

AS/NZS 5667.1:1998

Australian/New Zealand Standard[®]

Water quality—Sampling

**Part 1: Guidance on the design
of sampling programs, sampling
techniques and the preservation
and handling of samples**

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Australian and New Zealand Environment and Conservation Council
Griffith University, Australia
Minerals Council of Australia
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AS/NZS 5667.1:1998

Australian/New Zealand Standard®

Water quality—Sampling

Part 1: Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples

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PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee EV/8, Methods for Examination of Waters, to supersede AS 2031.1—1986, *Selection of containers and preservation of water samples for chemical and microbiological analysis*, Part 1: *Chemical*.

This is Part 1 in a series of Standards on the sampling of waters and waste waters. The objective of this series of Standards, is to provide guidance for the sampling and monitoring of waters and waste waters, including guidance on the design of sampling programs, sampling techniques, preservation, handling and transport of samples for the purposes of process control, quality characterization, identification of sources of pollution, compliance with water quality guidelines or standards, and other specific reasons.

The objective of this part of the series is to provide general principles to be applied in the design of sampling programs, general guidance on sampling techniques and guidance on the procedures to be taken to preserve and transport samples. Major changes from the 1986 edition include the addition of guidance on design of sampling programs, sampling techniques and the handling and transport of samples and its publication as a Joint Standards Australia/Standards New Zealand Standard.

However, the Tables providing guidance on preservation in Part 1 are for physico-chemical, chemical and radiological determinands only. It is envisaged that further parts of the series will provide guidance on suitable container types, preservation techniques and recommended holding times for samples for microbiological and biological analysis. At present AS 2031.2—1986, *Selection of containers and preservation of water samples for chemical and microbiological analysis*, Part 2: *Microbiological* provides guidance on the preservation techniques for samples for microbiological analysis.

During the preparation of this Standard, cognizance was taken of ISO 5667-1, *Water quality—Sampling*, Part 1: *Guidance on the design of sampling programs*, ISO 5667-2, *Water quality—Sampling*, Part 2: *Guidance on sampling techniques*, ISO 5667-3 *Water quality—Sampling*, Part 3: *Guidance on the preservation and handling of samples* and *Standard Methods for the Examination of Water and Waste Water*, APHA, 19th edition, 1996.

The term 'informative' has been used in this Standard to define the application of the appendix to which it applies. An 'informative' appendix is only for information and guidance.

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STANDARDS AUSTRALIA/STANDARDS NEW ZEALAND

Australian/New Zealand Standard

Water quality—Sampling

Part 1: Guidance on the design of sampling programs,
sampling techniques and the preservation and handling of samples

SECTION 1 SCOPE AND GENERAL

1.1 SCOPE This Standard provides general principles to be applied in sampling for the physical, chemical, microbiological or radiological analysis of waters and waste waters, including bottom sediment and sludges, for the purposes of process control, quality characterization, identification of sources of pollution and the monitoring of background levels.

The guidance on sampling procedures provided in this Standard is generally applicable. Where alternative procedures are used they are to be demonstrated to be at least as reliable as those provided in this Standard or that they will achieve the objectives of the sampling and analysis program.

The general principles and guidance contained in this Standard are as follows:

- (a) General principles to be applied in the design of sampling programs.
- (b) General guidance on sampling techniques.
- (c) General guidelines on the procedures to be followed to preserve and transport samples. These include guidelines for the selection of containers, quality control measures and tables that provide details of preservation techniques.

NOTE: Special care is needed when collecting samples for microbiological examination. Recommendations for the selection and preparation of sample containers and transport and storage of microbiological samples is provided in AS 2031.2.

1.2 REFERENCED DOCUMENTS The following documents are referred to in this Standard:

AS

- 2031 Selection of containers and preservation of water samples for chemical and microbiological analysis
- 2031.2 Part 2: Microbiological
- 2865 Safe working in a confined space
- 3550 Methods for the analysis of waters
- 3550.1 Part 1: Determination of dissolved sulphide—Spectrophotometric method

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- 5667 Water quality—Sampling
- 5667.4 Part 4: Guidance on sampling from lakes, natural and man-made
- 5667.5 Part 5: Guidance on sampling of drinking water and water used for food and beverage processing
- 5667.6 Part 6: Guidance on sampling of rivers and streams
- 5667.7 Part 7: Guidance on sampling of water and steam in boiler plants
- 5667.8 Part 8: Guidance on the sampling of wet deposition
- 5667.9 Part 9: Guidance on sampling from marine waters

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5667.10 Part 10: Guidance on sampling of waste waters

5667.11 Part 11: Guidance on sampling of groundwaters

ISO

3696 Water quality for analytical laboratory use—Specification and test methods

6107 Water quality—Vocabulary

6107.2 Part 2

7875 Water quality—Determination of surfactants

7875.1 Part 1: Determination of anionic surfactants by measurement of the methylene blue index (MBAS)

7875.2 Part 2: Determination of non-ionic surfactants using Dragendorff reagent

1.3 DEFINITIONS For the purposes of this Standard, the definitions in ISO 6107.2 and those below apply.

1.3.1 Analyte—the constituent to be analysed.

1.3.2 Composite sample—two or more samples or subsamples, mixed together in appropriate known proportions (either discretely or continuously), from which the average result of defined characteristics may be obtained. The proportions are usually based on time or flow measurements.

1.3.3 Grab sample—a discrete sample taken randomly, with regard to time and location, from a body of water, waste water, bottom deposit or sludge.

1.3.4 Isokinetic sampling—sampling at a rate such that the velocity and direction of the liquid entering the sampling nozzle is the same as that of the liquid in the sample stream at the sample point.

1.3.5 Maximum recommended holding time—that time from when the sample is taken to when the analytical process is commenced.

1.3.6 Sample—a portion, ideally representative, removed from a specified body of water, either discretely or continuously, for the purpose of examination of various defined characteristics.

1.3.7 Sampling—the process of removing a sample of a body of water for the purpose of examination of defined characteristics.

1.3.8 Sampling equipment—equipment used to obtain a sample of water, either discretely or continuously, for the purpose of examination of various defined characteristics.

1.3.9 Wet deposition—water precipitated from the atmosphere in either the liquid (rain) or solid state (snow/ice).

SECTION 2 OBJECTIVES

2.1 GENERAL Whenever a body of water, waste water, bottom sediment or sludge is to be characterized, it is generally impossible to examine the whole, therefore the objective in collecting samples is to obtain a small and representative portion of the body being investigated. All precautions should be taken to ensure that, as far as possible, the samples do not undergo any changes in the interval between sampling and analysis. Resources allocated to the setting of objectives and the proper design of a sampling program are usually well justified by ensuring that the required information is obtained efficiently and economically.

2.2 SETTING OF OBJECTIVES Before any sampling program is devised the objectives of the sampling program should be defined and it may be necessary to carry out a preliminary sampling and analysis program. The objectives, along with resource constraints are the major factors in determining the following:

- (a) Data quality objectives, i.e. the uncertainty that can be tolerated to meet the objectives of the sampling program.
- (b) Location of sampling sites.
- (c) Frequency and duration of sampling.
- (d) Sampling procedures.
- (e) Subsequent treatment and preservation of samples.
- (f) Chain-of-custody procedures.
- (g) Analytical requirements.
- (h) Traceability of data.

Consideration should also be given to—

- (i) the degree of detail and precision that will be required;
- (ii) the manner in which the results are to be expressed and evaluated (for example concentrations or loads, maximum and minimum values, arithmetic means, median values); and
- (iii) relevant data from previous programs at the same or similar locations and other information on local conditions.

The types of sampling program may have different requirements in terms of type and quality of data needed, sampling frequencies or number of samples and quality control considerations. Some of these considerations are dealt with in Section 5 and Section 6.

Four main types of sampling program are as follows:

- (A) Process control programs, e.g. for a water or waste water treatment plant to decide if process adjustments are required.
- (B) Quality characterization measurements, e.g. to assess compliance with guidelines, standards or discharge licence requirements.
- (C) Identification of pollution sources.
- (D) Monitoring of background levels.

NOTE: See Appendix A for further information.

2.3 DOCUMENTATION OF PROCEDURES Once the program design has been finalized, comprehensive procedures for sampling, laboratory analysis and reporting of the data should be precisely defined and documented. This documentation should include exact details of the sample site (see Clause 4.1.1). Detailed procedural steps for the method of collection of samples, provision of quality control samples, chain-of-custody procedures and the preservation and transport of samples are also required.

2.4 REVIEW OF OBJECTIVES For sampling programs of any significant duration, the program objectives should be reviewed on a regular basis. All factors considered in setting the original objectives should be reassessed in light of the data generated to date and the outcomes of other similar programs. The frequency of reviews should be established at the start of the program.

SECTION 3 SAFETY PRECAUTIONS

3.1 GENERAL The wide range of conditions encountered during sampling can subject personnel to a variety of safety and health risks. Thus, health and safety must always be considered in the development of any sampling program. Planning and execution of suitable safety protocols with due regard to occupational health and safety issues will help reduce accidents and exposure to hazardous or potentially hazardous substances. Sampling personnel should be informed of any necessary precautions to be taken in sampling operations and have the appropriate training.

3.2 SAFETY AND PERSONAL EQUIPMENT Safety plans should include requirements for the wearing of appropriate safety equipment. Such equipment may include gloves, protective glasses, hard hats, wide brimmed hats, sun block, safety boots and overalls or aprons. All safety equipment should be checked before beginning sampling.

3.3 HAZARDOUS SAMPLES If the samples are of a hazardous or potentially hazardous nature the appropriate safety equipment should be worn. Samples may be corrosive, radioactive, may contain toxic, allergenic or flammable materials or in the case of raw sewage or similar effluent may contain microbiological or virological hazards.

3.4 HAZARDOUS ATMOSPHERES OR CONFINED SPACES The concentration of oxygen and of any toxic vapour or gas likely to be present should be measured before personnel enter confined spaces. For detailed procedures and information on entry into confined spaces, see AS 2865. In addition, gas protection equipment, gas meters, breathing apparatus, safety harness, resuscitation apparatus and other safety equipment should be available when personnel have to enter hazardous atmospheres. If possible, the sample program design should allow sampling to take place without entry into confined spaces. For explosive atmospheres intrinsically safe sampling equipment should be used.

3.5 NATURAL HAZARDS In some situations, consideration should be given to natural hazards such as poisonous foliage, animals and reptiles.

3.6 SAMPLING SITES Every effort should be taken to ensure that sampling sites are safe. Sampling from unsafe sites, such as unstable banks, should be avoided if possible. If this is unavoidable, the operation should be conducted by a team using appropriate precautions rather than one person.

3.7 WEATHER CONDITIONS General environmental and climatic conditions should be considered in order to ensure the safety of personnel and equipment.

3.8 SAMPLING FROM BOATS Stability is an important property of any boat used for sampling purposes. Precautions should be taken in relation to other boats or ships, e.g. the correct signal flags should be flown, to indicate the nature of the work being undertaken. Safety flares, emergency beacons and communication devices should be considered. Lifejackets should always be worn when sampling from boats. Boats should be capable of reaching all sampling positions within the time-limits of the survey in suitable weather conditions.

3.9 ELECTRICAL HAZARDS The use of electrically operated sampling equipment in or near water can present electrocution hazards. Work procedures, site design and equipment maintenance should be planned to minimize these hazards.

SECTION 4 FACTORS AFFECTING SAMPLING

4.1 GENERAL CONSIDERATIONS

4.1.1 Identifying the sampling location Sampling locations should be clearly identified to enable comparative samples to be taken at other times.

NOTE: Map references, G.P.S. systems, photographs, site plans or reference to easily identifiable natural features may be required.

4.1.2 Access Ease of access to the sampling site is important, especially for frequent routine sampling.

4.1.3 Equipment integrity Precautions should be taken to avoid the installation of instruments or other items of equipment in situations where they will be susceptible to damage, e.g. by flooding or vandalism.

4.1.4 Character of flow The character of flow is important and is specific to the particular type of body to be sampled. Slugs of material may occur, e.g. dissolved contaminants, solids, volatile materials or oily surface layers.

NOTE: Details on flow measurement are given in Appendix B.

4.1.5 Changes in sample characteristics Temperature variation over long or short periods may cause changes in the nature of the system. Changes in meteorological conditions may induce marked variations in water quality. Such changes should be noted, if possible, and allowance made for them when interpreting results. Mixtures of waters of different densities can cause layering in a streamlined flow, for example the production of a layer of warm water over cold water or of fresh water over saline water.

4.1.6 Nature of the sample The sample may be corrosive or abrasive. Resistance of sampling equipment to these conditions and the possibility of contamination of the sample, e.g. by corrosion products, should be considered.

4.1.7 Sampling methods The sampling methods used will be determined by the objectives of the program and the water body characteristics such as—

- (a) flow;
- (b) stratification;
- (c) suspended matter; or
- (d) depth.

4.1.8 General sampling considerations The objectives of the program will determine the sampling method, sampling site, and the frequency, number and types of samples required. Items (a) to (k) provide some general sampling considerations, while Clauses 4.2.1 to 4.2.17 provide considerations for the sampling of specific situations. For more detailed guidance the appropriate Part of the AS/NZS 5667 series should be referenced.

NOTE: Appendix C provides a list of documents which provide further information on factors affecting sampling.

Factors which may apply to many sampling situations include—

- (a) spatial variations, (e.g. horizontal and vertical stratification);
- (b) temporal variations, (e.g. diurnal, weekly and seasonal variations);
- (c) the possibility of equipment vandalization;
- (d) the possibility of significant quality differences between different sample points;

- (e) the sample may only contain trace concentrations of the analytes of interest;
- (f) the use of automatic sampling devices that collect samples at regular intervals and which start at a prescribed flow offer many advantages;
- (g) the usually highly heterogeneous nature of some samples gives rise to difficulties in obtaining a representative sample and to blocking of sampling equipment;
- (h) the concentration of certain constituents may present special difficulties requiring individual consideration, e.g. the presence of oil or grease, high suspended solids, highly acidic effluents, flammable liquids or gases;
- (i) event related variations;
- (j) the possible need for isokinetic sampling; and
- (k) accidental or deliberate sample contamination.

4.2 SPECIFIC SAMPLING SITUATIONS

4.2.1 Sampling from pipes When sampling from pipes, factors which should be considered include—

- (a) pipes should be of adequate diameter (e.g. when sampling heterogeneous liquids, pipes of minimum nominal bore of 25 mm should be used);
- (b) linear velocities should be high enough to maintain turbulent flow characteristics; and
- (c) sampling from horizontal pipe runs should be avoided.

4.2.2 Lakes, natural and man-made When sampling from lakes, factors which should be considered include—

- (a) the possibility of the lake freezing; and
- (b) point source contamination may be slow to disperse.

For more detailed information refer to AS/NZS 5667.4.

4.2.3 Drinking water When sampling drinking water factors which should be considered include—

- (a) various points within the treatment process and distribution system may need to be sampled, including—
 - (i) inlet point and outlet point of the treatment plant;
 - (ii) service reservoirs;
 - (iii) points within the distribution system;
 - (iv) consumer taps; and
- (b) the monitoring of residual disinfecting agents before any loss occurs but after all reactions are completed.

For more detailed guidance on sampling of drinking water and water used for food and beverage processing refer to AS/NZS 5667.5.

4.2.4 Rivers and streams When sampling from rivers and streams, factors which should be considered include—

- (a) flow data is required for total load data or where flow-proportional composite samples are to be taken;
- (b) tidal effects;
- (c) the importance of mixing where point source contamination is of concern; and
- (d) concentration effects resulting from seasonal fluctuations.

For more detailed information refer to AS/NZS 5667.6.

4.2.5 Boiler system waters When sampling from boiler systems, factors which should be considered include—

- (a) the sample may be present as steam;
- (b) sample coolers may be required as samples are often at high temperature and pressure; and
- (c) the presence of unique safety hazards due to samples being at high temperature and pressure.

For more detailed guidance refer to AS/NZS 5667.7.

4.2.6 Wet deposition When sampling wet deposition, factors which should be considered include—

- (a) the sampling site should be selected to avoid contamination by extraneous matter;
- (b) the possibility of frozen samples; and
- (c) special collection techniques may be necessary in windy conditions.

For more detailed guidance refer to AS/NZS 5667.8.

4.2.7 Marine and estuarine waters When sampling from marine waters, factors which should be considered include—

- (a) dredging operations;
- (b) the boundaries of the area under investigation;
- (c) climatic and tidal conditions; and
- (d) shipping movements.

For more detailed guidance refer to AS/NZS 5667.9.

4.2.8 Sewage and sewage effluents When sampling sewage effluents, factors which should be considered include—

- (a) sewage composition can show considerable variation with time or with depth and across the diameter of the sewer;
- (b) inclusion of recirculated liquors when selecting the sampling site for sewage influent to a sewage treatment plant; and
- (c) the possibility of biological and chemical hazards.

For more detailed guidance refer to AS/NZS 5667.10.

4.2.9 Storm run-off When sampling storm run-off, factors which should be considered include—

- (a) the sampling of storm run-off presents special problems because of its intermittent nature and because the quality can change markedly throughout the period of discharge;
- (b) the quality may be worse in the first flush of the system as a result of initial cleansing; and
- (c) in many instances, flow-proportional sampling will be desirable.

For more detailed guidance refer to AS/NZS 5667.10.

4.2.10 Industrial effluents When sampling industrial effluents, factors which should be considered include—

- (a) possible hazardous nature of the sample; and
- (b) plant operating conditions.

For more detailed guidance refer to AS/NZS 5667.10.

4.2.11 Groundwaters When sampling groundwaters, factors which should be considered include—

- (a) preparation of the borehole;
- (b) the well or borehole should be sufficiently pumped prior to sampling to ensure that water drawn is representative of the aquifer;
- (c) the depth below ground level at which the sample is taken should always be recorded; and
- (d) filtering prior to preservation may be necessary.

For more detailed guidance refer to AS/NZS 5667.11.

4.2.12 Bottom sediments When sampling bottom sediments, factors which should be considered include—

- (a) variations of composition in both vertical and horizontal directions;
- (b) it may be necessary to obtain information on the depth of a bottom sediment or on its composition at different depths;
- (c) substrata are usually heterogeneous and special care should be taken to ensure that a sufficient number of samples are taken to provide a representative assessment of the parameters under consideration; and
- (d) redox conditions.

4.2.13 Sewage sludges When sampling sewage sludges, factors which should be considered include—

- (a) variability of composition;
- (b) if sampling is to be from a pipeline it should be at least 50 mm in diameter in order to minimize blockages; and
- (c) because of the possibility of biological hazards, suitable safety precautions should be applied.

4.2.14 Drinking water treatment sludges When sampling sludges from drinking water treatment plants, factors which should be considered include—

- (a) some treatment plants produce lime-softening sludges or biological sludges (most sludges produced in drinking water treatment, however, are of aluminium hydroxide or iron hydroxide); and
- (b) sludges may need to be sampled within coagulation or settling tanks at different depths and also in thickening tanks.

4.2.15 Industrial water sludges When sampling industrial water sludges the possible hazardous nature of the sludge should be considered.

4.2.16 Swimming pools When sampling from swimming pools, factors which should be considered include—

- (a) in swimming pools with recirculating systems, samples should be taken at the inlet, the outlet and from the body of the water; and
- (b) the monitoring of disinfection or chemical treatment.

4.2.17 Water from cooling systems When sampling from cooling systems, factors which should be considered include—

- (a) the type of cooling system under consideration, e.g. open evaporative, once-through or closed circuit (each type will involve different sampling conditions and locations);
- (b) the type of water treatment, e.g. biocidal and anti-corrosion water treatment; and
- (c) the possibility of health hazards, e.g. from the type of water treatment used or biological hazards such as legionellae, may need to be considered.

4.3 SAMPLING FOR MICROBIOLOGICAL ANALYSIS

4.3.1 General When sampling for microbiological analysis the sample container and cap need to be sterilized and aseptic techniques followed at all times. Care should always be taken not to touch the top of the bottle during removal or replacement of the cap. For more detailed guidance refer to AS 2031.2.

4.3.2 Sampling from taps All taps should be disinfected before samples are taken for microbiological analysis. When taking microbiological samples from taps, factors which should be considered include—

- (a) the sample container should never be rinsed out;
- (b) the cap should never be put on any surface and should be replaced immediately after the sample container is filled; and
- (c) the flow rate of the water leaving the tap should not be altered.

Methods for disinfection of taps include the following:

- (i) *Disinfection by flaming* Disinfection by flaming is suitable for metal taps. The tap should be flamed thoroughly, starting at the nozzle and working back to the body of the tap until the water held in the nozzle boils. After flaming, water from the tap should be run to waste until cool before a sample is taken.
- (ii) *Disinfection by using sodium hypochlorite solution* Disinfection using sodium hypochlorite solution is suitable for plastic taps, mixer taps and metal taps where flaming is not appropriate. The outside of the tap, and as much of the inside as possible, should be swabbed or sprayed with sodium hypochlorite solution and then left for 2 to 3 minutes to allow the sodium hypochlorite to disinfect the tap. After disinfection, water from the tap should be run to waste for a sufficient period to ensure that all the sodium hypochlorite is removed before the sample is taken.

4.3.3 Other sampling situations For other situations, grab samples are generally appropriate for obtaining samples for microbiological analysis. A method for obtaining a grab sample is as follows:

- (a) Hold the bottle near its base and plunge it, neck downward, below the surface.
- (b) Turn bottle until neck points slightly upward and mouth is directed toward the current. If there is no current, as in the case of a reservoir, create a current artificially by pushing bottle forward horizontally in a direction away from the hand.

When sampling from a boat, samples should be obtained from upstream side of boat.

SECTION 5 QUALITY CONTROL SAMPLES

5.1 INTRODUCTION Controls, blanks and replicate samples are essential components for sampling studies as firm conclusions cannot be drawn without the quality control information they provide. Sampling blanks are used in assessing sample contamination and are particularly important when the analytes of interest are present in trace quantities. Controls can be divided into two types:

- (a) Controls such as field spikes are used in quality control procedures; and
- (b) Control sites which are used to determine whether or not the analyte of interest is present at a specific site but not at other sites.

Replicate samples are used to determine the precision of the sampling program.

5.2 BLANKS

5.2.1 Sample contamination Sample contamination can occur during the following stages of the sampling process:

- (a) Collection of the sample.
- (b) Sample transportation and storage.
- (c) Sample preservation.

To determine at which stage contamination occurs, the following blanks should be taken:

- (i) *Field blank* This blank is used to estimate contamination of a sample during the collection procedure. Ideally at least one field blank should be taken per sampling team per trip per collection apparatus. Once a knowledge of the homogeneity of sampling conditions is established, it may be possible to reduce the frequency of collection of field blanks.
- (ii) *Transport blank* This blank is used to estimate the amount of contamination introduced during the transport and storage of samples from the time of sampling until the time of analysis. Ideally at least one transport blank should be allowed per group of samples.

To further determine sources of contamination, container blanks should be carried out on all new batches of containers (see Clause 5.2.3).

While guidance is provided regarding the number of blanks that should be taken, it is desirable that the actual number of blanks be determined using appropriate statistical techniques.

NOTE: The water chosen as the blank should have a low analyte concentration, ideally below the detection limit of the analytical technique employed.

5.2.2 Sampling blanks To obtain both a field and transport blank the following procedure should be followed:

- (a) Divide a water sample of appropriate quality into two parts.
- (b) Retain portion A at the laboratory and transport portion B to the sampling site.
- (c) Divide portion B into two parts—
 - (i) portion B1 is used to produce a field blank; and
 - (ii) portion B2 is used to produce a transport blank.
- (d) Process portion B1 using, as far as practicable, the same procedures used for sampling, i.e. portion B1 should be treated in the same way as a real sample.

- (e) Portions B1 and B2 should be preserved and transported using the same procedures as used for the samples. Return portions B1 and B2 to the laboratory.
- (f) Portions A, B1 (field blank) and B2 (transport blank) can be analysed and results compared.

This technique is useful to identify any errors relating to contamination of sampling devices and the sampling process. Its disadvantage is that it is prone to error by contamination of the field blank sample before use. This can be evaluated by analysing the transport blank on returning to the laboratory. The technique is not applicable as such to sediments and sludges; but it may be possible to use a sample of known concentration in a similar manner.

5.2.3 Container blank This blank estimates contamination from the container and preservation technique during storage of the sample. A cleaned sample container is filled with water of an appropriate quality, any preservative used in the sample is added, and then the blank is stored for the same time as the samples for analysis. This blank is important when the time between sampling and analysis is several days or weeks because of possible leaching of the analytes of interest from or to the container.

Generally, one container blank should be allowed per batch of containers, however the number of container blanks is dependent on the batch size, and variability and level of analytes of interest. The number of container blanks should be determined using appropriate statistical techniques.

5.3 CONTROLS

5.3.1 Field spikes Field spikes are useful for determining the overall adequacy of the sampling and analysis program, such as—

- (a) suitability of container;
- (b) preservation;
- (c) transport;
- (d) storage;
- (e) sample preparation;
- (f) analysis; and
- (g) matrix interferences.

Field spikes are particularly useful in determining the loss or cross-contamination of volatile or labile materials.

NOTE: The spike should take into account the chemical form of the analyte of interest, i.e. oxidation state, degree of complexation, organic or inorganic, etc.

5.3.2 Control sites If the results of the study are to be judged as high, low or insignificant, the results from the sample site should be compared with the results from control sites where possible. Control sites and sample sites should be as similar as possible except for the presence of the contaminant under investigation. When sampling from rivers, streams or groundwater the control site should be upstream from the site under investigation.

5.4 REPLICATE SAMPLES Replication is the collection and analysis of separate samples from the same sample site at the same time. This provides the experimental sampling error and thus a measure of the sampling precision. The number of replicate samples required is determined by the setting of statistical parameters and the programs data quality objectives.