# INTERNATIONAL STANDARD

# ISO 5667-22

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## Water quality — Sampling —

## Part 22:
## Guidance on the design and installation of groundwater monitoring points

*Qualité de l'eau — Échantillonnage —*

*Partie 22: Lignes directrices pour la conception et l'installation de points de contrôle des eaux souterraines*



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## Contents

Page

## 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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

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.

ISO 5667-22 was prepared by Technical Committee ISO/TC 147, *Water quality*, Subcommittee SC 6, *Sampling (general methods)*.



ISO 5667 consists of the following parts, under the general title *Water quality — Sampling*:

— *Part 1: Guidance on the design of sampling programmes and sampling techniques*



— *Part 3: Guidance on the preservation and handling of water samples*

— *Part 4: Guidance on sampling from lakes, natural and man-made*

— *Part 5: Guidance on sampling of drinking water from treatment works and piped distribution systems*

— *Part 6: Guidance on sampling of rivers and streams*

— *Part 7: Guidance on sampling of water and steam in boiler plants*

— *Part 8: Guidance on the sampling of wet deposition*

— *Part 9: Guidance on sampling from marine waters*

— *Part 10: Guidance on sampling of waste waters*

— *Part 11: Guidance on sampling of groundwaters*

— *Part 12: Guidance on sampling of bottom sediments*

— *Part 13: Guidance on sampling of sludges from sewage and water treatment works*

— *Part 14: Guidance on quality assurance of environmental water sampling and handling*

— *Part 15: Guidance on the preservation and handling of sludge and sediment samples*

— *Part 16: Guidance on biotesting of samples*

— *Part 17: Guidance on sampling of bulk suspended solids*

— *Part 19: Guidance on sampling of marine sediments*

— *Part 20: Guidance on the use of sampling data for decision making — Compliance with thresholds and classification systems*

— *Part 21: Guidance on sampling of drinking water distributed by tankers or means other than distribution pipes*

— *Part 22: Guidance on the design and installation of groundwater monitoring points*

— *Part 23: Determination of priority pollutants in surface water using passive sampling*



 

## Introduction

The guidance contained in this part of ISO 5667 covers design and installation of groundwater quality monitoring points (GQMPs). It should be used in parallel with other guidance on sampling groundwater and for investigating contaminated or potentially contaminated sites, as any groundwater sampling from such sites is likely to form part of a much wider investigation programme.

Groundwater sampling, in general, is carried out to determine whether or not the groundwater in or beneath a site is contaminated. It can also be used to:

a) establish whether any migration of contaminants, derived from the site, is occurring and characterize the spatial extent (both laterally and vertically) of any contamination and its form;

b) determine the direction, rate and variability of groundwater flow and contaminant migration;

c) provide data for undertaking a risk assessment;

d) provide an early warning system for the impact of contaminants on the quality of groundwater resources, surface waters and other potential receptors in the vicinity of the site;

e) monitor the performance and effectiveness of remedial measures or facility design;



f) demonstrate compliance with licence conditions, or collect evidence for regulatory purposes;



g) assist in the selection of remedial measures and remediation process design.



The design and installation of groundwater monitoring points is critical to ensure that representative measurements are to be made of groundwater quality. A wide range of methods and materials is currently used with no, or very little, guidance on their applicability to the issues being addressed. This results in data and information that are at best difficult to interpret as well as being highly misleading; at worst, they are completely useless. The costs involved in installation, sampling and analysis are significant and the potential impacts of incorrect decisions made on poor quality data even greater. There is therefore a need to develop best practice guidance to establish a framework that can be adopted to ensure a much greater level of confidence in groundwater quality data.

Prescriptive guidance on methods and applications is not possible. Therefore, this guidance provides information on the most commonly applied and available techniques, and lists their advantages, disadvantages and limitations of use where these are known. When considering design of sampling strategies, the properties of potential sources of contaminants, pathways for migration, receptors, the purpose of the investigation and the environment into which the installations are to be emplaced need to be considered.

# Water quality — Sampling —

## Part 22:
## Guidance on the design and installation of groundwater monitoring points

## 1 Scope

This part of ISO 5667 gives guidelines for the design, construction and installation of groundwater quality monitoring points to help ensure that representative samples of groundwater can be obtained. Within the guidance consideration is given to:

a) the impact of installation materials on the environment;

b) the impact of the installation on sample integrity;



c) the impact of the environment on the installation and the materials used in its construction.



These guidelines allow the impacts to be considered and accounted for when designing a groundwater sampling programme. They also allow an informed assessment of data and results obtained from existing installations, the construction of which can potentially have an impact on sample integrity.



These guidelines are intended for installations and monitoring in different environments including those where background or baseline groundwater conditions are being established or monitored and those in which impacts of contamination are being investigated.

## 2 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

**2.1**
**annulus**
void between any piping, tubing or casing and the piping, tubing or casing immediately surrounding it

**2.2**
**aquifer**
geological formation (bed or stratum) of permeable rock or unconsolidated material (e.g. sand and gravels) capable of yielding significant quantities of water

NOTE Adapted from ISO 6107-3:1993[8], 6.

**2.3**
**bentonite**
clay, formed by the decomposition of volcanic ash, that swells as it absorbs water

NOTE 1 Adapted from ISO 6707-1:2004[9], 3.2.18.

NOTE 2 Refined bentonite is used to make a watertight seal. Sodium is often added in the refining process to enhance the swelling properties.

**2.4**
**dense non-aqueous phase liquids**
**DNAPL**
organic compounds that have low water solubility and a density greater than that of water, e.g. chlorinated hydrocarbons such as trichloroethane

[ISO 6107-2:2006[7], 34]

**2.5**
**effective porosity**
proportion of saturated openings or pores within a water-bearing formation which contribute directly to the flow of groundwater

[ISO 6107-2:2006[7], 43]

NOTE Effective porosity is represented as the ratio of this volume of pore spaces to the total volume of rock.

**2.6**
**geotextile wrap**
synthetic inert woven material wrapped around the outside of the screen to prevent entry of solid particles into the borehole or piezometer without restricting flow of water

**2.7**
**groundwater**
water which is being held in, and can usually be recovered from, a saturated or unsaturated underground formation or artificial deposit such as made ground

NOTE Adapted from ISO 6107-1:2004[6], 41.

**2.8**
**hydraulic conductivity**
property of a water-bearing formation that relates to its capacity to transmit water through its internal, interconnected pathways



[ISO 6107-2:2006[7], 53]

**2.9**
**light non-aqueous phase liquid**
**LNAPL**
organic compounds which have low water solubility and a density less than that of water, e.g. petroleum products

[ISO 6107-2:2006[7], 59]

**2.10**
**multi-level sampler**
single installation for sampling groundwater from discrete depths within the subsurface

[ISO 6107-2:2006[7], 67]

NOTE The device can be driven directly into the ground, installed in a pre-existing borehole or installed in a purpose-drilled hole. When installed in a borehole, integral packers are used to isolate individual sample ports.

**2.11**
**multiple boreholes**
group of individual boreholes or piezometers installed separately to form a monitoring network adequate for the purposes of an investigation

**2.12**
**nested piezometers**
group of piezometers installed within a single larger diameter borehole

[ISO 6107-2:2006[7], 69]

NOTE In general, each piezometer is designed to allow sampling over a specific depth interval within the aquifer. Piezometer tips are surrounded by a sand pack which in turn is isolated from adjacent sampling points by installing a permanent impermeable seal between them to eliminate leakage between sample points.

**2.13**
**packer**
device or material for temporarily isolating specified vertical sections within boreholes in order to perform groundwater sampling from discrete zones or locations within the borehole or aquifer

[ISO 6107-2:2006[7], 75]

**2.14**
**perched groundwater**
isolated body of groundwater, which is limited in lateral and vertical extent, located within the unsaturated zone overlying a much more extensive groundwater body

NOTE Adapted from ISO 6107-2:2006[7], 79, "perched water table".

**2.15**
**piezometer**

device consisting of a tube or pipe with a porous element or perforated section (surrounded by a filter) on the lower part (piezometer tip), which is installed and sealed into the ground at an appropriate level within the saturated zone for the purposes of water level measurement, hydraulic pressure measurement or groundwater sampling



NOTE Adapted from ISO 6107-2:2006[7], 81.

**2.16**
**receptor**
⟨sampling of ground water⟩ entity that is vulnerable to the adverse effect(s) of a hazardous substance or agent

[ISO 6107-2:2006[7], 100]

NOTE An entity is something that may suffer harm or damage if exposed to the hazard, e.g. humans, animals, aquatic ecosystems, vegetation or building services.

**2.17**
**groundwater response zone**
section of a borehole or groundwater monitoring point that is open to the host strata

**2.18**
**saturated zone**
part of an aquifer in which the pore spaces of the formation are completely water-saturated

[ISO 6107-2:2006[7], 119]

**2.19**
**well screen**
section of borehole casing that is perforated with either slots or holes to allow the entry of groundwater

**2.20**
**tremmie pipe**
narrow (25 mm to 50 mm) diameter plastic pipe placed down the annulus of an installation for the purpose of adding filter materials and sealants

**2.21**
**unsaturated zone**
part of an aquifer in which the pore spaces of the formation are not totally filled with water

[ISO 6107-2:2006[7], 150]

# 3 Principle

## 3.1 General

The installation and operation of groundwater monitoring points generally forms one part of an investigation or operation that also involves other technical considerations and objectives. This guidance includes consideration of the broader objectives of the investigation and the purpose of boreholes or monitoring points, and the need to build in flexibility.

The development of a design plan is recommended. This plan should consider all potential factors that can influence monitoring point installation and operation. This includes whether the facility is required for short-term or long-term use, the range of parameters that are to be measured or determined, acceptable tolerances, and quality of data. The design framework in Figure 1 can be used to support the process and allow the relevant factors and key considerations for monitoring point design and construction to be considered.



## 3.2 Monitoring objectives



The principal objective of all groundwater quality monitoring installations is to obtain a representative groundwater sample to be collected. The purpose for which the sample is being obtained should fall into one of three categories:

a) strategic: monitoring to obtain background or baseline information on groundwater quality and to identify wide-scale trends in quality due to changing natural conditions or pollution;

b) defensive: monitoring around a known activity such as a waste disposal site, around a sensitive receptor (e.g. a groundwater dependent wetland) or to monitor remediation of groundwater;

c) investigative: monitoring to investigate and characterise groundwater below or adjacent to areas of known or suspected contamination — this also includes monitoring of free-phase liquids (e.g. LNAPLs).

Objectives may change during the lifetime of a groundwater quality monitoring installation and they may also have multiple objectives at any one time. The monitoring installation should be designed to be as versatile as possible.

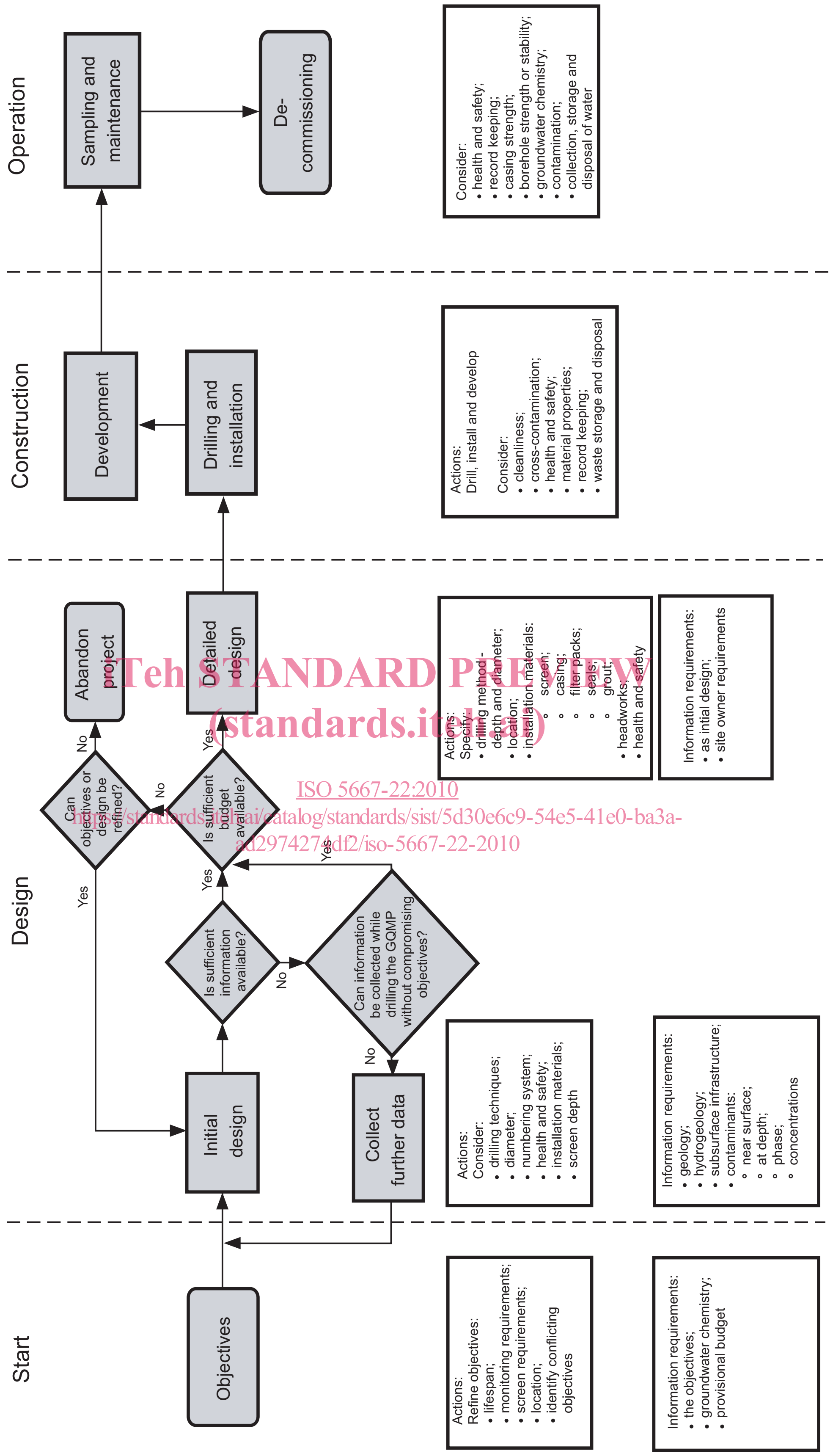




**Figure 1 — Design and Installation flow chart**

# 4 Design

## 4.1 Introduction

### 4.1.1 General

The design considerations for a groundwater quality monitoring installation can be divided into two phases: a) initial design and b) detailed design.

Initial design represents a preliminary assessment of the considerations, while detailed design represents a thorough in-depth examination of the issues and the decision-making leading to installation.

### 4.1.2 Initial design

The initial design phase should be a quick and relatively simple process. It should consider the design basics and available options. This includes drilling method (and flushing medium to be used), borehole location and depth, outline design and cost estimates, and identification of information gaps. This stage of work should form the basis of the information needed to hold preliminary discussions with stakeholders, clients, and drillers. Following the initial design stage, potential difficulties should have been identified along with potential solutions, the likely costs, and any significant health and safety issues.

### 4.1.3 Detailed design

At this stage, the groundwater quality monitoring installation design is developed in detail to allow the specification to be finalised, and procurement and construction commissioning processes to be put in place.



## 4.2 Conceptual model



### 4.2.1 General

An understanding of the subsurface environment is vital if the groundwater quality monitoring installation is to operate effectively. This understanding can be developed within the context of a conceptual site model. The conceptual site model represents a collection of information that allows the subsurface conditions to be visualised. For groundwater quality monitoring installations, it should comprise geological or hydrogeological information. The geological environment is the most significant factor in the selection of a drilling technique. The strata type and thickness influence drilling methodology, choice of materials and design of response zones. The degree of understanding required to allow a suitable design is determined by:

a) the (anticipated) complexity of the environment;

b) cost-benefit analysis, e.g. whether the cost of further investigation is justified by improved design or understanding;

c) type of installation being considered, e.g. multi-level installations require more detailed information.

Examples of the geological information that is required for soils and rock are listed in the following.

For soils, the following factors may influence drilling technique selection:

1) degree of cohesion, where fine soils are more likely to stand open than coarse soils;

2) density of coarse, granular deposits, where temporary casing is almost always required in granular deposits, which tend to “blow” below the water table and require the addition of water;

3) absence or presence of cobbles, boulders, and stones which some soil-drilling techniques may be unable to penetrate;

 

4) thickness, where difficult drilling conditions may often be overcome if the soil is thin, but may require specialist techniques when they are thick;

5) saturated or unsaturated conditions, where unsaturated sands may run into the hole while saturated sands may blow.

For rock, the important factors are:

i) rock strength, where weak rock can often be penetrated using soil-drilling techniques, while strong rock slows drilling progress and causes refusal of some techniques;

ii) depth or thickness to be penetrated;

iii) presence of weathered or weak zones, which may require the borehole to be supported by temporary casing;

iv) presence of voids such as fractures, solution features, and mine workings, which may cause loss of flushing medium.

### 4.2.2 Rock strength

The relative strength of a geological deposit affects the rate of drilling, the need for support of the borehole walls and the strength required of the installation materials. Loose, coarse and soft, fine deposits always need support with temporary casing or the use of drilling muds, except where direct push installation methods are used. Support may also be needed in highly-fractured rock where blocks or wedges may move into the borehole. Drilling through mine workings may encounter loose ground which can block the borehole.

Swelling clays can lead to difficulties during drilling and installation, as these deposits can swell into the borehole void, reducing the effective diameter. If support cannot be given to the borehole walls (either because of the drilling method or the risk of having temporary casing seize in the hole), then installation should immediately follow drilling to reduce the potential loss of the hole. Chemical additives may slow or eliminate the swelling effect; however, because of their potential effect on groundwater chemistry, additives should only be used after careful consideration.

Loose sands below the water table often “blow” into the borehole. This results from a head difference between the water level inside the temporary casing and the surrounding soil, leading to sand moving into the casing. This effect may be further enhanced by suction created by the drilling action, which draws more material inwards. The potential outcome is that the temporary casing fills with sand at a faster rate than the drilling operation can remove it, and it can then become difficult to remove the temporary casing. To minimise the effect of blowing, it may be necessary to maintain the water level inside the temporary casing above that of the outside, by adding water.

### 4.2.3 Depth

The required depth of the groundwater quality monitoring point (GQMP) influences the choice and quantity of casing materials and the choice of drilling technique (see 4.3). Most techniques are capable of drilling shallow boreholes, but as depth increases, so does its impact on the design. Some drilling techniques are limited in the depth to which they can penetrate because of physical constraints, such as excessive frictional resistance in augering and direct push techniques.

Cable tool drilling is usually limited by the rate of progress, which decreases with depth, and by the size of equipment needed, where larger rigs are required for deeper holes.

Rotary drilling techniques can be used in shallow boreholes, but the ancillary equipment and relatively expensive mobilization can constitute a large outlay.



 