger	Rotary	With auger	50 mm	50	Non-cohesive gravel, large stones, lumps of material	Clay, silt, cohesive and similar ground	No	Disturbed	0,05 to 2,0	Sampling to 5,0 m possible in cohesive sandy ground

NOTE Table 3 is only indicative.

[a] Where a minimum depth is given, a "starter pit" of the specified depth is usually required.

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Table 3 *(continued)*

Designation	Method	Method of sample extraction	Normal area/ diameter	Soil profile detail	Suitability for ground type		Suitable below water table	Type of sampling possible	Typical depth of sampling[a]	Comments
				mm	Unsuitable for soil type	Suitable for soil type			m	
Continuous flight auger	Rotary drilling with solid stem auger	Not possible	150 mm to 500 mm	300 to 500	Solid obstructions and hard rock/ boulders	All soils	No	None	0 to 20	Suitable for passing through top layers which are of interest
Hollow stem auger	Rotary drilling	With sampling equipment down stem	150 mm to 500 mm	50	Solid obstructions and hard rock/ boulders	All soils	Yes	Disturbed and undisturbed	0 to 20	Sampling down centre stem with auger *in situ* possible
Pulse boring/ dynamic probe	Ramming	With sample tool on machine	50 mm to 100 mm	25	Hard rock Gravels, large stones, lumps of material Very dense sands and gravels	Clay, silt, cohesive sand and similar ground subject to grain size and cohesiveness	Yes	Disturbed and undisturbed	0,5 to 10	
Light cable	Percussion	With boring tools	150 mm to 300 mm	100	Obstructions, e.g. tyres, wood, concrete, solid obstructions and hard rock/ boulders	Clay, silt, cohesive sand and similar ground	Yes	Disturbed and undisturbed	0,5 to 30 (but can be deeper)	

NOTE Table 3 is only indicative.

[a] Where a minimum depth is given, a "starter pit" of the specified depth is usually required.

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