WATER QUALITY SAMPLING PROCEDURES

BY

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This project is submitted in part fulfilment of the NCEA requirements for the award of M.Sc.(Hons) in Environmental Protection

June, 2004

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ABSTRACT

Sampling is the first operational stage in any water quality monitoring programme. No matter how good the analytical method is or how carefully the analysis is performed if the sampling is not carried out correctly then subsequent analytical results will not be representative of the water body sampled.

Detailed water sampling requirements are specified in ISO 5667. A questionnaire found that no laboratory, which responded, is currently accredited or in the process of attaining accreditation to this standard. In general, the procedures and practices in environmental laboratories questioned fall significantly short of the requirements of ISO 5667, particularly in relation to the preservation of samples, the documentation of sampling training procedures and the maintenance of training records.

Information received from the questionnaire indicated similar trends between Limerick County Council and other Local Authority (LA) laboratories. For example, LA laboratories generally do not preserve samples, very few analyse quality control field blanks or have considered obtaining accreditation specifically to ISO 5667. The trends in EPA laboratories are somewhat different from those in LA laboratories in that all of the laboratories use chain-of custody forms and most analyse quality control field blanks and preserve samples. The majority of EPA laboratories have considered obtaining accreditation specifically to ISO 5667, although none are in the process of doing so.

Current water sampling procedures and practices employed at the environmental laboratory of Limerick County Council were used, as a case study, to determine the level of work required to achieve ISO 5667 accreditation. This study revealed that approximately 80% of the requirements of ISO 5667 could be implemented using existing facilities provided adequate resources are allocated e.g. the documentation and implementation of comprehensive sampling programmes and sampling procedures and the maintenance of detailed records. The implementation of the remainder of the requirements would however, require specific expertise, unlikely to be available within most laboratories. For example, ISO requires that sampling locations should be assessed for stratification and degree of turbulence. This information could not be readily obtained using existing resources and therefore external consultants would have to be employed requiring a significant financial backing.

ACKNOWLEDGEMENTS

I wish to express my gratitude to the many people who helped me in the completion of this thesis.

I would like to express my sincere gratitude to my project supervisor, Dr. Ann-Marie Duddy whose suggestions and ideas in relation to the content of this thesis were invaluable.
Thanks also to all those people who took time to complete the questionnaire and to my work colleagues who gave me guidance along the way.

A special thanks to my best friend and fiancé Aidan who gave me great support and encouragement throughout the project. Thanks also to my family and friends for their encouragement and support.

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Local Authorities and the Environmental Protection Agency (EPA) are primarily responsible for monitoring and assessing water quality in Ireland. This is primarily done to assess compliance with specific regulatory requirements.

In order for water quality to be assessed, a monitoring programme must be implemented. Sampling is the first operational stage in any monitoring programme and is defined as "the process of selecting a portion of material, in some manner, to represent or provide information about a larger body of material." (Crosby, Day, Hardcastle, Holcombe and Treble, 1999)

The importance of the sampling stage cannot be over emphasised. If the sample taken is not representative, it will not be possible to relate the analytical result obtained to that in the original water body, no matter how good the analytical method is or how carefully the analysis is performed.

This study concentrates specifically on the sampling stage of a water quality monitoring programme and aims to:

1. Review international standards, environmental legislation (and associated implementation handbooks), Standard Methods (A.P.H.A, 1998) and other relevant literature to identify and collate the important aspects related to sampling.
2. Obtain information, by means of a questionnaire, with regard to current water quality sampling procedures and practices in EPA, Local Authority and private laboratories.
3. Identify the measures and resources required to obtain accreditation to the water quality sampling standard, ISO5667, using Limerick County Council's current sampling procedures as a case study.

1.0 LITERATURE REVIEW

1.1 INTRODUCTION

The monitoring of surface water quality is required to asses it's suitability for a number of purposes including the abstraction of drinking water and the support of fish life and other aquatic organisms. Local Authorities and the Environmental Protection Agency (EPA) are primarily responsible for monitoring and assessing water quality (as well as the quality of other environment media) in Ireland.

Local Authorities are required to monitor the quality of surface water under a number of pieces of legislation including the Local Government (Water Pollution) Act, 1977, Local Government (Water Pollution) Act 1977 (Water Quality Standards for Phosphorus) Regulations 1998, European Communities (Quality of Salmonid Waters) Regulations 1988, European Communities (Quality of Surface Water Intended for the Abstraction of Drinking Water) Regulations 1989, European Communities (Drinking Water) Regulations 2000,

The EPA are responsible for monitoring surface water quality under the EPA Act 1992 and Protection of the Environment Act 2003. This legislation also obliges them to publish reports on the quality of Irish waterways. A number of these reports have been published to date (EPA, 2004; McGarrigle, Bowman, Clabby, Lucey, Cunningham, MacCárthaigh, Keegan, Cantrell, Lehane, Clenaghan, and Toner, 2002; Stapleton, Lehane and Toner, 2000; Lehane, Le Bolloch, and Crawley, 2002).

Wastewaters discharged from various sources, for example sewage treatment plants or industrial facilities, may impair water quality. Local Authorities and the EPA are responsible for monitoring, assessing and controlling these discharges and their subsequent impact on the receiving water. This is required under the Local Government (Water Pollution) Act, 1977, EPA Act, 1992 and EPA Act, 1992 Urban Waste Water (Treatment) Regulations, 1994.

Yet another responsibility of the local authorities is the provision of a safe and wholesome supply of drinking water. The European Communities (Drinking Water) Regulations, 2000 requires that water 'be free from any micro-organisms and parasites and from any substances which, in numbers or concentrations constitute a potential danger to public health.'

In order for water quality to be determined, a monitoring programme must be implemented. The main elements of a monitoring programme include:

a) Identification of specific objectives of the programme.
b) Sampling.
c) Sample analysis and interpretation.

This study concentrates specifically on parts a and b above. The other elements are discussed in detail by other workers (Crosby *et al.*, 1999; Anon., 1998 and Butler, Carty, Kelly and Lehane,1995).

The specific objectives of a monitoring programme will be determined by the nature of work being carried out e.g. these objectives may be the establishment of baseline monitoring results or assessing compliance with specific legislative requirements or specific licence conditions.

Sampling is the first operational stage in any water monitoring programme. Sampling is defined as "the process of selecting a portion of material, in some manner, to represent or provide information about a larger body of material." (Crosby *et al.*, 1999). The importance of the sampling stage in a water quality monitoring programme cannot be over emphasised. If the sample taken is not representative, it will not be possible to relate the analytical result obtained to that in the original water body, no matter how good the analytical method is or how carefully the analysis is performed.

In order for sampling to be carried out correctly, sampling procedures are necessary. A sampling procedure is a set of instructions that must be followed when sampling. They are designed to give credibility to data by ensuring that the same procedures are followed each time sampling is performed. Procedures for sampling are generally less well documented than for analytical procedures. This is due to the difficultly in specifying universal sampling procedures which are applicable to each set of conditions at each sampling location The use of various sampling procedures has been investigated by many workers (Anon., 1998; ISO, 1998; ISO, 1992; ISO, 1991; ISO, 1990; ISO, 1987; NSAI, 1994; NSAI, 1996) and a number of sampling guidelines do exist. These include ISO 5667, Standard Methods for the Examination of Water and Wastewater (Anon, 1998) and ISO 17025. In addition, sampling guidelines are provided in various pieces of environmental legislation and associated implementation handbooks.

This Section attempts to review the various sampling guidelines in relation to sampling procedures. Before doing so, an overview of these guidelines is provided.

1.2 SAMPLING GUIDELINES

1.2.1 ISO 5667

ISO 5667 is the most comprehensive guideline that exists in relation to water quality sampling. The various parts of the standard were prepared by ISO (the International Organisation for Standardisation), which is a worldwide federation of national standards bodies. The work of preparing ISO 5667 was carried out through various ISO technical committees.

ISO 5667 is comprised of a number of parts under the general title - Water quality – Sampling. These parts are;

Part 1: Guidance on the design of sampling programmes

Part 2: Guidance on sampling techniques.

Part 3: Guidance on the preservation and handling of samples.

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

Part 5: Guidance on sampling of drinking water and water used from food and beverage processing.

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 sampling of wet deposition.

Part 9: Guidance on sampling from marine waters.

Part 10: Guidance on sampling of wastewaters.

Part 11: Guidance on sampling of groundwaters.

Part 12: Guidance on sampling of industrial cooling water.

Part 13: Guidance on sampling of sludges and sediments.

Parts 1, 2 and 3 of this standard have been adopted as Irish standards, I.S. EN 25667-1: 1994; I.S. EN 25667-2: 1994; I.S. EN ISO 5667-3:1994, respectively

1.2.2 Standard Methods for the Examination of Waters and Wastewaters

Standard Methods specifies methods and techniques for the sampling and examination of many types of samples encountered in the assessment and control of water quality and water pollution. A Joint Task Group is established for the approval of each method. The twentieth edition is the most recent edition in which significant revision occurred, from the previous, in the section on sampling.

1.2.3 ISO 17025

ISO 17025 (General requirements for the competence of testing and calibration laboratories) contains very detailed guidelines in relation to the testing of samples but contains very general guidelines in relation to sampling. Requirement 5.6 of ISO 17025 requires a laboratory to have a sampling plan, procedures for sampling, and procedures for recording relevant data but does not specify what detail each of these should contain. ISO 17025 replaced the standard EN45001 in 1999. EN45001 did not specify any requirements with regard to sampling.

1.2.4 Environmental Legislation and Associated Implementation Handbooks

Most pieces of environmental legislation (e.g. EPA Act, 1992, European Communities (Drinking Water) Regulations, 2000, European Communities (Water Policy) Regulations, 200 etc.) require the taking of samples for monitoring purposes and in most cases make reference to sampling procedures. The EPA issue handbooks to local authorities on the implementation of such legislation. These implementation handbooks, formerly issued by the Department of Environment, give guidance, *inter alia,* on sampling procedures. A number of implementation handbooks relevant to sampling exist. These include:

- ENV 1/81 (27th February 1981), Local Government (Water Pollution) Act, 1977 - Guidelines on sampling and analysis of waters and effluents.
- European Communities (Quality of Surface Water Intended for the Abstraction of Drinking Water) Regulations, 1989: A handbook on implementation for sanitary authorities (Department of Environment, September 1990)
- The Environmental Protection Agency Act, 1992 (Urban Wastewater Treatment) Regulations, 1994: A handbook on implementation for sanitary authorities (EPA, 1996)
- European Communities (Drinking Water) Regulations, 2000 – A handbook on implementation for sanitary authorities (EPA, 2003).

1.3 SAMPLING PROCEDURES

The principle objective of water sampling is to collect a volume of water that adequately represents the relative concentrations of all components present in the water or wastewater being sampled (NSAI, 1994*b*). In order that this objective be met, the development of a sampling procedure is crucial. Sampling procedures are task specific since they depend on the type of medium being sampled, the proposed method of sampling, the equipment used, the intended use of the sample and data recording procedures (Anon., 1998; NSAI, 1994b). Each laboratory should produce a sampling manual that includes the procedures and precautions to be adopted for each parameter or group of parameters of interest (Flanagan et al, 2003; ISO, 1998; NSAI, 1994*a*). This procedure should include information on sampling location, sample type, sampling method, sample collection and sample storage and preservation. It is important when documenting a sampling procedure to ensure that all of the terms used are clearly defined so that the procedure will be clear to other users (Working Group CITAC & EURACHEM, 2002).

1.3.1 Sampling location

The exact sites chosen for sampling must provide samples that are either representative of the whole aquatic system (in the case of river catchment monitoring) or of a particular problem area (in the case of a pollution investigation). In either case sample locations are best chosen using local knowledge (Crosby and Patel 1995 and Galal-Gorchev and Lewis, 1984).

Anon., 1998 state that sampling points should be fixed by detailed description in the sampling plan, by maps, or with the aid of stakes, buoys or landmarks in a manner that will permit their identification by other persons without reliance on memory or personal guidance. This will make it easier to repeat the sampling at a later date and also may assist in drawing conclusions from the test results. Global positioning systems (GPS) can also be used to supply accurate sampling position data. (Working Group CITAC & EURACHEM, 2002)

Sampling location is dealt with in a very general sense in environmental legislation. For example;

- Article 6 (1) of the European Communities (Quality of Surface Water Intended for the Abstraction of Drinking Water) Regulations, 1989 states: "that a sanitary authority shall regularly monitor the quality of surface water, and for this purpose samples shall be taken for analysis at the point or points at which the water is abstracted prior to treatment".

- Article 10(1) of the Environmental Protection Agency Act, 1992 (Urban Waste Water Treatment) Regulations, 1994 states that; "A sanitary authority shall carry out, cause to be carried out, or arrange for, the monitoring of:
  (a) discharges from urban wastewater treatment plants in accordance with the procedures set out in the Fifth Schedule to the Regulations.
  (b) waters subject to a discharge from an urban waste water treatment plant where it can be expected that the receiving waters will be significantly affected."

- Article 6 of the European Communities (Drinking Water) Regulations, 2000 states "A sanitary authority shall ensure that the parametric values specified are complied with in the case of:-

(a) water supplied from a distribution network, at the point within a premises or an establishment, at which it emerges from the tap or taps that are normally used for the provision of water for human consumption.
(b) water supplied by a tanker, at the point at which it emerges from the tanker."

The difficulty in selecting a sampling location has been recognised by the Department of Environment in the implementation handbook published with respect to the European Communities (Quality of Surface Water Intended for the Abstraction of Drinking Water) Regulations 1989. In this document it was stated that "As actual conditions e.g. accessibility of site, immersion depth of sample intake pipe, distance from lake shore/bank of actual inlet, and so on, will vary from case to case, it is not possible to specify a definitive sampling procedure".

The draft implementation handbook published, by the EPA, with respect to the European Communities (Drinking Water) Regulations, 2000 requires that a monitoring programme set out each point at which drinking water samples are to be taken for particular parameters and that these points should be selected at random.

ISO 5667 provides more detailed guidelines in relation to sampling locations for rivers, lakes, drinking waters and wastewaters. For example, when sampling from rivers the following guidelines should be adhered to;

- Samples should preferably be taken where marked quality changes are likely to occur or where there are important river uses.
- Sample should be taken where flow data is available.

- Sampling of weirs or small discharges that are only very local in effect should be avoided.
- If only one sample can be collected, take it in the middle of the main channel of the stream and at mid-depth.
- If monitoring the effects of a discharge at least two sites are necessary, one just upstream of the confluence and the other sufficiently downstream to ensure mixing is complete.

(NSAI, 1994*a*), (ISO, 1990)

With regard to lake monitoring, the exact sampling locations can only be properly decided after detailed preliminary investigations using a large number of sampling locations. This will provide the information to which statistical analysis may be applied (ISO, 1987). In the case of drinking water, sampling points should be at different locations and in particular from the end of the distribution system (ISO, 1991). Wastewaters samples should be taken where the wastewater is well mixed and representative of the entire flow (ISO, 1992).

1.3.2 Sample type

The method of choosing a representative sample should be governed by the purpose of the sampling and by the general physical conditions of the waters of interest. A number of different sample types exist. These include grab samples, composite samples and integrated (discharge-weighted) samples

1.3.2.1 Grab sample.

Grab samples are single samples collected at a specific location over a period of time (typically seconds or minutes). These samples represent only the composition of the source at the time and place of collection. The use of grab sampling is best applied when the composition of the water/wastewater under investigation is fairly constant both spatially and temporally, or where the objective of a sampling programme is to estimate compliance with a specific standard not related to average quality i.e. conditions attached to a discharge licence issued under Local Government (Water Pollution) Act, 1977 and 1990 or EPA Act, 1992.

Grab samples should always be used for parameters whose concentrations are susceptible to being changed relatively rapidly in the interval between sampling and analyses because of physical, chemical or biological reactions e.g. parameters such as pH, temperature, cyanides, total phenols, residual chlorine, oils, fat, grease and faecal coliforms (Carty, O'Leary, Donlon

and Henry, 1998 and Anon., 1998). In the case of river and lake sampling, grab samples are acceptable for quality characterization over a long period of time. Grab samples are the only relevant types of sample for monitoring drinking water quality (NSAI, 1994)

1.3.2.2 Composite samples

Composite samples are obtained either manually by combining portions of multiple grab samples or automatically by using specially designed sampling devices. Composite samples taken manually are done so at pre-determined time intervals e.g. hourly, over the specified sampling period. The volume of each sample taken is accurately measured to ensure the same volume is taken at each sampling time. The samples taken are then mixed manually normally using a large container. The sampling period for composite samples should be long enough to reflect the normal variations in quality (Anon., 1998; NSAI, 1994*a*; ISO, 1992)

Automatic composite samplers may be either time dependant or volume dependent. Time dependent samplers collect a predetermined sample volume at a number of pre-determined time intervals. Volume dependant samplers also collect samples at pre-determined time intervals however, the volume collected is proportional to the flow at the time of sampling.

Composite samples are best suited to situations where information is required on the average composition of a water/wastewater over a given period of time. They should not be used where information is required on transient peak conditions as information on the time and duration of occurrence will not be apparent. If pollutants peak for only short periods at a time, taking composite samples will result in the potential dilution of the parameters of interest, perhaps below limits of detection.

Where composite samples are used, it should be verified that the parameters of interest do not vary significantly during the sampling period due to, for example, increased interactions between analytes or an increase in potential analytical interference (Anon., 1998 and NSAI, 1994). Composite sampling is unsuitable for certain unstable parameters such as oil and grease, acidity, alkalinity, carbon dioxide, chlorine residual, iodine, nitrate, volatile organic compounds, dissolved oxygen, temperature and pH, particularly where quantitative values are required. Changes in these components may produce secondary changes in certain inorganic constituents such as iron, manganese, alkalinity or hardness (Anon., 1998).

Composite sampling is required under certain legislation. For example, the EPA Act, 1992 (Urban Waste Water Treatment) Regulations, 1994 require that 'Flow-proportional or time-based 24-hour samples shall be collected at the same well-defined point in the outlet and if necessary in the inlet of the treatment plant, in order to monitor compliance with the requirements for discharged waste water specified in these Regulations' Composite sampling of wastewaters is also required under ISO 5667-10 (ISO, 1992). Composite sampling is generally not recommended for drinking water (ISO, 1991)

1.3.2.3 Integrated (discharge-weighted) samples

Integrated samples are obtained by combining portions of grab samples collected from different points simultaneously, or as nearly so as possible. This is done using discharge-weighted methods such as equal-width increment (EWI) or equal-discharge increment (EDI) procedures and equipment (Anon., 1998, Carty *et al.,* 1998, Crosby *et al.,* 1995). An example of the need for integrated sampling occurs in a river or stream that varies in composition across its width and depth. Preparation of integrated samples usually requires equipment designed to collect a sample of water uniformly across the depth profile. Knowledge of the volume, movement and composition of the various parts of the water being sampled is generally required. The collection of integrated samples is a complicated and specialised process. (Anon., 1998). Neither ISO 5667 nor environmental legislation or associated implementation handbooks make any recommendation requiring integrated samples to be taken.

1.3.3 Sampling methods

The sampling method used must ensure that the sample will be handled in such a way that no significant changes in composition occur before analyses is carried out. A number of different sampling methods exist. These include manual sampling, automatic sampling and sorbent sampling.

1.3.3.1 Manual sampling

Manual sampling is normally used to take grab samples. It occurs when samples are physically taken at a given time by an individual into an appropriate sample container. Details on the taking of grab samples from rivers and drinking water systems are provided in ISO 5667. Although manual sampling involves minimal equipment it does require trained field technicians and this may prove unduly costly and time-consuming for routine or large-scale sampling programmes. Manual sampling is often necessary for regulatory and research investigations for

which critical appraisal of field conditions and complex sample collection techniques are essential (Department of Environment, 1981).

1.3.3.2 Automatic sampling

Automatic samplers are used where a number of individual samples or a composite sample is required over an extended period of time e.g. 24 hours. Automatic samples are taken using specialised equipment, which consists of a sample pump, sample line and sample container(s). Details in relation to the selection of automatic samplers are provided in ISO 5667 (ISO, 1992) Once the sampler is preset, it is left at the sampling site and will take the specified volume of sample at the specified times. The samples are either composited immediately or collected in separate containers for subsequent analysis or compositing.

Automatic sampling has a number of advantages over manual sampling. For example, human errors associated with manually compositing samples are often reduced, labour costs are lower and more frequent sampling is possible.

1.3.3.3 Sorbent sampling

Sorbent sampling involves the use of a special sorbent material to capture the pollutant of interest. This sorbent is retained within a container known as a sorbent tube. The water being sampled is pumped through the sorbent material, usually, with the aid of a pump. The sorbent material used must have a high affinity for the pollutant of interest. The capture of pollutants directly onto a sorbent material *in-situ* eliminates the need for collecting and transporting water samples to the laboratory. Instead, the sorbent material together with the captured pollutants is returned to the laboratory for analysis. A knowledge of the volume of water drawn through the tube together with the analytical determination of the concentration of pollutant retained on the sorbent will determine the concentration of the pollutant in the waterbody.

Sorbent sampling is useful when the parameter of interest is present only in trace amounts. Sorbent sampling offers advantages of rapid, inexpensive sampling when the analyte of interest is readily adsorbed and desorbed from the sorbent. The water sampled must be free of particulate matter since these tend to plug the sorbent. ISO 5667 recommends the use of sorbent sampling for virological sampling.

1.3.4 Sampling equipment.

A variety of equipment is used for sampling waters and wastewaters including samplers and sample containers. Samplers may be a bucket or long-armed sampler with liquid holding device or an automatic sampling device. Sample containers are discussed in Section 2.3.5 below. Portable field meters such as pH, conductivity and D.O. meters are also used when monitoring water quality *in situ.*

The sampling equipment used must be suitable to site location and the sample to be taken (NSAI, 1994). It must be such that it will not contaminate the sample from its constituents or through lack of cleanliness. Sampling equipment must be constructed from a suitable material and be of adequate strength suitable for the purpose. It is also important to ensure that the sampling equipment and containers are mutually compatible. Sampling equipment should be cleaned, prior to use, with detergent and water (ISO, 1992; Crosby and Patel, 1995; Anon., 1998).

1.3.5 Sample containers

Sampling containers are required in order to transport the water sample from the sample location to the laboratory. Crosby and Patel (1995) and ISO 5667 (ISO, 1992) state that the nature of the sample should not be altered by the sampling container. To this end sampling containers should have the following characteristics - high resistance to breakage, good sealing efficiency, ease of re-opening, good resistance to temperature extremes, practicable shape and mass, good potential for cleaning and re-use and low cost. The particular type of sampling container to be used will depend on the analyte of interest, preservatives (if any) being used and the possibility of adsorption/desorption and leaching. Some analytes may be constituents of the sample container e.g. sodium is a constituent of glass and some metals may be a component of plastic. Desorption of these constituents from the sample container may result in artificially elevated results for some analytes.

Prior to sampling, the sampler should ensure that the sample container is clean, free of contaminants and pre-prepared as per the required analytical method. (Flanagan *et al.*, 2003; Anon., 1998; NSAI, 1996; ISO, 1987 and Department of Environment, 1981). Sample containers should be tested to ensure that they are free of analytes of interest, especially when sampling and analysing for very low analyte levels (Anon., 1998).

There are two main types of sample containers used. These are glass and plastic.

1.3.5.1 Glass containers.

Glass bottles may be clear or brown. They may be made of soda glass or borosilicate glass. Borosilicate glass, such as pyrex bottles, have a greater resistance to heat and chemical attack than soda glass.

Although glass is generally thought of as an inert material, it may not be suitable for some samples. For example, sodium, potassium and boron are major constituents of glass. The use of glass bottles for the storage of samples, intended for analysis of these parameters, is not recommended as they may be leached from the bottle to the sample in the interval prior to analysis. Soda-glass bottles are unsuitable for the storage of poorly buffered waters (i.e. those of low conductivity or alkalinity).

A number of workers specify that glass containers should be used for phosphates, oil and grease, hydrocarbons, detergents and pesticides. (Anon., 1998 and Crosby and Patel 1995). Bacteriological sampling also requires the use of glass bottles, with a minimum capacity of 250ml. These bottles should be capable of withstanding temperatures used in sterilisation procedures. (Flanagan, 1990*a* and Flanagan *et al.*, 2003).

1.3.5.2 Plastic containers

Plastic bottles may be made of polypropylene or polyethylene. Polypropylene bottles are more durable than polyethylene bottles. Plastic bottles have a number of advantages over glass bottles e.g. they are generally resistant to breakage and are considerably cheaper to buy. Plastic bottles are suitable for most aqueous samples except if organic micro-pollutants, such as pesticides and phosphates, are to be determined. (Crosby *et al.*, 1999; Department of Environment, 1981; and Flanagan *et al.*, 2003).

1.3.6 Sample Volume

The volume of sample to be collected depends on the number and types of analyses to be performed. The volume must be small enough to be transported conveniently and yet large enough for analytical purposes. There should be sufficient sample volume in an appropriate container to allow for sample handling, storage and preservation requirements. A sample volume

of one litre is usually sufficient for most physical and chemical analyses (Anon., 1998). Reference should be made to the relevant International Standards for the volumes required for each analytical method. (NSAI, 1994*b*)

1.3.7 Time of sampling

If a water body exhibits predominantly random variations in water quality then the timing of sampling is generally not important. Timing of sampling is however important where a water body exhibits definite trends in water quality. These trends may be systematic (e.g. similar most of the time) or cyclic (e.g. follow a know trend over a period of time). If cyclic variations occur then the timing of sampling must ensure that the whole cycle is represented and maximum concentrations of analytes are sampled. Sample times should be spaced approximately equally over trend periods. (NSAI, 1994*a*)

1.3.8 Sample collection

The manner in which the sample container is filled should be taken into account to ensure that the sample collected does not undergo significant changes in the interval between sampling and analysis. (Anon., 1998). Samples taken from rivers and streams should be collected beneath the surface in quiescent areas. The sampling container should be opened below the water surface with the mouth directed toward the current. This avoids collecting surface scum. Samples should be taken at the water surface where oil and grease are the constituents of interest. (Anon., 1998)

In contrast to the above NSAI, 1994 specifics that samples, ideally, should be taken from turbulent, well-mixed liquids and whenever possible turbulence should be induced in flows that are streamlined. NSAI 1994 does state however that sampling in turbulent areas does not apply to the collection of sample whose concentration may be altered by induced turbulence e.g. dissolved gases and volatile materials. NSAI, 1994 also specifies that when sampling physical and chemical parameters, it is often sufficient to immerse an open-mouthed vessel (e.g. a bucket or can) just below the surface in order to collect the sample. In situations where it is necessary to sample at specified depths other sampling devices (e.g. a weighted bottle with removable stopper or plunger device) may be used.

Opinions differ among workers in relation to the rinsing of sampling containers. The Department of Environment Implementation handbook (1981) states that sampling bottles should be rinsed out two to three times prior to sampling. Flanagan (1990) states that the sampling container should be rinsed out with the liquid to be sampled before the actual sample is taken except in the case of microbiological sampling. Anon., (1998) specify that containers should not be pre-rinsed with sample as pre-rinsing results in loss of any pre-added preservative and sometimes can bias results yielding artificially high concentrations when certain components adhere to the sides of the container. ISO 5667 does not specify any requirement with regard to the pre-rinsing of containers.

Sampling containers should be filled to the brim for most organic compound determinations e.g. BOD, ammonia, iron, and manganese. (Flanagan *et al.*, 2003; Flanagan *et al.*, 2002; Anon., 1998; NSAI, 1996 and Crosby and Patel, 1995). In the case of microbiological sampling, samples should not be filled to the brim but allowed a space for aeration purposes (Flanagan *et al.*, 2003; Flanagan *et al.*, 2002; Anon., 1998; Crosby and Patel, 1995; ISO, 1994*b*).
The collection of samples for microbiological analysis requires extreme care in order to prevent contamination by micro-organisms other than those of interest. (Flanagan *et al.*, 2002; ISO, 1991; Flanagan, 1990*a*; Hammer, 1986 and Galal-Gorchev and Lewis, 1984).

1.3.9 Sample preservation

Waters and waste waters, are susceptible to being changed to differing extents as a result of physical, chemical or biological reactions which may take place between the time of sampling and analysis. (Flanagan *et al.*, 2002; Anon., 1998; Bartram, Makela and Makela, 1996). The nature and rate of these reactions are often such that if the necessary precautions are not taken in the interval between sampling and analysis the concentrations determined will be different from those existing at the time of sampling.

There are many reasons why a water sample may undergo physical, chemical and/or biological reactions. These include;

- Bacteria, algae and other organisms can consume certain constituents present in the samples and/or modify the nature of the constituents to produce new constituents. This biological activity may affect dissolved oxygen and carbon dioxide levels. It may also affect, nitrogen, phosphorus and sometimes silicon concentrations (Anon., 1998 and NSAI, 1996).

- Certain compounds can be oxidized by the dissolved oxygen contained in samples or by atmospheric oxygen e.g. organic compounds and iron(II), sulphides (Flanagan *et al.*, 2003 and NSAI, 1996).
- Certain substances can precipitate out of solution or be lost to the vapour phase e.g. oxygen, cyanides, and mercury (NSAI, 1996).
- pH, conductivity and carbon dioxide levels can be modified by the absorption of carbon dioxide from the air (NSAI, 1996 and Galal-Gorchev and Lewis, 1984).
- Dissolved metals, metals in the colloidal state and certain organic compounds can be adsorbed or absorbed irreversibly onto or into the sampling containers or solid materials contained in the samples (Anon., 1998 and NSAI, 1996)
- An increase in temperature (even if slightly elevated above ambient temperatures) can favour microbiological activity. This may cause changes in sample composition (Flanagan *et al.*, 2003 and NSAI, 1996).

Prompt analysis is undoubtedly the most positive assurance against error due to sample deterioration. When the interval between sample collection and analysis is long enough to produce changes in either the concentration or the physical state of the constituent to be measured, water samples should be preserved. A preservative is an additive, which will retard biological, chemical or physical changes in the target analyte. A suitable preservative should not interfere with the subsequent analytical determination or have its effects countered by the chemistry of the test method (Crosby and Patel 1995 and Flanagan, 1990*b*). The most common methods of preservation are acidification, filtration or cooling/freezing.

Acidification is normally used for the preservation of metals, ammonia, total phosphorus, oil and grease. The sample is normally acidified to pH <2 using a suitable concentrated acid (such as sulphuric acid or nitric acid) which is added to the sampling container either prior to leaving the laboratory or at the sampling location. The amount of acid to be added should be determined beforehand on a separate sample and then the same relative amount of acid added to all samples. Ultra-pure acid preservative should be used to prevent contamination. The dilution caused by acidification should be negligible or sufficiently reproducible to apply an appropriate correction factor (Flanagan *et al.*, 2002; Anon., 1998; NSAI, 1996; ISO, 1987 and Department of Environment, 1981).

Sample filtration is necessary if the analyte of interest is dissolved in solution e.g. heavy metals. Filtration should take place in the field, if possible. If carried out in conjunction with acidification then filtration should be performed first (Anon., 1998 and Crosby and Patel 1995). Care must be taken to ensure that the filter used is not a cause of contamination and is carefully washed before use (Anon., 1998)

Cooling is used for the preservation of samples for BOD, conductivity, suspended solids, sulphates and microbiological analysis. Cooling or freezing of samples is only truly effective if it is applied immediately after sampling. This necessitates the use of cool-boxes or refrigerators in vehicles at the sampling site. In most cases, cooling to temperatures of less than 4^0C is sufficient to preserve samples during transport to the laboratory and for a relatively short period of time afterwards. Cooling is not considered as a means of long-term storage.

Freezing to temperatures of less than 20^0C allows an increase in the period of storage however, it is necessary to control the freezing and thawing technique fully in order to return the sample to its initial equilibrium after thawing. (Crosby and Patel 1995 and NSAI, 1996).

There is no "catch-all" preservative that is suitable for a wide range of parameters. In some instances the use of a particular preservation technique for one analyte may prove determinantal to the analysis of another analyte. For example, samples preserved with nitric acid cannot be analysed for pH, acidity, alkalinity or nitrate. The use of preservatives for a range of analytes and sample types are discussed in a number of publications including Flanagan *et al.*, 2003; Flanagan *et al.*, 2002; Anon., 1998; NSAI, 1996 and Flanagan, 1990.

Quality control tests must be performed on the chosen method of preservation to ensure that there is no significant difference between the result of an analytical determination carried out immediately and the result obtained after preservation. The time elapsed between sampling and analysis should be recorded together with the name of the preservative added (Anon., 1998; Carty *et al.*, 1998; NSAI, 1996 and ISO, 1990).

Sample preservation is a requisite of a number of pieces of legislation and associated implementation handbooks. For example, the EPA Act, 1992 (Urban Waste Water Treatment) Regulations, 1994 states that 'good international laboratory practices aiming at minimizing the degradation of samples between collection and analysis shall be applied'- (Fifth Schedule

Paragraph 2). The associated implementation handbook (EPA, 1996) states that each hourly sample portion taken (whether of influent or effluent) should be stored immediately under refrigeration, until the 24-hour composite sampling period is completed. It is recognised in the handbook, however, that it would be unreasonable to expect sanitary authorities to retrospectively equip all their treatment plants with two refrigerated flow-proportional samplers, especially in the case of smaller works where less frequent sampling is required.
European Communities (Quality of Surface Water Intended for the Abstraction Drinking Water) Regulations, 1989 states that sample preservation should not significantly affect the values of the results obtained from samples.

1.3.10 Sample label and field records

The sample label and field records are an important aspect of documentation and should unambiguously link a sample to related plans or notes. Labels must be firmly attached to the sample packaging and where appropriate, be resistant to fading, autoclaving, sample or reagent spillage and reasonable changes in temperature and humidity (Working Group CITAC and EURACHEM, 2002).

Every bottle should be identified with a unique sample number, preferably by attaching an appropriately inscribed tag or label using a waterproof ink. Sufficient information should be documented to provide positive sample identification at a latter date. If there is insufficient space for all pertinent information on the label, the information should be recorded in a bound field logbook at the sampling site at the time of sample collection (Anon., 1998; ISO, 1992; ISO, 1991; ISO, 1990; ISO, 1987; NSAI, 1994 and NSAI, 1996). Some workers require that a detailed field log sheet be filled in (in duplicate) at the time of sampling (Flanagan *et al.*, 2002 and Flanagan *et al.*, 1990).

The amount of detail required in the sampling records will depend on the objectives of the sampling programme. If the same sampling location is used permanently, it is not necessary to repeat all details every time. Many workers have cited that at a minimum, the following details be recorded– unique sample identification number, purpose of sampling, sampling date and time, name of sampler, sampling location point, weather conditions, name and address of field contact (if applicable), type of sample, preservation carried out and data generated in the field (Anon., 1998; Bartram *et al.*, 1996; Crosby and Patel,1995; ISO, 1992; ISO, 1991; ISO, 1990; Flanagan *et al,* 2003*a*, 2003b and 1990 and Department of Environment, 1981). In some instances,

additional information must be recorded. For example, in Local Authority pollution investigations, information relating to the name and address of the discharger and the name of the receiving watercourse or sewer must also be recorded (Department of Environment, 1981).

1.3.11 Laboratory records.

Chain-of-custody forms should be used to trace sample history from the time of sample collection to final reporting. Each person who has responsibility for the sample must complete the form and this includes anyone taking possession of samples during transport e.g. a courier company as they are technically part of the chain of custody and may need to account for the samples whilst they are under their immediate control (Treble and Nicholson, 2000 and Anon., 1998). This process is essential when the data is to be used for litigation purposes.

It is essential that all field records and chain-of-custody forms are legible and maintained in a secure location for a predetermined length of time. Accurate sample records are essential in order to allow correlation between the laboratory analytical result and the field situation, thereby allowing conclusions to be drawn and subsequent action taken if required.

Each laboratory must devise their own sampling record requirements since guidelines are not provided in ISO 5667, Standard Methods, relevant environmental legislation or associated implementation handbooks. The records maintained will normally be dependent on individual laboratory requirements.

1.3.12 Sample transport

Containers holding samples must be protected and sealed in such a way that they do not deteriorate or lose any part of their contents during transport. During transport, samples should be stored in an environment that minimises the alteration of the specific parameters of interest. In general, samples should be protected from direct sunlight and held in a cool environment, particularly so, in the case of bacteriological samples (Flanagan *et al.*, 2003; Flanagan *et al*, 2002; Anon., 1998; Crosby and Patel, 1995; NSAI, 1996; ISO, 1994, ISO, 1990 and Galal-Gorchev and Lewis, 1984).

The conditions under which a sample is stored during transport depends on the analyte of interest. For example, samples undergoing bacteriological assays must be stored in an icebox and maintained at temperatures not greater than 10^0C during transport. These samples should not be

stored for more than 30 hours, particularly if analysing for coliform bacteria (Flanagan *et al*, 2003 and Flanagan *et al*, 2002). In the case of volatile components (e.g. ammonia) the sample must be stored in a gas-tight bottle to prevent evaporative loss of the component (Flanagan *et al*, 2003; Flanagan *et al*, 2002 and Anon., 1998). Easily oxidised components, e.g. nitrite, sulphite and hydrogen sulphide, must be stored in air-tight-bottles to prevent the oxidation process (Flanagan *et al*, 2003 and Flanagan *et al*, 2002).

ISO 5667 states that samples should be kept as cool as practicable and protected from light during transportation. European Communities (Quality of Surface Water Intended for the Abstraction Drinking Water) Regulations, 1989 states that sample transport should not significantly affect the values of the results obtained from samples. There is no reference made to sample transport in EPA (1996).

1.3.13 Sampling quality control

Sampling always contributes to the measurement of uncertainty and knowledge of the potential sampling error is important (Anon., 1998). Sources of sampling error include the use of incorrect sampling procedures or equipment, sample contamination or incorrect sample preservation or storage. Quality control procedures are required in order to quantify and control these sources of error.

ISO 5667 (ISO, 1998) describes a number of quality control techniques and these include:

- the collection of replicate samples as a check on the precision of sampling
- the use of field blank samples. This is done by dividing a sample of deionized water into two parts, one of which is processed as a real sample (i.e. by filling into a sample container and adding preservative etc.) while the other is unused. The comparison of results from both samples identifies errors due to contamination of sampling containers or sampling process.
- the use of spiked samples. This is done by either spiking deionized water samples or environmental samples with a known concentration of the analyte of interest. The spiked sample used is divided into two parts, one of which is processed as a real sample using the sampling container while the other is unused. The comparison of results from both samples identifies errors due to contamination of sampling containers or sampling processes.

Standard Methods (Anon 1998) recommends that field blanks are used in order to assess whether the sampling container used is affecting the analyte result obtained.

Legislation implementation handbooks e.g. Flanagan *et al* 2003; EPA, 1996 and Flanagan P.J., 1990a) do not specify specific requirements with regard to sampling quality control techniques. More recent implementation handbooks e.g. Flanagan *et al* 2003 deal in detail with analytical quality control but do not refer to sampling quality control.

1.4 LIMERICK COUNTY COUNCIL SAMPLING PROCEDURES.

There are 39 Local Authorities (LA) and 6 EPA laboratories with responsibility for monitoring water quality in Ireland. Of the 39 Local Authorities just 74% are involved in water analysis, this includes 27 of the 29 county councils and 2 of the 10 city/borough councils. Of the six EPA laboratories five are involved in water analysis. In addition to LA and EPA laboratories, an ever-increasing number of private laboratories are involved in water sampling and analyses. These laboratories work on behalf of Local Authorities, EPA, Department of Environment, private companies and members of the public.

Limerick County Council (LCC) carries out its own water sampling using trained scientific staff and is currently in the process of attaining accreditation to ISO 17025 (General requirements for the competence of testing and calibration laboratories). In order to comply with Condition 5.7 of this standard the laboratory has produced a sampling programme and sampling procedures.

The laboratory's current sampling programme contains maps and lists of all sampling locations in the county. These sampling locations include rivers, surface waters used for the abstraction of drinking waters, licensed industrial plants and urban wastewater treatment plants. The sampling programme also contains a map and list of all drinking water supplies in the county and details the number of samples required per year for each supply.

The laboratory's sampling procedures are documented in SOPs (Standard Operating Procedures). These have been prepared by senior members of staff who carry out the sampling procedure on a regular basis, using guidelines given in Standard Methods (A.P.HA. 1998), legislation and associated handbooks. The sampling SOPs describe the sampling equipment, sampling location, sampling method, field analyses required, the sample storage conditions and safety precautions necessary when sampling various water bodies. They therefore describe the sampling tasks in sufficient detail in order that a competent sampler unfamiliar with the method can conduct the

procedure and provide a solid training tool in assuring uniform procedures are adhered to at all times.

LCC SOP's are identified with a unique number together with the date of issue, revision number and page numbers and are only issued by authorised personnel. A master list identifying current revision status of SOP's and their distribution status established. This ensures that only valid copies are available and that obsolete SOP's are properly removed. The control over SOP's, in such a manner, is required under Condition 4.3 of ISO 17025. A copy of the current sampling SOPs, documented by Limerick County Council, are given in Appendix C.

1.5 SAMPLING FOR LITIGITAION PURPOSES.

Water samples, particularly those taken by local authorities and the EPA, are sometimes required as evidence in a court of law, where a prosecution is pending. Guidance, with regard to taking samples for litigation purposes are detailed in the implementation handbook for the Local Government (Water Pollution) Act, 1977, published by the Department of the Environment in 1981. This handbook states "when court proceedings are anticipated, samples should be taken by a trained and experienced sampler under the supervision of a qualified analyst. Where on the spot analyses are required it would be preferable that these be performed by a qualified laboratory technician or analyst".

Samples taken correctly may have serious implications if legal action is initiated on foot of the subsequent results. For example a prosecution taken by LCC against A.I.B.P Ltd. under Section 3 of the Local Government (Water Pollution) Act, 1977, in July 1997, was dismissed from the district court case for the following reasons:

1. The samples were not taken properly
2. The samples were not taken from the proper location
3. The chain of evidence with regard to handling of the samples was not established.
4. The improper handling and storage of the samples by the sampler, the courier and the sub-contracting laboratory raised question of possible contamination.

A copy of the court report filed by Mr. Michael Finbarr Collins, Barrister-at-law is given in Appendix A.

2.0 MATERIALS AND METHODS

2.1 QUESTIONNAIRE

2.1.1 Introduction

In order to investigate how laboratories in Ireland are currently taking water samples (physical, chemical and microbiological) a questionnaire was forwarded to a number of Local Authority (LA), EPA and independent laboratories. This questionnaire was of the format shown in Figure 2.1. The questionnaire was accompanied by a cover letter which gave details on the purpose of the questionnaire, guaranteed confidentiality on all information obtained and offered a copy of the findings to interested laboratories.

In order to obtain an overview of common water sampling practice and procedures in various environmental laboratories, recipients of the questionnaire were asked to answer a total of 32 questions. The questions were based on requirements of the ISO 5667 standard, Standard Methods (Anon, 1998), specified requirements in relevant legislation and associated handbooks (Refer to Section 1.2 of the Literature Review). In order to reduce the length of time that the survey would take to complete several of the questions asked required yes/no answers. This was hoped to encourage a high response rate.

2.1.2 Questionnaire circulation

For the purpose of the questionnaire, three sectors of laboratories were chosen and these were LA, EPA and private laboratories. These were selected as they are the main bodies with responsibility for water sampling in Ireland. The questionnaire was distributed by e-mail to the various laboratory managers. This included 39 Local Authority, 6 EPA and 11 independent laboratories. Therefore 100% of LA and EPA laboratories and approximately 65% of independent laboratories, which carry out water sampling, were targeted as part of the questionnaire.

Once the laboratories had responded to the questionnaire the results from the various laboratory sectors were collated and summarised. This allowed statistical analysis to be carried out, the results to be presented in graphical format and comparisons to be made between the various sectors.

Figure 2.1 The Questionnaire forwarded to laboratories

Laboratory: _____
Contact Name:_____
Contact Telephone No.: _____

Q. No.		Answer
1.	Does the laboratory carry out its own sampling?	
2.	Does the laboratory have personnel designated solely for sampling?	
3.	Are sampling procedures documented?	
4.	Are there documented procedures for the training of personnel involved in sampling?	
5.	Is the above training carried out in-house or by an independent outside body?	
6.	Are sampling training records maintained?	
7.	Has the laboratory ever considered obtaining accreditation specifically for sampling work carried out by the laboratory?	
8.	If **YES** to Q7please give brief details:	
9.	Does the laboratory use any of the following as a guide when preparing sampling programmes and procedures? (Please tick) ISO5667 ☐ LA Implementation handbooks ☐ Standard Methods (Anon) ☐	
10.	Are samples taken/analysed by the laboratory used as evidence in court?	
11.	Have laboratory sampling procedures used by your laboratory ever been questioned in court?	
12.	Which of the following samples are routinely sampled by your laboratory: (Please tick) River water: ☐ Wastewater – Industrial effluent: ☐ Wastewater – Sewage treatment plants: ☐ Drinking water: ☐	

Figure 2.1 (ctd.)

Q. No.		Answer
13.	Please list the parameters which are routinely monitored at the following sampling locations; (a) Drinking water: (b) River water: (c) Wastewater (Industrial effluent): (d) Wastewater (Sewage treatment plants):	
14.	Are field meters calibrated/checked prior to sampling?	
15.	Is the above recorded?	
16.	Are chain of custody forms used in any of the following situations: Samples taken by laboratory personnel: ☐ Samples taken by non-laboratory personnel: ☐ Samples taken for prosecution cases: ☐	
17.	What type of sampling containers does the laboratory use to sample the following: a. Microbiological : b. Fluoride : c. Oil and grease : d. Phosphate : e. Metals :	
18.	Do the laboratory procedures document what type of sampling container is to be used?	
19.	Are field blanks analysed for each sample run?	
20.	Are any of the following samples chemically preserved prior to analysis: a) Ammonia: ☐ b) Phosphate: ☐ c) Total Phosphorus: ☐ d) Metals: ☐ e) Oil and grease: ☐	
21.	If **YES** to Q20 – How soon after sampling are samples preserved? a) Ammonia: b) Phosphate: c) Total Phosphorus: d) Metals: e) Oil and grease:	

Figure 2.1 (ctd.)

Q. No.		Answer
22.	Do the laboratory procedures document which samples are to be preserved?	
23.	Are records maintained of the preservation carried out?	
24.	Are quality control tests carried out in order to ensure that the preservatives used does not interfere with subsequent determinations? If **YES** please give brief details:	
25.	Is sodium thiosulphate (or similar chemical) added to drinking water sampling bottles prior to sterilisation, in order to neutralise the effects of chlorine?	
26.	Are samples transported from the sampling site to the laboratory in a refrigerated van or cooler box?	
27.	Are there documented procedures with regard to the labeling of samples?	
28.	Is information regarding sample location and on-site analysis written on the sampling bottle or on a field log-sheet?	
29.	Are there standard field log-sheets for the various water bodies being sampled?	
30.	Is the laboratory accredited to ISO17025?	
31.	If **YES** to Q30 how many tests is the laboratory accredited for?	
32.	If **NO** to Q30 is the laboratory in the process of attaining accreditation to ISO17025?	

2.2 GAP ANALYSIS

2.2.1 Introduction

There is currently no laboratory in Ireland accredited specifically to ISO 5667, nor is there any published information available with regard to attaining accreditation to the standard. In order to ascertain the level of work required attaining accreditation to ISO 5667 a gap analysis was carried out.

2.2.2 Gap Analysis

Current water sampling procedures and practices at Limerick County Council's (LCC) Environmental Laboratory were used as a case study in order to determine the level of work required to attain accreditation to ISO 5667. This was done by carrying out a gap analysis. The gap analysis looked in detail at the requirements of the standard versus current practice and procedures in the laboratory.

The following parts of ISO5667 are relevant to the work carried out by the laboratory and were therefore used for the gap analysis:

- Part 1: Guidance on the design of sampling programmes
- Part 2: Guidance on sampling techniques.
- Part 3: Guidance on the preservation and handling of samples.
- Part 5: Guidance on sampling of drinking water and water used from food and beverage
- processing.
- Part 6: Guidance on sampling of rivers and streams.
- Part 10: Guidance on sampling of wastewaters.
- Part 14: Guidance on quality assurance of environmental water sampling and handling.

The following laboratory documented standard operating procedures (SOP's) are relevant to the gap analysis:

- SOP No. 6 - Routine Drinking Water Supply Schemes
- SOP No. 8 - Routine River Sampling
- SOP No. 10 - Sewage Treatment Plant Sampling
- SOP No. 11 - Industrial Effluent Sampling
- SOP No. 43 – Procedure for Handling Test Samples/Items

- SOP No. 47– Surface Waters for Abstraction of Waters Intended for Human Consumption – Sampling Procedure.

(Refer to Appendix B for copies of the above SOP's)

The gap analysis was performed by comparing each relevant section of each part of the ISO 5667 standard with current procedures and practices in LCC's environmental laboratory. This allowed non conformances between the requirements of ISO 5667 and current practices and procedures in the LCC's environmental laboratory to be quickly identified. A non-conformance was raised where there was evidence of a failure to comply with a requirement of ISO 5667. When there was evidence of a non-conformance, appropriate corrective actions were identified.

For ease of assessment, the corrective actions were categorised into a number of areas, namely.

- Sampling programme
- Quality control
- Preservation
- Drinking water sampling
- River water sampling
- Wastewater sampling

Each proposed corrective action was then assessed in order to determine the following:

- Whether the facilities/resources are currently available within the laboratory to implement the corrective action.
- A proposed time scale for implementation i.e.
  - Short term: less than 6 months
  - Medium term: 6 months - year
  - Long term: greater than 1 year

  The time scale was based on one member of the laboratory personnel having 30-40% (1.5-2 days) of their working week dedicated solely to the implementation of this standard.
- An estimated cost for implementation of the corrective standard
  - Low: Cost is minimal.
  - Medium: Cost can probably be met using the laboratory's annual allocated budget.
  - High: Cost cannot be met using the laboratory's annual allocated budget.
- Whether staff can be trained on-site or if off-site training is required.

3.0 RESULTS AND DESCRIPTION OF RESULTS

3.1 RESULTS OBTAINED FROM THE QUESTIONNAIRE

A questionnaire (Section 2.1) was forwarded to 6 EPA laboratories, 39 Local Authority (LA) laboratories and 11 independent laboratories. All of the EPA laboratories responded to this questionnaire while 28 LA laboratories and 4 independent laboratories responded. This corresponds to a 100%, 72% and 36 % response rate from EPA, LA and private laboratories, respectively.

There are currently 6 EPA laboratories in Ireland. Since each of these laboratories responded to the questionnaire, the information obtained from these can be considered to be truly representative of water sampling practices in the EPA laboratory sector.

There are currently 39 LA laboratories in Ireland, 28 of which responded to the questionnaire. This represents a response rate of 72%. Such a high response rate allows significant conclusions to be drawn regarding water sampling practices in the LA sector.

There are approximately 17 independent laboratories, involved in water analysis, in Ireland. The questionnaire was forwarded to 11 of these laboratories. Although 4 independent laboratories replied to the questionnaire, one of these laboratories does not carry out routine water quality sampling. Drawing conclusions from the results obtained from 3 independent laboratories cannot be considered to be truly representative of water sampling practices in this sector. These results, therefore, are not discussed as part of this dissertation, but summarised in Appendix C (Table C3).

Table 3.1 Comparison of the percentage 'yes' responses received from LA and EPA laboratories when questioned in relation to various aspects of sampling and sampling procedures. The Table also shows the responses from Limerick County Council Laboratory.

	LCC Lab Yes/No	**LA Labs (% 'Yes')**	**EPA Labs (% 'Yes')**
Carry out water sampling	Yes	68	83
Have personnel designated solely for sampling	No	11	80
Document sampling procedures	Yes	74	60
Document sampling training procedures	No	32	20
Maintain sampling training records	Yes	11	40
Have considered accreditation specifically for sampling	Yes	16	60
Use the following guides when preparing sampling programmes and procedures:			
- ISO 5667	No	11	20
- LA Implementation handbooks	Yes	56	20
- Standard Methods	Yes	83	60
Use samples as evidence in court, as necessary?	Yes	47	100
Sampling procedures have, in the past, been questioned in court	Yes	16	25
Routinely sample:			
- River water	Yes	72	100
- Wastewater – Industrial effluent	Yes	67	100
- Wastewater – STP	Yes	72	60
- Drinking water	Yes	61	40
Calibrate/check field meters prior to use	Yes	100	100
Maintain records with regard to the calibration/checking of field meters.	Yes	63	50
Use chain of custody forms for samples taken:			
- by laboratory personnel	No	25	100
- by non- laboratory personnel	Yes	47	100
- for prosecution cases	Yes	36	100
Use correct type of sampling container when sampling for:			
- Microbiological organisms	Yes	100	100
- Fluoride	Yes	100	100
- Oil and Grease	No	63	100
- Phosphates	No	0	0
- Metals	Yes	100	100

Table 3.1(ctd.)

	LCC Lab Yes/No	LA Labs (% 'Yes')	EPA Labs (% 'Yes')
Have documented methods that identify the type of sampling container to be used	No	56	100
Analyse field blanks along with each sample run	No	27	60
Preserve samples for:			
- ammonia	No	5	67
- phosphate	No	6	33
- total phosphorus	No	6	33
- metals	Yes	53	100
- oil and grease	No	0	100
Have documented methods that identify the samples to be preserved	No	64	80
Maintain records of preservation carried out	No	45	40
Carry out quality control tests on preservatives used	No	18	80
Add sodium thiosulphate to drinking water sampling bottles, prior to sterilisation	Yes	100	75
Transport samples in cooled environment	Yes	68	60
Document procedures with regard to labelling of samples	Yes	53	60
Have standard field log-sheets	Yes	33	100
Have obtained accreditation to ISO 17025	No	0	60
Are in the process of attaining accreditation to ISO 17025	Yes	50	50

Note: Summaries of the results obtained from the questionnaire sent to LA and EPA laboratories are included in Appendix C (Table C1 and C2 respectively)

3.1.1 Laboratories Involvement in Water Sampling

Table 3.1 and Figure 3.1 indicate that 68% of the LA laboratories that replied to the questionnaire undertake water quality sampling. None of the city/town councils, which replied, carry out routine water quality sampling, while one of the LA's has its sampling and monitoring carried out by the EPA. Just 11 % of the LA laboratories have personnel designated solely for sampling, as most LA sampling staff also carry out the subsequent laboratory analysis.

Of the 6 EPA laboratories in Ireland, just 5 carry out water sampling i.e. 83%. Of the laboratories which carry out water sampling, 80% have personnel designated solely to sampling.

Figure 3.1 Percentage of LA and EPA laboratories which (a) carry out their own water sampling and (b) have personnel designated solely for sampling.

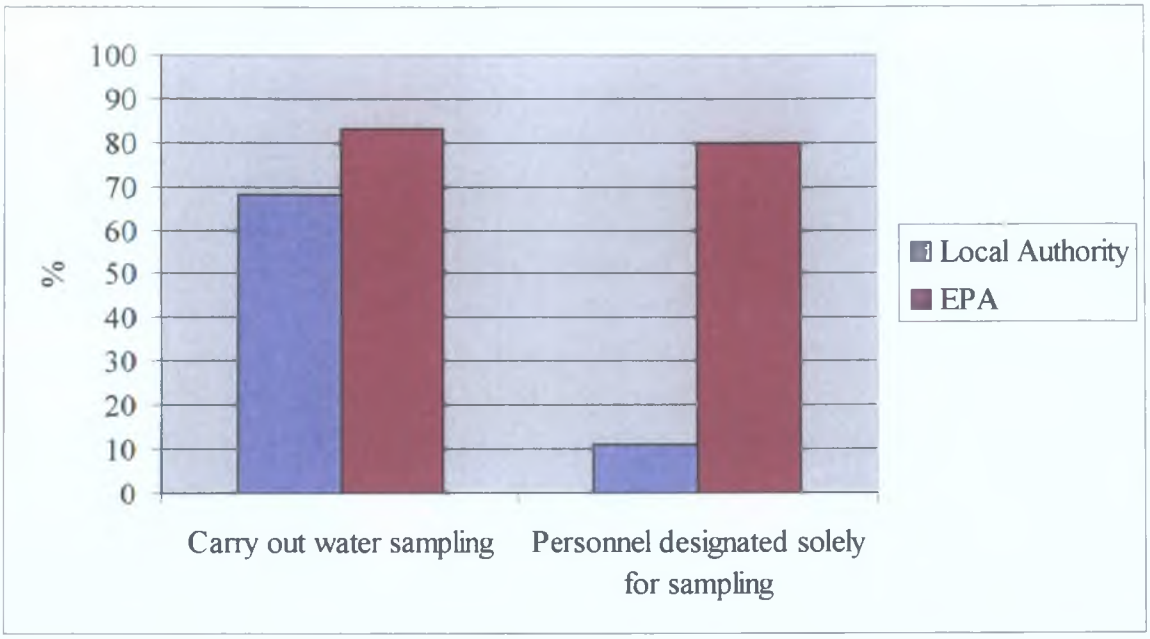
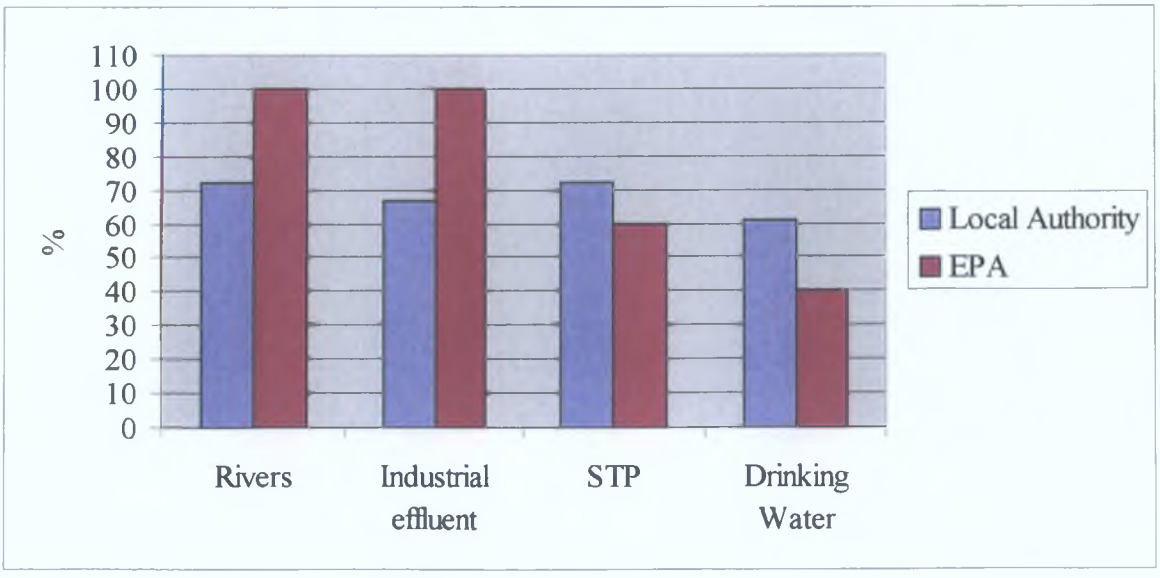


Figure 3.2 details the type of water samples collected by the LA, EPA and private laboratories, which replied to the questionnaire.

Figure 3.2 Percentage of LA and EPA laboratories, which routinely sample rivers, industrial effluents, sewage treatment plants and drinking waters.



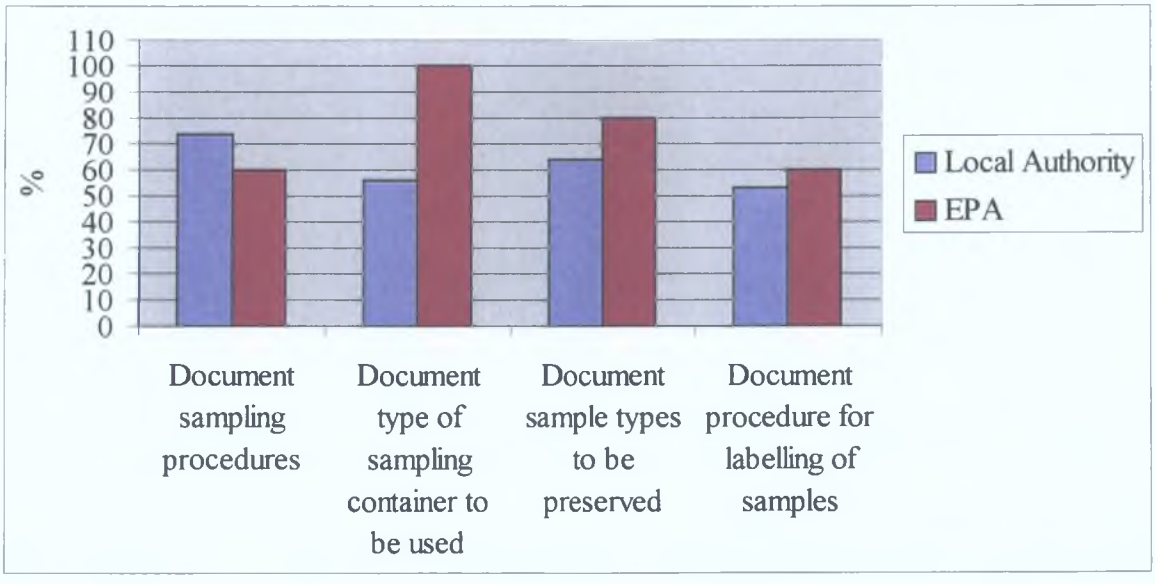
The routine sampling carried out by LA laboratories varies. Of the LA laboratories that replied to the questionnaire, 72% routinely sample rivers, 67% routinely sample industrial wastewaters, 72% routinely sample sewage treatment plants and just 61% routinely sample drinking waters.

All EPA laboratories routinely sample industrial wastewaters and rivers. 60% of EPA laboratories routinely monitoring sewage treatment plants while 40% routinely monitor drinking waters.

3.1.2 Sampling Procedures

A number of questions were asked regarding the existence and documentation of sampling procedures in the laboratory. Tables 3.1 and Figure 3.3 summarise the replies obtained.

Figure 3.3 Percentage of LA and EPA laboratories that document (a) sampling procedures (b) the type of sampling container to be used (c) the sample types that are to be preserved and (d) procedures for labelling samples

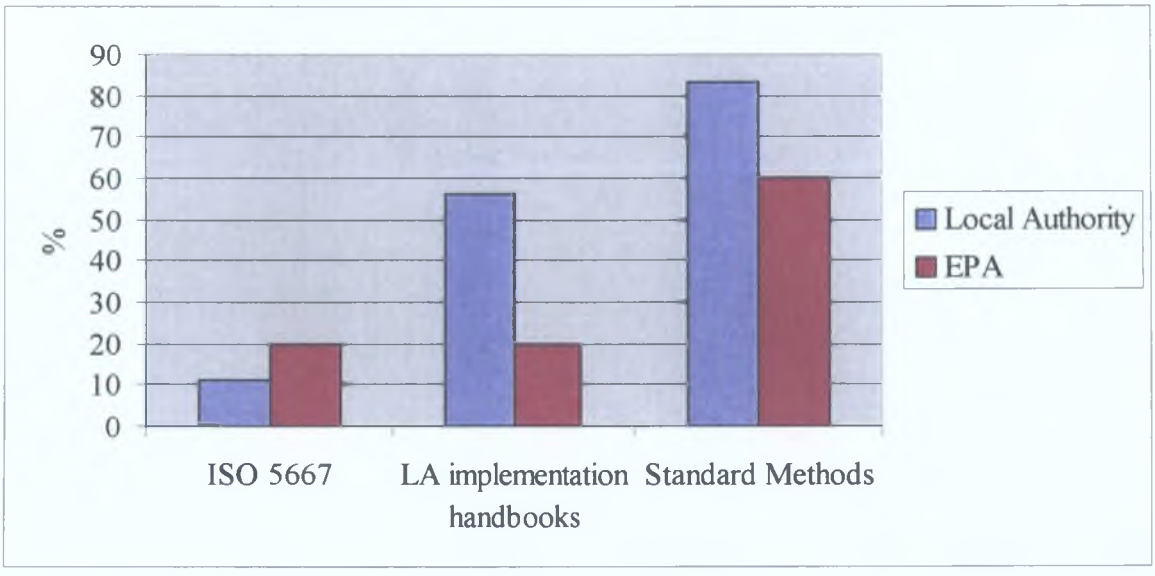


Of the laboratories which responded to the questionnaire, 74% of LA laboratories and 60% of EPA laboratories have documented sampling procedures in place. The level of detail in these sampling procedures varies. For example, 100% of EPA and 56% of LA laboratories document the type of sampling container to be used. 80% of EPA and 64% of LA laboratories document, which samples are to be preserved. 60% of EPA and 53% of LA document procedures regarding the labelling of samples.

3.1.3 Guides used in Preparing Sampling Programmes and Procedures

Figure 3.4 shows the guides used by the laboratories in preparing sampling programmes and procedures.

Figure 3.4 Percentage of LA and EPA laboratories, which use (a) ISO 5667 (b) Local Authority Implementation Handbooks and (c) American Public Health Association 'Standard Methods' when preparing sampling programmes and procedures.



Among the laboratories questioned, Standard Methods (Anon., 1998) is the most commonly used guide for preparing sampling procedures i.e. 83% of LA laboratories and 60% of EPA laboratories use this guide. A significantly lower number of the laboratory respondents use ISO 5667 as a guide namely 11% of LA laboratories and 20% of EPA laboratories. 56% of LA laboratories, which responded, use these LA implementation handbooks when preparing sampling programmes and procedures however only 20% of EPA laboratories use these handbooks.

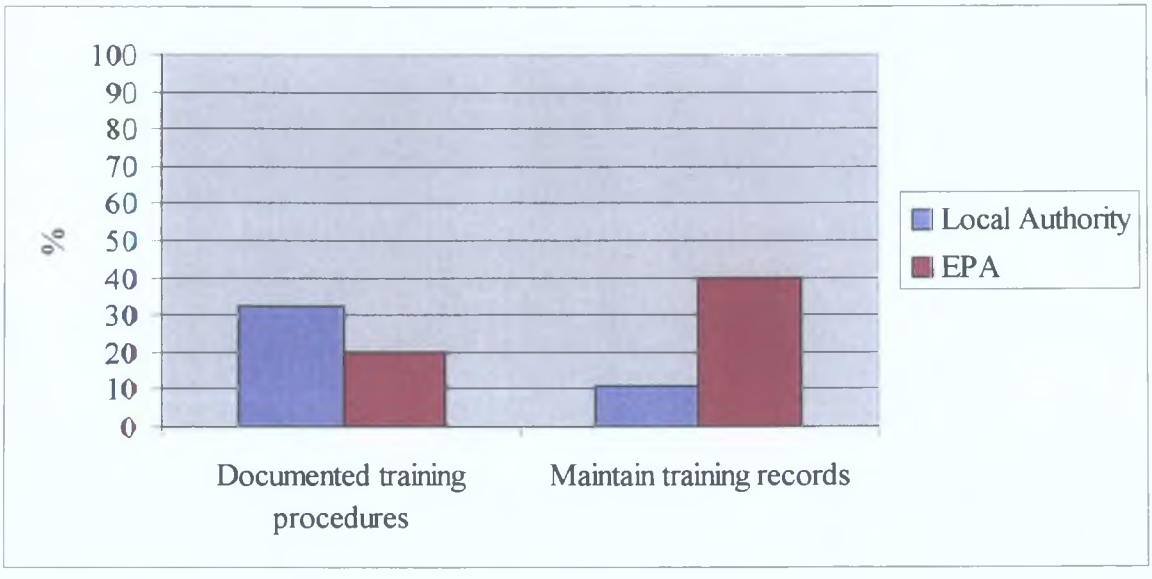
3.1.4 Training of Sampling Personnel

Only 32% of LA and 20% of EPA laboratories, which responded to the questionnaire, have documented procedures in place with regard to the training of sampling personnel.

Although 32% of LA laboratories have documented procedures with regard to the training of sampling personnel, only 11% maintain sampling training records. A higher percentage of EPA

laboratories (40%) maintain sampling training records (Figure 3.5). All laboratories questioned carry out in-house training of sampling personnel.

Figure 3.5 Percentage of LA and EPA which (a) have documented procedures with regard to training sampling personnel and (b) maintain sampling training records



3.1.5 *In-situ* analysis of water quality parameters.

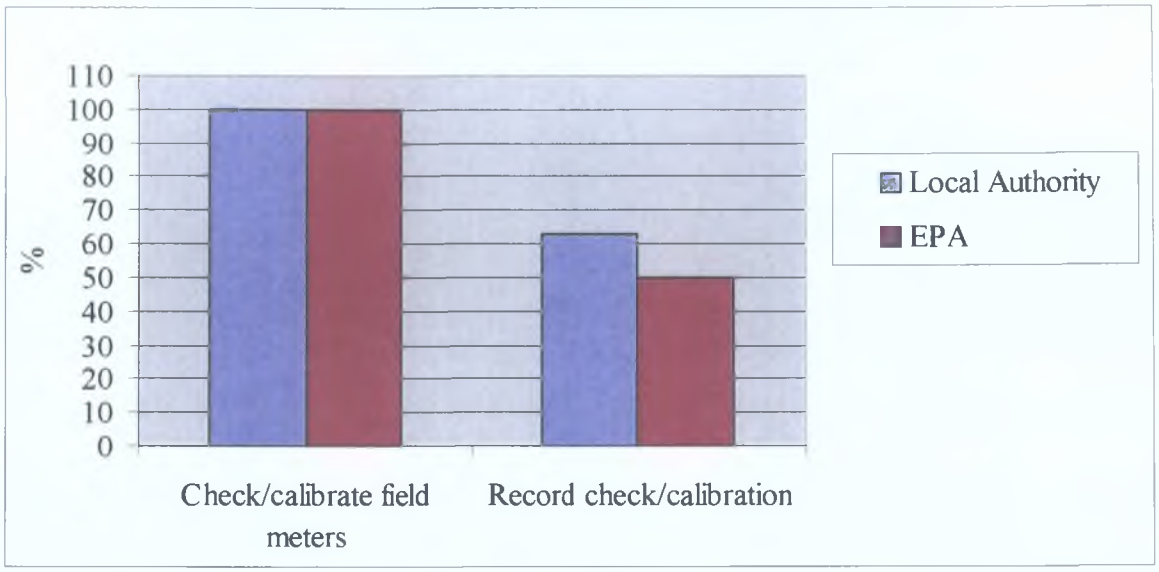
Q13, of the questionnaire, stated 'please list the parameters which are routinely monitored at the following sampling locations...' . This question was looking specifically for those parameters measured in the field. Unfortunately in most cases the laboratories, which responded, misunderstood this question. Most interpreted the question as meaning all the parameters that are monitored both in the field and in the laboratory during drinking water, river and wastewater sampling.

In total five laboratories interpreted the question correctly. Temperature, chlorine and dissolved oxygen are measured in the field by all these laboratories. However pH and conductivity are only measured in the field by two of these laboratories.

3.1.6 Calibration and checking of *in-situ* monitoring equipment

Figure 3.6 indicates the percentage of laboratories that check/calibrate monitoring equipment prior to use at the sampling site. While all laboratories, which replied to the questionnaire check/calibrate monitoring equipment, only 63% of Local Authority laboratories and 50% of EPA record this calibration/check.

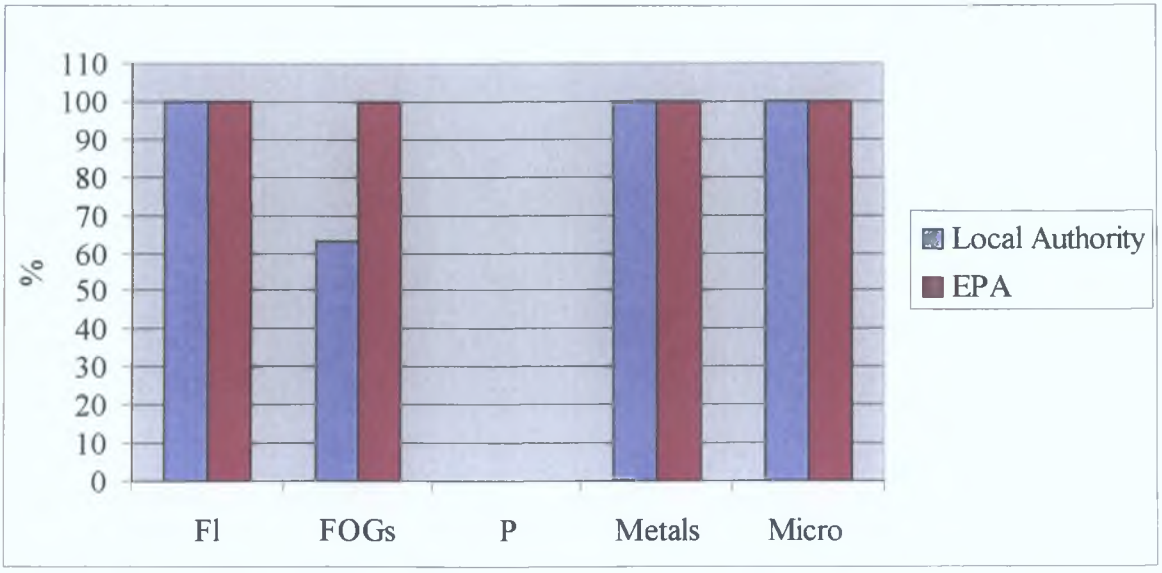
Figure 3.6 Percentage of LA and EPA laboratories that (a) check or calibrate field meters prior to sampling and (b) record this calibration/check



3.1.7 Sampling Containers Used for Sampling

Q17, of the questionnaire asked what type of sampling container was used to sample for microbiological, fluoride, oil and grease, phosphate and metals. Figure 3.7 shows the percentage of laboratories which use the correct type of sampling container for the various analytes of interest.

Figure 3.7 Percentage of LA and EPA laboratories that use the correct sampling containers for fluoride (glass), FOGs (glass), phosphates (glass), metals (glass/plastic) and microbiological samples (sterile glass/plastic).

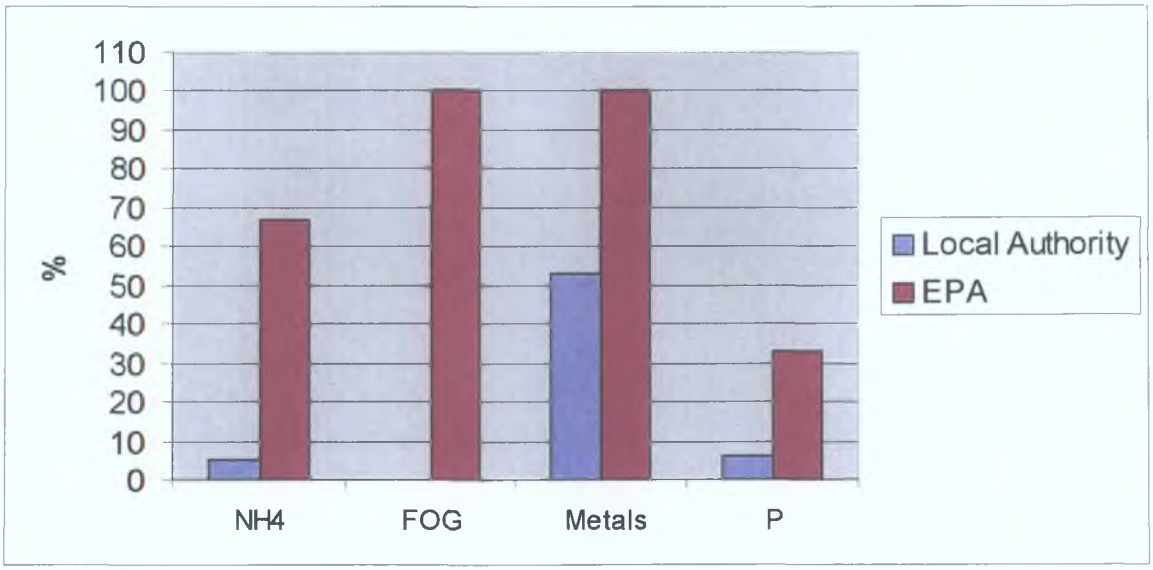


All laboratories use the correct type of sampling containers when sampling for fluoride, metals and microbiological samples. In relation to oil and grease, all EPA laboratories use the correct container i.e glass, when sampling for this parameter however only 63% of LA laboratories use the correct container. All laboratories who replied to the questionnaire use the incorrect type of sampling container i.e. plastic containers, when sampling for phosphate. Nevertheless, one LA laboratory did state that it used plastic or glass for very low levels.

3.1.8 Sample Preservation

Table 3.1 and Figure 3.8 portrays the percentage of laboratories that chemically preserve samples for various types of determinands, namely ammonium, phosphate, metals and oils and grease, prior to analysis.

Figure 3.8 Percentage of LA and EPA laboratories, which chemically preserve samples taken for ammonia, oil and grease, metal, phosphate and total phosphorus analyses.



67% of EPA laboratories chemically preserve samples for ammonia analysis, however, only 5% of LA laboratories that responded preserve for this parameter. All EPA laboratories chemically preserve samples taken for oil and grease analysis. None of the LA laboratories, which responded, preserve for oil and grease. All EPA laboratories chemically preserve samples taken for metal analysis. 60% of the LA laboratories also preserve samples taken for metal analyses. Of the laboratories that responded, only one LA and one EPA laboratory chemically preserve for phosphate.

With regard to the preservation of drinking water samples, all LA laboratories, which responded use sodium thiosulphate to counteract the effects of chlorine during sample transport. Only 75% of EPA laboratories however use sodium thiosulphate.

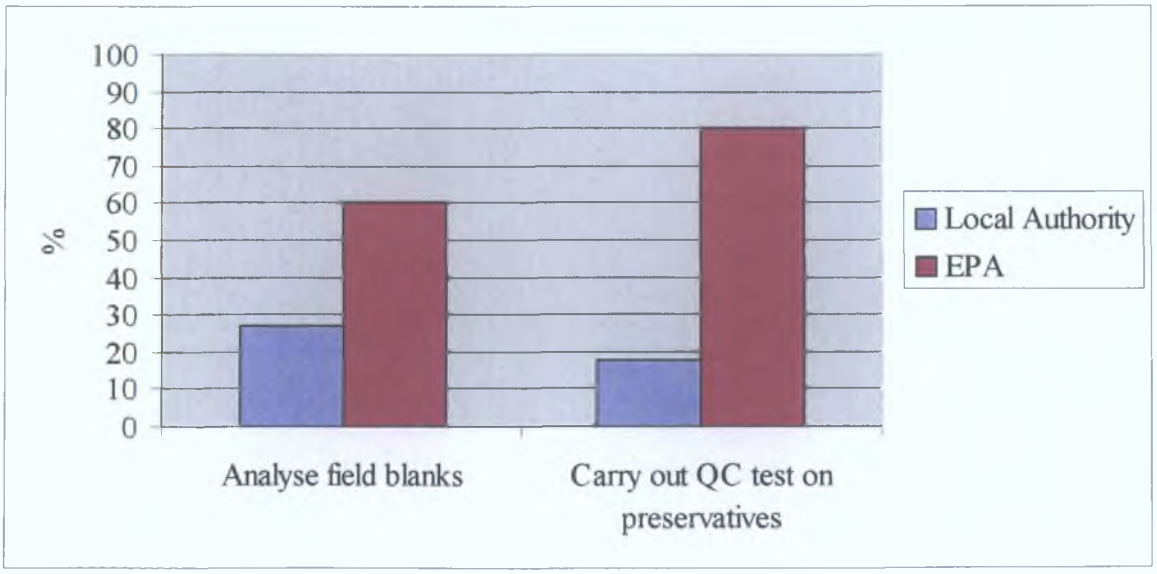
Q21 of the questionnaire, asked, "how soon after sampling are samples preserved?" the most common answer given was 'when samples are returned to the lab"

Although 80% of EPA laboratories and 64% of LA laboratories document, as part of their methods, the samples which are to be preserved, a much lower percentage maintain records of the preservation carried out i.e. 40% of EPA and 45% of LA laboratories.

3.1.9 Quality Control

Q19 of the questionnaire asked "Are field blanks analysed for each sample run?" while Q24 of the questionnaire asked "Are quality control tests carried out in order to ensure that the preservative used do not interfere with subsequent determinations?" The replies obtained from the respondents are shown in Table 3.1 and Figure 3.9.

Figure 3.9 Percentage of LA and EPA laboratories which (a) analyse field blanks with each each sample run (b) carry out quality control tests on preservative used.



LA laboratories generally do not use the above quality control procedures with only 27% of LA respondents analysing field blanks and 18% carrying out quality control tests with regard to the preservatives used. Most EPA laboratories use the quality control procedures outlined above with 60% analysing field blanks and 80% carrying out quality control tests on preservatives used.

3.1.10 Labelling of Sampling Containers

Q28 of the questionnaire asked, "Is information regarding sample location and on-site analysis written on the sampling bottle or on a field log-sheet?" This question aimed to specifically identify which of the above was used to document the required information. Unfortunately, 40% of the laboratories, which responded, misunderstood the question and answered just "Yes". (Appendix C Table C1-C2).

60% of the EPA respondents answered "yes" to the above question. The remaining 40% of EPA laboratories use field sheets to record sampling information. 37% of LA respondents replied "yes" to the above question. Of the remaining laboratories, 50% record the information on the sampling bottle, 25% use field sheets and 25% use both sampling bottles and field sheets.

Of the laboratories which use a log-sheet 100% of EPA laboratories and 33% of LA laboratories have standard field log-sheets for the various water bodies being sampled.

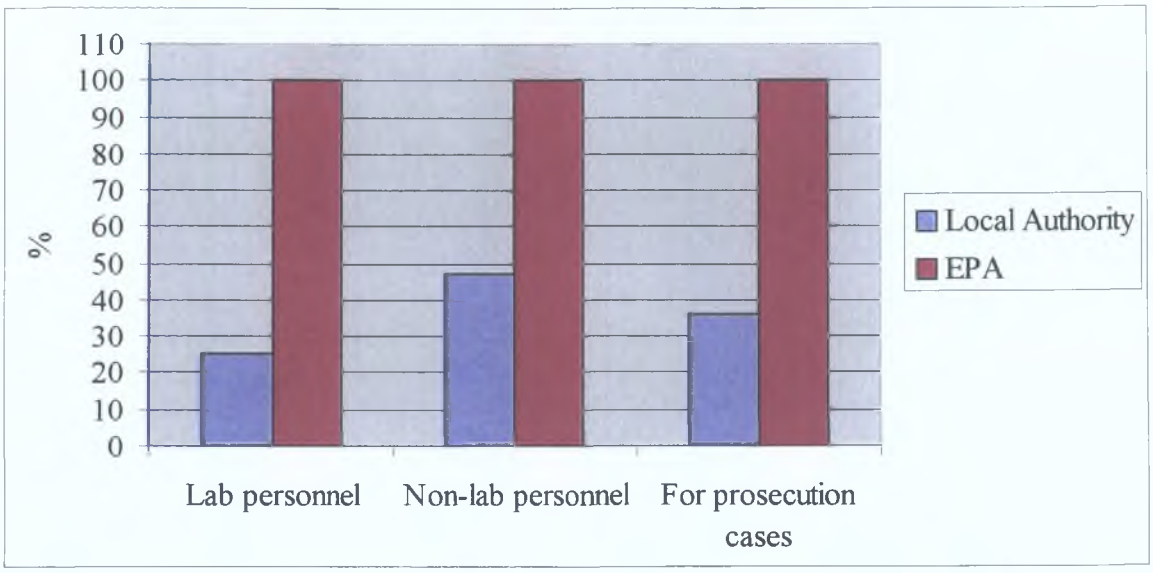
3.1.11 Transportation of Samples

Table 3.1 details the percentage of laboratories which transport samples from the sampling site to the laboratory in a refrigerated van or cooler box. Of the laboratories which responded, 68% of LA laboratories and 60% of EPA laboratories transport samples from the sampling site to the laboratory in a refrigerated van or cooler box.

3.1.12 Use of Chain-of-Custody Forms

Table 3.1 and Figure 3.10 show the percentage of laboratories, which use chain-of-custody forms.

Figure 3.10 Percentage of LA and EPA laboratories that use chain-of-custody forms for samples taken (a) by laboratory personnel (b) by non-laboratory personnel and (c) for prosecution cases.

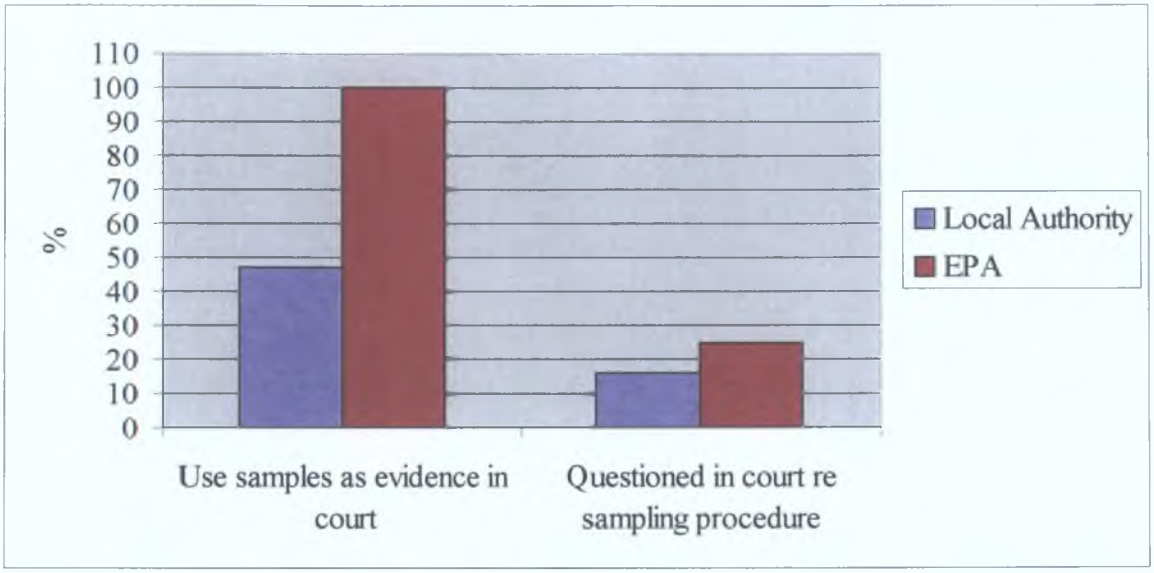


All EPA laboratories use chain-of-custody forms for samples taken by laboratory personnel, by non-laboratory personnel and for prosecution cases. In contrast, LA laboratories do not frequently use chain-of-custody forms. Figure 3.10 shows that only 25% of LA respondents use chain-of-custody forms for samples taken by the laboratory personnel, 36% use the forms for samples taken for prosecution cases and 47% of LA laboratories use the forms for samples taken by non-laboratory personnel.

3.1.13 Samples used as Evidence in Court Cases

Water samples, particularly those taken by LAs and the EPA, are sometimes required as evidence in a court of law, where a prosecution is pending. As part of the questionnaire laboratories were asked firstly if samples taken by their laboratory were used as evidence in court and secondly if the sampling procedure had ever been questioned in court. Table 3.1 and Figure 3.11 summarises the replies obtained to this question.

Figure 3.11 Percentage of LA and EPA laboratories that (a) use samples taken as evidence in court, as required and (b) have had their sampling procedures questioned in court.



From Figure 3.11 it is evident that all EPA laboratories use the results from samples analysed as evidence in court, when necessary. In contrast, only 47% of LA laboratories use the results from samples analysed as evidence in court. 25% of EPA laboratories indicated that they have had their sampling procedures questioned in a court of law. A lower percentage (16%) of LA laboratory respondents indicated that they have had their sampling procedures questioned in a court of law. Details regarding the areas cross-examined in court were not requested in the questionnaire.

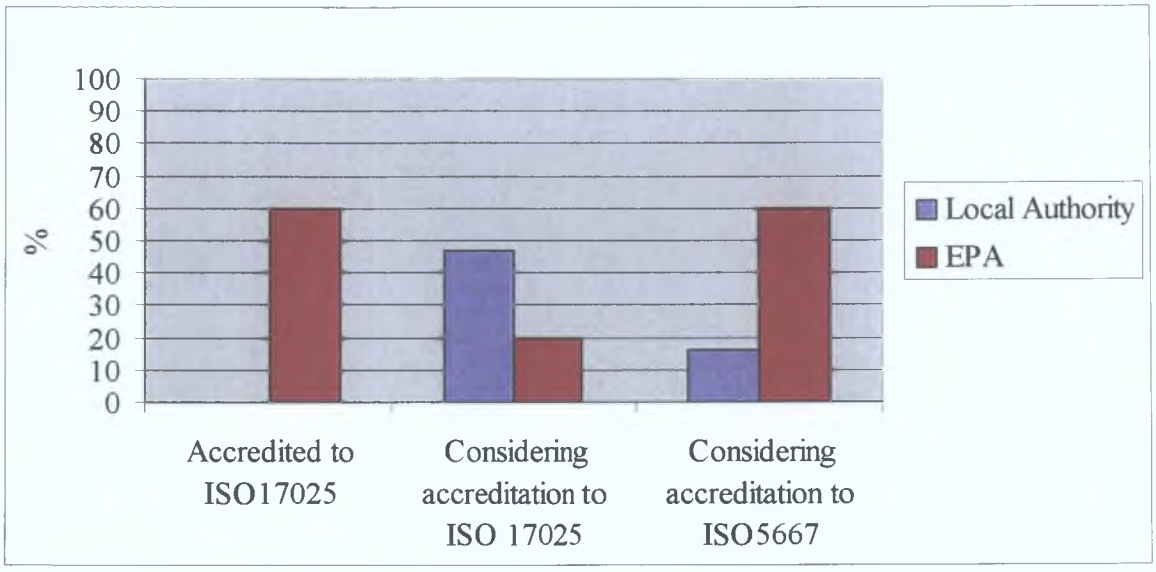
3.1.14 Accreditation of laboratories

The two main standards to which analytical laboratories may be accredited to in Ireland are ISO17025:1999 (General requirements for the competence of testing and calibration laboratories) which deals primarily with the analyses of samples and ISO 5667 which is a water quality sampling standard.

There are currently 66 laboratories in Ireland accredited by the National Accreditation Board (NAB) to ISO17025. Several of these laboratories are based in private industrial plants and were not considered as part of the survey.

Figure 3.12 shows the accreditation status of the LA and EPA laboratories which replied to the questionnaire.

Figure 3.12 Percentage of LA and EPA laboratories which are (a) accredited to ISO 17025 (b) considering accreditation to ISO 17025 and (c) considering accreditation to ISO 5667.



Although none of the LA laboratory respondents are presently accredited to ISO 17025, 48% are currently considering attaining accreditation to this standard. Subsequent investigations revealed that two LA laboratories were accredited to ISO 17025 when the questionnaire was sent out however, these did not reply to the questionnaire. 60% of EPA laboratories are accredited to ISO 17025 while 50% of those not currently accredited are considering accreditation to this standard.

There are currently no laboratories in Ireland accredited to the ISO 5667 water quality sampling standard. However, 16% of the LA laboratories, which responded, have considered obtaining accreditation specifically for sampling. One LA laboratory stated that it would be more cost effective to contract out the sampling work than apply for accreditation.

60% of EPA respondents have considered obtaining accreditation to ISO 5667. Two EPA laboratories have it as part of their long-term plan, while another EPA laboratory found it too complex to implement and decided after some preliminary investigations not to apply.

3.2 RESULTS OBTAINED FROM THE GAP ANALYSIS

In order to determine the level of compliance of Limerick County Council's (LCC) environmental laboratory with ISO 5667 (Parts 1, 2, 3, 5, 6, 10 and 14) a gap analysis was undertaken. A non-conformance was identified where there was evidence of a failure of LCC to comply with a requirement of ISO 5667. This resulted in a number of corrective actions being compiled for each part of the standard.

3.2.1 Sampling Programme

Table 3.2 outlines ten C.A.s, which are required in order to bring LCC's sampling programme in line with the requirements of ISO 5667 (Parts 1, 2, 5, 6 and 10). C.A. No. 1 requires that the sampling programme at LCC be amended to include details on how the various sampling sites in the region were selected and how the frequencies of analysis at these sites were calculated. The sampling programme should also detail when spot and composite samples are to be taken. It is envisaged that these measures can be dealt with in the short term at a low cost as it is simply a matter of collating and documenting current practices at LCC, in particular, as the frequency of most sampling programmes and the type of sample(s) to be taken is dictated by the relevant legislation.

C.A.'s No. 2 and 3 require that the objectives of sampling and the degree of detail and precision adequate for analytical field results be documented in the sampling programme. These measures can be dealt with in the short term at a low cost because most of the sampling currently undertaken is specifically done in order to assess compliance with particular pieces of legislation. The manner in which results are to be presented is often stated in legislation. The relevant legislation would have to be identified for each sampling programme.

C.A. No. 4 requires that sampling locations be reviewed in order to ensure samples are taken from turbulent, well-mixed liquids. This would involve the assessment of each sampling location to ensure there is adequate mixing throughout the body of the water, thereby ensuring that representative samples are taken. To assess this would require external expertise thereby incurring a high cost and hence long term implementation.

Table 3.2: An assessment of the ability of Limerick County Council's Environmental Laboratory to implement the proposed corrective actions to their sampling programme.

Note: More detailed information with regard to these corrective actions are contained in Appendix D

Corrective Action	Are the facilities/ resources available	Proposed time scale for implementation: Short/Medium/ Long term	Cost of implementation: High/Medium/ Low	Staff training: on-site /off-site	Comments
1. Amend sampling programme to include details of: *a)* how sampling sites (location and point) were selected, ensuring that safety and health aspects are considered.*(ISO 5667-1:1980 Section 1 (3))* b) how the frequency of analysis is calculated, ensuring it is done in a systematic manner. *(ISO 5667-1:1980 Section 3 (16.1), ISO 5667-6:1990 (1), (5.2))* c) when spot and composite samples are to be taken. *(ISO 5667-2:1991 (4.2), (5))*	Yes	Short	Low	N/A	- The frequency of most sampling programmes is dictated by the relevant legislation.
2. State the objectives for the various sampling programmes. *(ISO 5667-1:1980 Section 1 (3), ISO5667-5:1999 (1), ISO 5667-10:1992 (1), (5.1.3), (5.3.1.1))*	Yes	Short	Low	N/A	
3. a) Identify and document the degree of detail and precision that will be adequate for analytical field results. Outline the manner	Yes	Short	Low	N/A	

Table 3.2(ctd..):

Corrective Action	Are the facilities/ resources available	Proposed time scale for implementation: Short/Medium/ Long term	Cost of implementation: High/Medium/ Low	Staff training: on-site /off-site	Comments
3. (ctd.) a) in which the results are to be expressed and presented. as part of the sampling programme. (ISO 5667-1:1980 Section 1 (3)) b) Amend sampling programme to include definition of the magnitude of the tolerable error in analytical field results. *(ISO 5667-6:1990 (1), (5.2))*	Yes	Short	Low	N/A	
4. Review the sampling locations ensuring samples are taken from turbulent, well-mixed liquids. *(ISO 5667-1:1980 Section 2 (8.3))*	No	Long	High	Off-site	- Would require external expertise to determine whether there is sufficient turbulence at the various sampling locations
5. Amend sampling programme to give details on the introduction of turbulent flow conditions, where necessary. *(ISO 5667-10:1992 (5.1.2))*	No	Long	High	Off-site	- Would require external expertise to determine whether there are turbulent flow conditions at the sampling site and how the turbulent flow conditions should be introduced, if required.
6. Ascertain the need to statistically determine the number of samples required for a given	Yes	Medium	Low	N/A	

Table 3.2(ctd.)

Corrective Action	Are the facilities/ resources available	Proposed time scale for implementation: Short/Medium/ Long term	Cost of implementation: High/Medium/ Low	Staff training: on-site /off-site	Comments
6. (ctd.) confidence interval. If required, carry out statistical analysis, document results and amend sampling programme as required. *(ISO 5667-1:1980 Section 3 (16.4))*	Yes	Medium	Low	N/A	
7. Identify and document the wastewater sampling times required. These can be ascertained using the formulae given in *ISO 5667-10:1992 (5.2.3)*, which calculates the sampling times over a specified control period e.g. one year, a number of months or weeks.	Yes	Short	Low	N/A	
8. a) Identify whether the water bodies sampled have random or systematic variations in quality. b) Determine statistically the number of samples required to determine whether random or systematic variation occurs. c) If systematic variations in quality exist, determine the times of sampling (these should be spaced approximately equally over trend periods) d) Document results and amend sampling programme as required. *(ISO 5667-1:1980 Section 3 (16.5))*	No	Long	High	Off-site	- Would require outside expertise to determine: a) whether the water bodies sampled have random or systematic variations in quality b) statistically the number of samples required to determine whether random or systematic variation occurs c) the times of sampling, if systematic variation

Table 3.2(ctd.)

Corrective Action	Are the facilities/ resources available	Proposed time scale for implementation: Short/Medium/ Long term.	Cost of implementation: High/Medium/ Low	Staff training: on-site /off-site	Comments
9. As part of the sampling programme compile a list of the parameters of interest for each sample body e.g wastewater, river, etc. with reference to the relevant analytical procedure used in the laboratory. *(ISO 5667-1:1980 Section 1 (3))*	Yes	Short	Low	N/A	
10. Amend 'sampling programme' to include map of surface waters used for the abstraction of drinking water. Outline the various sampling points in these water bodies *(ISO 5667-6:1990 (5.1.1))*	Yes	Short	Low	N/A	

C.A. No. 5 follows from the above and requires details to be given on how turbulent flow conditions would be introduced, where necessary. This again would require external expertise and its implementation would occur only after C.A. No. 4 is implemented.

C.A. No. 6 deals with identifying the need to statistically determine the number of samples required for establishing a given confidence interval. This would firstly involve identifying the confidence interval necessary, from either legislation or other appropriate documentation. The sampling programme would then have to be amended if the current sample numbers were not sufficient. This corrective may not be necessary for all sampling programmes as the number of samples required is often specifically stated as part of the legislative requirements. Where required, the number of samples can be determined for a given confidence interval using the formulae provided in ISO 5667-1:1994 (16.4).

C.A No. 7 requires that the sampling programme document wastewater sampling times and details on how these were selected. The EPA Act, 1992 (Urban Wastewater Treatment) Regulations, 1994 and associated implementation handbooks state the number of samples required per calender year. This is based on the size of the wastewater treatment plant. Currently, LCC environmental laboratory takes the required number of samples but the exact sampling dates are not documented, therefore the sampling may not be spread evenly over the calender year. In order to comply with ISO 5667-10:1992 the sampling times should be spread evenly throughout the year. This can easily be calculated using the formulae given in ISO 5667-10:1992 (5.2.3) and the sampling programme amended accordingly. This measure could therefore be dealt with in the short time at a low cost.

C.A. No 8 action deals with identifying whether the water bodies sampled have random or systematic variations in quality and based on these results determining statistically the number of samples required to be taken. The sampling programme may have to be amended based on these findings. In-house expertise is not available to determine this and therefore a high cost would be incurred in obtaining external expertise as each of the water bodies being sampled would have to be assessed.

C.A. No. 9 requires that as part of the sampling programme a list of the parameters of interest for each sample body e.g wastewater, river etc be complied together with reference to the relevant

analytical procedure. This could be carried out within a short period as it simply involves collating the methods used within the laboratory.

C.A. No. 10 requires that a map of the sampling points in surface waters, used for the abstraction of drinking water, be included in the sampling programme. This could be collated in the short term using current mapping facilities within the Local Authority.

3.2.1 Quality Control

Table 3.3 outlines seven corrective actions which are required in order to bring LCC's quality control procedures, in relation to sampling, in line with the requirements of ISO 5667. C.A. No. 1 requires a procedure to be implemented to assess whether the filter type used to filter water/wastewater samples is a cause of contamination. Presently samples are not filtered on-site by LCC staff and therefore the requirement to filter samples will first have to be assessed as per ISO 5667-3:1994 (3.2.5).

C.A. No. 2 requires that a procedure be developed, documented and implemented to deal with situations where the time-of-travel exceeds the maximum recommended preservation time. This cannot be accurately documented until a comprehensive preservation programme is firstly implemented as per ISO 5667- 1, 3 and 14.

C.A. No. 3 requires that a procedure be developed, documented and implemented in order to verify that the number of samples received at the laboratory coincides with the number recorded on the field sheet. On arrival at the laboratory, samples are currently logged and marked by the sampler with a unique laboratory identification (ID) code. As it is simply a matter of documenting current procedure, the above could be dealt with in the short term at a low cost.

C.A. No. 4 requires that a method be developed, documented and implemented to ensure samples are preserved and stored in the correct containers as soon as possible after sampling. This may require using different storage containers and preservation techniques for each analyte of interest, which would significantly increase the sampling time.

Table 3.3: An assessment of the ability of Limerick County Council's Environmental Laboratory's to implement the proposed corrective actions to their quality control programme.

Note: More detailed information with regard to these corrective actions are contained in Appendix D

Corrective Action	Are the facilities/ resources available	Proposed time scale for implementation: Short/Medium/ Long term.	Cost of implementation: High/Medium/ Low	Staff training: on-site/off-site?	Comments
1. Implement a procedure for assessing whether the filter type used to filter samples is a cause of contamination. *(ISO 5667-3:1994 (3.2.5))*					- At present, samples are not filtered on-site. The need for this will have to be assessed as per ISO 5667-3:1994 (3.2.5)
2. Develop, document and implement a procedure for situations where the time-of - travel exceeds the maximum recommend preservation time. *(ISO 5667-3:1994 (5))*.	Yes	Medium	Low	On-site	- Correct preservation techniques are currently not in place. This will have to be addressed first, as per ISO 5667- 1, 3 and 14.
3. Develop, document and implement procedure for verifying that the number of samples received at the laboratory coincides with the number recorded on the field sheet. *(ISO 5667-3:1994 (6))*.	Yes	Short	Low	On-site	- Samples are currently logged and marked by the sampler, on arrival at the laboratory, with the appropriate laboratory identification code.
4. Develop, document and implement method to ensure samples are preserved and stored in the correct containers as soon as possible after sampling. *(ISO5667-5:1999 (7.2))*	Yes	Medium	Low	On-site	- Document the container type to be used for various parameters. - Document which samples are to be preserved and

Table 3.3(ctd.)

Corrective Action	Are the facilities/ resources available	Proposed time scale for implementation: Short/Medium/ Long term.	Cost of implementation: High/Medium/ Low	Staff training: on-site/off-site?	Comments
4. (ctd.)					- how this preservation is to be carried out. - Implement system of recording the type of container used together with preservation technique.
5. Develop, document and implement analytical quality control (QC) programme for periodically testing the sampling methods used. This should include the use of field blanks, samples with added determinands and/or duplicate samples. *(ISO 5667-6:1990 (5.5)), (ISO 5667-14:1998(E))*	Yes	Long term	High	On-site (may need some outside training)	- A lot of time is required to implement and carry out the QC programme fully - Document the various QC techniques and implement procedure for recording and interpreting the results obtained from the QC programme. - Determine when to accept/reject the results, by the application of statistical methods i.e. Shewart charts (Standard Methods Anon 1998) - Identify measures necessary when QC result has to be rejected based on

Table 3.3 (ctd.)

Corrective Action	Are the facilities/ resources available	Proposed time scale for implementation: Short/Medium/ Long term.	Cost of implementation: High/Medium/ Low	Staff training: on-site/off-site?	Comments
5. (ctd.)					- the above statistical method.
6. a) Develop, document and implement procedure for training sampling personnel with regard to correct sampling and on-site measurement techniques. *(ISO5667-5:1999 (9).* b) Document the sampling training procedure and develop detailed training records.*(ISO 5667-14:1998 (5.1))*, (ISO 5667-3:1994 (3.2.1))	Yes	Short	Low	On-site	- Identify the training required - Review the training process on a regular basis.
7. Identify, document and implement a procedure to assess the suitability of polyethylene containers for the collection of samples for trace metal analyses. *(ISO 5667-6:1990 (4.1))*	Yes	Short	Low	On-site	

C.A. No. 5 requires that an analytical quality control (QC) programme be developed, documented and implemented for periodically testing the sampling methods used. This should include the use of field blanks, samples with added determinands and/or duplicate samples. The QC programme must document how the results of the above are to be recorded and subsequently interpreted i.e. accepted/rejected. The method use to determine when to accept/reject results must be clearly stated. This is normally done by statistical methods e.g. Shewart charts (Anon 1998). Shewart charts set control and warning limits. If the result obtained is outside the control limit the result is rejected. If the result is outside the warning limit the result is rejected if the previous two results are also outside the warning limit but accepted if the previous two results are within the warning limit. The measures necessary when a QC result must be rejected should be clearly documented. The complete implementation of this measure could take a long time and incur a high cost owing to the increased workload on both the sampler and the analyst.

C.A. No. 6 requires that a procedure is developed, documented and implemented for training sampling personnel with regard to correct sampling and on-site measurement techniques. Detailed training records would also have to be maintained. As the laboratory currently has a non-documented training procedure it is simply a matter of collating and documenting what is currently being carried out. This can achieved in the short term at a low cost.

C.A. No. 7 requires that a procedure is identified, documented and implemented to assess the suitability of polyethylene containers for the collection of samples for trace metal analyses. ISO 5667 (Part 6) states that polyethylene containers may not be suitable for collecting samples undergoing some trace metal analyses since they may be a source of contamination of some trace metals e.g. mercury. An assessment of the suitability of polyethylene containers for trace metal analysis would involve carrying out a series of metal analyses on known samples stored in polyethylene containers. This could be carried out in the short term using existing resources.

3.2.3 Preservation.

Table 3.4 outlines four corrective actions which are required in order to bring Limerick County Council's sample preservation procedures in line with the requirements of ISO 5667.

Table 3.4 An assessment of the ability of Limerick County Council's Environmental Laboratory's to implement the proposed corrective actions to their preservation programme.

Note: More detailed information with regard to these corrective actions are contained in Appendix D

Corrective Action (Standard Ref.)	**Are the facilities/ resources available**	**Proposed time scale for implementation: Short/Medium/ Long term.**	**Cost of implementation: High/ Medium/ Low**	**Staff training: on-site/off-site?**	**Comments**
1. a) Identify and document the preservation method(s) required for various sample types b) Implement preservation methods, where required. c) Develop method of recording when samples are preserved. *(ISO 5667-1:1980 Section 1 (3), (5.3)), (ISO 5667-3:1994 (3.1)), (ISO 5667-14:1998 (6))*	Yes	Medium	Low	On-site	- The implementation of comprehensive preservation techniques will increase the sampler's workload. - Refer to ISO 5667 and Standard Methods (Anon., 1998) for reference to the correct preservation techniques for the various parameters.
2. Ascertain the need to preserve samples during the collection of composite samples. If necessary, implement system of sample preservation. *(ISO 5667-2:1991 (4.6)), (ISO 5667-10:1992 (5.4))*	No	Long	Medium	On-site	- The laboratory is presently operating at maximum capacity therefore the resources e.g. staff/ time are not currently available - Develop method to determine whether the parameters of interest vary significantly during the composite sampling

Table 3.4 (ctd.)

Corrective Action (Standard Ref.)	Are the facilities/ resources available	Proposed time scale for implementation: Short/Medium/ Long term.	Cost of implementation: High/ Medium/ Low	Staff training: on-site/off-site?	Comments
2. (ctd.)					- period, when preservation is not used. - Determine if there is a statistical difference between the samples with and without preservation. Implement appropriate preservation method(s).
3. Document and implement method for ensuring that the preservative used does not result in dilution of the analyte or interfere with the subsequent analysis thereby influencing the final result. *(ISO 5667-3:1994 (3.2.6)), (ISO 5667-14:1998 (6)).*	Yes	Medium	Medium	On-site	
4. The efficiency of the preservation process depends on the constituents which have to be analysed, their levels and on the nature of the sample. Therefore develop, document and implement a procedure to verify whether or not the preservation suggestions in ISO 5667-3:1994 (Table 1-5) are suitable for the sample with which it is concerned. *(ISO 5667-3:1994 (3.3))*	Yes	Long	Medium	On-site	- The laboratory is presently operating at maximum capacity therefore the resources e.g. staff/ time are not currently available

C.A. No. 1 requires that the preservation method(s) for the various sample types be identified, documented and implemented. The preservation method required shall be identified from either Standard Methods (Anon, 1998) and/or ISO 5667 Part 3. All preservation carried out should be accurately recorded in order that the analyst is aware of the preservative used. This could take time to implement fully as the sampler's workload is increased, particularly in relation to the increased number of samples to be taken and associated preparatory work.

C.A. No. 2 relates to ascertaining the need to preserve samples during the collection of composite samples and if required implementing an appropriate preservation system. To determine whether the above is required would involve taking a number of samples with and without preservatives and determining statistically if there is a difference. The laboratory currently does not have the resources in terms of staff/ time to carry this out and hence the time scale for implementation would be long term.

C.A. No. 3 requires that a method be documented and implemented for ensuring that the preservative used does not result in dilution of the analyte or interfere with the subsequent analysis, thereby influencing the final result. This would have to be considered in conjunction with C.A. No. 1 as the preservation methods are not yet documented or implemented. This C.A. could be implemented in the medium term.

C.A. No. 4 requires that a procedure be developed, documented and implemented to verify whether or not the preservation suggestions in ISO 5667 are suitable for the sample for which it is to be used. As the efficiency of the preservation process depends on the constituents to be analysed, their levels and on the nature of the sample, it shall be necessary to examine the preservation suggestions in Table 1 to 5 of ISO 5667-3:1994 for each type of sample. This would involve a significant amount of work and could only be implemented in the long term, provided there are adequate resources.

3.2.4 Drinking water sampling.

Table 3.5 outlines eleven C.A.s which are required in order to bring LCC's drinking water sampling procedures in line with the requirements of ISO 5667 namely Parts 1, 2, 3 and 5.

Table 3.5: An assessment of the ability of Limerick County Council's Environmental Laboratory to implement the proposed corrective actions in relation to drinking water sampling.

Note: More detailed information with regard to these corrective actions are contained in Appendix D

Corrective Action (Standard Ref.)	**Are the facilities/ resources available**	**Proposed time scale for implementation: Short/Medium/ Long term**	**Cost of implementation: High/ Medium/ Low**	**Staff training: on-site/ off-site?**	**Comments**
1. (a) Map drinking water locations and predetermined sampling points for the various water supplies. *(ISO 5667-1:1980 Section 1 (3), Section 2 (8.2)),(ISO5667-5:1999 (4.1.4)).* (b) Amend sampling programme to include details on how the various drinking water sampling points are selected. *(ISO 5667-1:1980 Section 2 (9.8.1))*	Yes	Short	Low	N/A	- Currently done as part of EC (Drinking Water) Regulations, 2000 - Slow process as there are currently 42 Public Water Supplies and 84 Group Water Supplies in Co. Limerick.
2. Amend SOP 6 to include details regarding; a) selection of drinking water sampling taps, stating that "anti-splash or similar devices should be removed before sampling and that mixer taps are not recommended for sampling". *(ISO 5667-1:1980 Section 2 (9.8.1), (9.8.3)), (ISO5667-5:1999 (4.1.5).* b) sampling in areas of low flow and avoiding disturbance of sedimentary material. *(ISO5667-5:1999 (4.1.4))*		Short	Low	On-site	

Table 3.5 (ctd.)

Corrective Action (Standard Ref.)	Are the facilities/ resources available	Proposed time scale for implementation: Short/Medium/ Long term.	Cost of implementation: High/ Medium/ Low	Staff training: on-site/ off-site?	Comments
2 (ctd.) c) flushing for extended periods prior to sampling from stagnant systems. *(ISO5667-5:1999 (5.3)).* d) the exact type of sampling container that is to be used for each parameter. *(ISO 5667-2:1991 (6.1.1)), (ISO 5667-3:1994 (3.2.2), (3.2.3.2), (3.2.3.3))* e) cleaning and preparation of the sampling containers used for each parameter. *(ISO 5667-3:1994 (3.2.3.1) (3.2.3.2) (3.2.3.3))* f) calibration/checking of field meters prior to sampling. *(ISO 5667-14:1998 (5.1))* g) volume of sample that is to be collected for the various parameters. *(ISO 5667-2:1991 (6.3.1)) (ISO5667-5:1999 (7.1)).* h) sampling large volumes e.g. for *Cryptosporidium* analysis. *(ISO 5667-2:1991(4.7))* i) minimum sample bottle capacity of 300ml *(ISO5667-5:1999 (5.3))* j) filling and sealing of sample container *(ISO 5667-3:1994 (3.2.1), (3.2.2)), (ISO5667-5:1999 (5.1), (5.3), (7.2))*	Yes	Short	Low	On-site	

Table 3.5 (ctd.)

Corrective Action (Standard Ref.)	Are the facilities/ resources available	Proposed time scale for implementation: Short/Medium/ Long term.	Cost of implementation: High/ Medium/ Low	Staff training: on-site/ off-site?	Comments
2 (ctd.) k) parameters, which are measured on site. *(ISO 5667-2:1991 (4.1)), (ISO 5667-3:1994 (3.1)), (ISO 5667-14:1998 (6)) (ISO5667-5:1999 (4.1)).* l) the taking, preservation and analyses of blank samples. *(ISO 5667-3:1994 (3.2.2)), (ISO5667-5:1999 (9)).* m) the requirement to complete the field sheet *(ISO 5667-2:1991 (7.1)), (ISO 5667-3:1994 (4),(ISO5667-5:199 (8))* n) sealing samples and transportation of samples to laboratory *(ISO 5667-2:1991 (6.2.4)), (ISO 5667-3:1994 (3.1), (3.2.4), (5)), (ISO 5667-14:1998 (5.1),(6)), (ISO5667-5:1999 (7.2))* o) prompt storage of samples in refrigerator in cases where immediate analyses is not being carried out *(ISO 5667-3:1994 (6)).* p) safety precautions required with reference to the Safety Statement for the Environment Section *(ISO 5667-1:1980 Section 2 (7.1))*, (ISO5667-5:1999 (6))					
3. Assess the need to use a flexible inert tube, to deliver liquid to the bottom of the sampling bottle, when sampling from a tap or pump	Yes	Medium	Low	On-site	- An accurate assessment would have to be based on a large number of samples.

Table 3.5 (ctd.)

Corrective Action (Standard Ref.)	Are the facilities/ resources available	Proposed time scale for implementation: Short/Medium/ Long term.	Cost of implementation: High/ Medium/ Low	Staff training: on-site/ off-site?	Comments
3. (ctd.) outlet. *(ISO 5667-2:1991 (6.7))*					- Must address the possibility of cross contamination by repeat use of the tube.
4. Asses need to disinfect using a chlorine solution versus alcohol (which is currently being used). Amend SOP if necessary. *(ISO5667-5:1999 (4.1.5))*	Yes	Medium	Low	On-site	- Refer to Standard Methods and other relevant published documentation.
5. Develop, document and implement method of on-site analysis of odour and taste. *(ISO5667-5:1999 (4.1))*	Yes	Short	Low	On-site	- May be a safety risk in tasting samples on-site, as the quality of water is unknown.
6. Develop, document and implement procedure for: a) sampling from water treatment plants. *(ISO5667-5:1999 (4.1.2))*; reservoirs *(ISO 5667-1:1980 Section 2 (9.5), (9.8.2))*, *(ISO5667-5:1999 (4.1.1))* and hydrants. *(ISO5667-5:1999 (4.1.4))* b) assessing efficiency of disinfection plant. *(ISO5667-5:1999 (4.1.3))* c) investigating dissolution of materials from	Yes	Short	Low	On-site	- Necessary for compliance with EC (Drinking Water) Regulations 2000.

Table 3.5 (ctd.)

Corrective Action (Standard Ref.)	Are the facilities/ resources available	Proposed time scale for implementation: Short/Medium/ Long term	Cost of implementation: High/ Medium/ Low	Staff training: on-site/ off-site?	Comments
6. (ctd.) from pipework or growth of microorganisms within pipework. *(ISO5667-5:1999 (4.1.4), (4.1.5))* d) sampling during abnormal conditions i.e. drinking water contamination, and the subsequent reporting of these results. *(ISO 5667-1:1980 Section 3 (17)), (ISO 5667-14:1998 (8)).* e) selection and purchase of sampling containers (for microbiolgical, physical and chemical analysis). Include details on cap types to be used for the various parameters. *(ISO 5667-2:1991 (6.1.1), (6.2.1), (6.2.3), (6.2.4), (6.5))*					
7. Develop, document and implement SOP detailing how bottles are to be sterilized and a method to assess if the sampling container materials used produce or release chemicals. *(ISO5667-5:1999 (5.3))*	Yes	Short	Low	On-site	- Blank /known samples are run with each batch of microbiological samples in the same type of sampling container. If the sample container were releasing chemicals this would affect microbiological count.
8. Identify and document samples (a) with which contact with the air must be avoided and	Yes	Short	Low	On-site	

Table 3.5 (ctd.)

Corrective Action (Standard Ref.)	Are the facilities/ resources available	Proposed time scale for implementation: Short/Medium/ Long term	Cost of implementation: High/ Medium/ Low	Staff training: on-site/ off-site?	Comments
8. (ctd.) (b) that require vigorous mixing before taking portions for analyses. Document procedure for dealing with both types of samples. *(ISO5667-5:1999 (7.2))*					
9. Identify samples that require to be filtered/ centrifuged at the time of taking the sample or immediately afterwards. Implement procedure for filtration/ centrifuging of samples. *(ISO 5667-3:1994 (3.2.5)), (ISO5667-5:1999 (7.2))*	Yes	Medium	Medium	On-site	- Document samples to be filtered/ centrifuged and method for same - Document which samples are filtered/centrifuged and how it was carried out
10. Amend SOP No. 43 to include details on the max. length of sample storage for the various analyses, making reference to guidelines in Standard Methods (Anon. 20th Ed.). *(ISO 5667-3:1994 (3.1))*	Yes	Short	Low	On-site	
11. Amend field sheet to include details on weather conditions, unusual observations and information on samples taken for a specific reason. *(ISO 5667-1:1980 Section 2 (8.13)), (ISO 5667-2:1991 (7.2), ISO 5667-3:1994 (4)), (ISO5667-5:1999 (8))*	Yes	Short	Low	On-site	

C.A. No. 1 requires the mapping of drinking water sampling locations for the various water supplies within the county. Details should be included in the sampling programme as to how the various drinking water sampling points were selected. Mapping of the various water sampling locations is currently being undertaken at LCC in order to comply with the EPA implementation handbook on the EC (Drinking Water) Regulations, 2000. This is a slow process as there are currently 42 Public Water Supplies and 84 Group Water Supplies in Co. Limerick.

At present, LCC's drinking water sampling SOP (SOP 6) does not contain sufficient detail to meet the requirements of ISO 5667. C.A. No. 2 requires the inclusion, in SOP 6, of specific details on correct sampling equipment, sampling procedures, *in-situ* monitoring, sample preservation, completion of field report forms and sample storage and transportation.

In relation to sampling equipment, details must be included on the type of container to be used for various samples and the type of treatment required of these containers prior to sampling. This information is available in both ISO 5667 Part 3 and Standard Methods (Anon., 1998) and therefore can be readily collated. Detailed instructions must also be included in SOP 6 in relation to correct procedures to be followed prior to taking a drinking water sample e.g. adequate flushing of stagnant systems, avoidance of mixer taps, removal of anti-splash devices. These procedures are currently being used by LCC environmental samplers and therefore merely require the incorporation of relevant details into the SOP. Details on the actual sampling process itself (e.g. sample volume to be taken for various parameters), preservation of samples (if required) and sealing of sample container must also be included in SOP 6 in order to fulfil ISO 5667 requirements.

Current practice at LCC is to take a 250ml sample for microbiological analyses and a 500ml sample for all other analyses. Sodium thiosulphate is added to microbiological sample containers prior to sterilisation in order to neutralise any effect of chlorine during transit, other samples are not preserved. The samples requiring preservation need to be identified and an appropriate method(s) implemented. As information with regard to the above is readily available, the above can be documented in the short term. The implementation of a comprehensive preservation programme may take somewhat longer due to the increased workload on the sampler.

Certain unstable parameters must be measured *in-situ* when monitoring drinking water quality otherwise the result obtained will not be representative. Currently, LCC samplers monitor pH, temperature, conductivity and total and free chlorine at the sampling site. Some of these parameters are omitted in the current SOP and therefore this must be amended. This can easily be done in the short term. Details must also be included in SOP No. 6 on the way in which field meters are checked/calibrated prior to use. LCC environmental samplers transport all drinking water samples from the sampling location to the laboratory in a cooler box. On arrival to the laboratory, samples not undergoing immediate analysis are stored in a refrigerator. SOP No. 6 needs to be amended to incorporate these details.

C.A. No. 3 deals with assessing the need to use a flexible inert tube, to deliver liquid to the bottom of the sampling bottle, when sampling from a tap or pump outlet. ISO 5667 Part 2 recommends this is done to ensure that liquid is displaced from the bottom of the bottle thereby minimising aeration. In order to assess if the above is required a large number of samples would have to be analysed from samples taken with and without the use of tubing. The possibility of cross contamination by repeat use of the tube would also have to be addressed. If flexible inert tubes were to be used the cost incurred would be minimal however, the sampling rate would be decreased.

ISO 5667 Part 5 states that plastic taps should be disinfected using an available chlorine solution. LCC sampling staff currently use 90% isopropanol alcohol to sterilise taps. C.A. No. 4 deals with the need to assess the current practice of disinfection using alcohol versus the requirement of ISO 5667 to disinfect using a chlorine solution. Standard methods and other relevant published documentation would have to be consulted in order to determine the above.

C.A. No. 5 requires that a method be documented and implemented for the on-site analysis of odour and taste. A safety risk may be posed in tasting samples on-site, as the quality is unknown at this stage. This would have to be taken into account prior to documenting or implementing a procedure.

C.A. No. 6 requires that procedures be documented and implemented for a number of different situations. These include sampling from water treatment plants, reservoirs, hydrants and also sampling during abnormal conditions. Procedures must also be developed , documented and implemented to investigate the dissolution of materials from pipework and also the growth of

materials within the pipework. These requirements are also necessary for compliance with the EC (Drinking Water) Regulations 2000 and therefore will most likely be implemented in the short term.

C.A. No. 7 requires that a SOP be documented and implemented to include details on how bottles are to be sterilized. The SOP should include details on how the sampling container material used is assessed in order to determine whether it produces or releases chemicals. Current practice at LCC is to run blank and known samples with each batch of microbiological samples in the same type of sampling container as the sample in order to determine whether materials are released from the container. As this procedure is currently in place within the laboratory, the SOP can be documented in the short term and at no additional cost to the laboratory.

C.A. No. 8 requires the identification and documentation of samples types for which contact with air must be avoided and those that require vigorous mixing before taking portions for analyses. If contact of the sample with air has to be avoided the sample container should be filled completely and then immediately stoppered. If samples require vigorous mixing before taking portions for analyses, the sample container should not be filled completely. If air has to be excluded a few pieces of clean, sterile, inert solids should be placed in the sampling container. The above types of samples should be identified and an appropriate procedure documented and implemented. This corrective action can be implemented in the short term at a relatively low cost as these types of samples can be readily identified and an appropriate procedure implemented.

C.A. No. 9 requires the identification of drinking water samples that need to be filtered/centrifuged at the time of taking the sample or immediately afterwards. A procedure for the filtration/ centrifuging of these samples will then have to be implemented and details on how the specific samples are filtered/centrifuged recorded. Drinking water samples are not currently filtered/centrifuged at the time of sampling by LCC staff. This corrective action could take some time to implement and incur a medium cost in purchasing the required consumables.

SOP No. 43 deals with the handling of test samples on arrival to the laboratory and states that samples are to be stored in the appropriate fridge until analysis is complete. C.A. No. 10 requires that SOP No. 43 is amended to include details on the maximum time allowable for sample

storage for each of the parameters of interest. Details regarding maximum sample storage can be obtained from Standard Methods (Anon. 1998).

C.A. No. 11 requires that the existing field report sheet be amended to include details on the weather conditions and any unusual observations noted at the time of sampling. In addition the field report sheet should be amended to provide information on samples taken for a specific reason (e.g. determination of compliance of drinking water with specific Regulations or contamination investigation). This corrective action can be implemented in the short term at a relatively low cost.

3.2.5 River water sampling.

Table 3.6 outlines thirteen corrective actions necessary to bring LCC's river water sampling procedures in line with the requirements of ISO 5667, namely Parts 1, 2, 3, 6 and 14. C.A. No. 1 requires that the river sampling locations be reassessed. This should be done in order to ensure the locations selected take into account areas where there are important river uses, where marked quality changes are likely to occur and where flow stations are located. River quality is currently assessed based on median results over a calendar year. As the sampling programme for the current year has already been initiated this reassessment cannot be carried out until the beginning of the next calendar year. When sites are selected, it should be ensured that they are accessible all year round. The sampling programme would have to be amended to take into account any new sampling locations selected.

C.A. No. 2 requires that an appropriate method be identified to assess stratification at each river sampling location. As in-house expertise is not available to assess stratification, a high cost would be incurred in engaging the services of external consultant, particularly as there are a large number of sampling sites to be assessed. This assessment could only be carried out in the long-term when adequate funding is secured.

Table 3.6: An assessment of the ability of Limerick County Council's Environmental Laboratory to implement the proposed corrective actions in relation to river water sampling.

Note: More detailed information with regard to these corrective actions are contained in Appendix D

Corrective Action (Standard Ref.)	**Are the facilities/ resources available**	**Proposed time scale for implementation Short/Medium/ Long term**	**Cost of implementation High/ Medium/ Low**	**Staff training: on-site/off-site?**	**Comments**
1. Reassess river sampling locations to: a) take flow stations into account. *(ISO 5667-1:1980 Section 2 (8.1))* b) ensure they provide representative samples by taking into account locations where marked quality changes are likely to occur or locations where there are important river uses. *(ISO 5667-1:1980 Section 2 (9.3.2))*	Yes	Long.	Low	N/A	- Time scale is 'Long' because the river sampling programme for this year has already been initiated - Sampling points must be accessible all year round. - Ensure sampling personnel can carry out sampling using existing resources. - - Amend sampling programmes accordingly.
2. Identify appropriate method to assess each river sampling location for stratification and take appropriate measures following the results of this assessment. *(ISO 5667-1:1980 Section 2 (9.3.1))*	No	Long	High	Off-site	- In-house expertise not available to assess stratification - May be considered under the Water Framework Directive (WFD)
3. Identify and document an appropriate method to assess the effects of a discharge on a river by selecting representative upstream and downstream locations. (Note: the discharge	No	Long	High	Off-site	- Identify and document how the relevant points will be selected.

Table 3.6 (ctd.)

Corrective Action (Standard Ref.)	Are the facilities/ resources available	Proposed time scale for implementation: Short/Medium/ Long term	Cost of implementation High/ Medium/ Low	Staff training: on-site/off-site?	Comments
3. (ctd.) may be a wastewater discharge or an adjoining tributary). *(ISO 5667-1:1980 Section 2 (9.3.2)), (ISO 5667-6:1990 (5.1.1.1)).*	No	Long	High	Off-site	- May be considered under the WFD
4. Amend SOPs No. 8 and 47 to include details of the: a) safety precautions necessary when sampling from rivers, with reference to 'Safety Statement for the Environment Section'. *(ISO 5667-1:1980 Section 2 (7.1)), (ISO 5667-6:1990 (6)).* b) measures required to ensure the sampling location is safe prior to commencing sampling. *(ISO 5667-1:1980 Section 2 (7.4))* c) calibration/ checking of field meters prior to sampling. *(ISO 5667-14:1998 (5.1))* d) sampling equipment to be used *(ISO 5667-6:1990 (4.2)).* e) type of sampling container that is to be used for each parameter. *(ISO 5667-2:1991 (6.1.1)), (ISO 5667-3:1994 (3.2.2), (3.2.3.2), (3.2.3.3), (ISO 5667-6:1990 (4.1)).* f) cleaning and preparation of the sampling containers used for each parameter.	Yes	Short	Low	On-site	

Table 3.6 (ctd.)

Corrective Action (Standard Ref.)	Are the facilities/ resources available	Proposed time scale for implementation: Short/Medium/ Long term	Cost of implementation High/ Medium/ Low	Staff training: on-site/off-site?	Comments
4. (ctd.) *(ISO 5667-3:1994 (3.2.3.1) (3.2.3.2) (3.2.3.3))* g) when the sampling of surface films is required and when it should be avoided. *(ISO 5667-6:1990 (5.3.1)).* h) when sample containers can/cannot be pre-rinsed. *(ISO 5667-6:1990 (5.4)).* i) volume of sample to be collected for various parameters *(ISO 5667-2:1991 (6.3.1))* j) filling and sealing of sample container(s) *(ISO 5667-3:1994 (3.2.1), (3.2.2)),* k) parameters which are to be measured and recorded on site. *(ISO 5667-2:1991 (4.1), ISO 5667-3:1994 (3.1), ISO 5667-6:1990 (5.4), ISO 5667-14:1998 (6)).* l) taking, preservation and analyses of blank samples.*(ISO 5667-3:1994 (3.2.2).* m) labelling of sampling bottles and completion of the field sheet. *(ISO 5667-2:1991 (7.1)), (ISO 5667-3:1994 (4)), (ISO 5667-6:1990 (7)).* n) sample transportation and the sealing of sampling containers. *(ISO 5667-2:1991 (6.2.4)), (ISO 5667-3:1994 (3.1), (3.2.4), (5)), (ISO 5667-6:1990 (5.4)),*					

Table 3.6 (ctd.)

Corrective Action (Standard Ref.)	Are the facilities/ resources available	Proposed time scale for implementation: Short/Medium/ Long term	Cost of implementation High/ Medium/ Low	Staff training: on-site/off-site?	Comments
4. (ctd.) *(ISO 5667-14:1998 (5.1),(6))* o) storage of samples in a refrigerator on arrival to the laboratory, where immediate analyses is not being carried out *(ISO 5667-3:1994 (6)).*					
5. Amend SOP No. 47 to include details on: a) the type of sampling containers to be used for microbiological samples and preparation of same b) how microbiological samples are to be taken. *(ISO 5667-6:1990 (4.2), (5.3.2))*	Yes	Short	Low	On-site	
6. Develop appropriate field report sheet for sampling rivers and surface water used for abstraction. *ISO 5667-1:1980 Section 2 (8.13)), (ISO 5667-2:1991 (7.2)), (ISO 5667-3:1994 (4)), (ISO 5667-6:1990 (7)).*	Yes	Short	Low	On-site	
7. Identify the samples which require to be filtered/centrifuged at the time of taking the sample or immediately afterwards. Implement a procedure for the filtration/ centrifuging of these samples. *(ISO 5667-3:1994 (3.2.5)), (ISO5667-6:1990 (5.4))*	Yes	Medium	Medium	On-site	- Document the samples which require to be filtered/ centrifuged and the appropriate method to be used. - Purchase required consumables.

Table 3.6 (ctd.)

Corrective Action (Standard Ref.)	Are the facilities/ resources available	Proposed time scale for implementation: Short/Medium/ Long term.	Cost of implementation: High/ Medium/ Low	Staff training: on-site/off-site?	Comments
7. (ctd.)					- Document, which samples are filtered/centrifuged and how it was carried out
8. Document and implement procedures for the selection of effective samplers *(ISO 5667-2:1991 (6.3.1))* and containers. Include details on the cap types to be used for the various parameters. *(ISO 5667-2:1991 (6.1.1), (6.2.1), (6.2.3), (6.2.4), (6.5)).*	Yes	Short	Low	N/A	- Ensure personnel responsible for purchasing laboratory goods are aware of the sampling container and sampler types to be purchased.
9. Identify abnormal sampling situations (e.g. flood conditions in a river or times of an algal bloom). Prepare SOP detailing the procedure for sampling during these conditions and the subsequent reporting of these results. (ISO 5667-1:1980 Section 3 (17), ISO 5667-14:1998 (8)).	Yes	Short	Medium	On-site	- Identify and document possible abnormal conditions and the sampling requirements for each. - Purchase appropriate sampling containers and preservatives.
10. Assess whether an accurate determination of dissolved oxygen (D.O.) is required i.e. a measurement of D.O. taken directly in the water-body as opposed to the current practice of measuring D.O. in the sampling bucket. *(ISO 5667-2:1991 (6.7))*	Yes	Short	Unknown	On-site	- If D.O readings must be taken in the waterbody then new DO probes will have to be purchased, which shall incur a high cost. - Sampling time will be increased as probes have to be extended from bridge.

Table 3.6 (ctd.)

Corrective Action (Standard Ref.)	Are the facilities/ resources available	Proposed time scale for implementation: Short/Medium/ Long term	Cost of implementation: High/ Medium/ Low	Staff training: on-site/off-site?	Comments
11. Assess the need to ascertain the time-of-travel of pollutants in rivers. If required identify, document and implement method for assessing the time-of-travel of pollutants in rivers. (*ISO 5667-6:1990 (5.1.1.2)*)	No	Long	High	Off-site	- External resources required, as in-house expertise not available. - May be considered under the WFD
12. Determine the possibility of a non-homogeneous distribution of determinands of interest at the various sampling sites. Identify, document and implement method for assessing same *ISO 5667-6:1990 (5.1.2)*	No.	Long	High	Off-site	- External resources required, as in-house expertise not available. - May be considered under the WFD
13. Amend SOP No. 43 to include details on the max. length of sample storage for the various analyses *(ISO 5667-3:1994 (3.1))*	Yes	Short	Low	On-site	

C.A. No. 3 requires that an appropriate method be identified and documented to assess the effects of a discharge (wastewater discharge or an adjoining tributary) on a river by selecting representative upstream and downstream locations. The distance over which the discharges mixes in the vertical, lateral and longitudinal dimensions need to be considered in the selection of sampling sites. Therefore the physical characteristics, water velocity and physico-chemical parameters of the water body need to be taken into account. In-house expertise is not available to assess all of the above accurately thus a high cost would be incurred in employing external consultants. This could only be carried out in the long-term when adequate funding is secured.

C.A. No. 4 deals with the amendments which are required to the current laboratory river sampling SOPs (SOP No. 8 and 47) to meet the requirements of ISO 5667. A significant number of these amendments involve the documentation of procedures which are currently being carried out. For example, the calibration and checking of field meters prior to sampling, the monitoring of parameters *in-situ*, the recording of monitoring results and sample details on a field sheet and the transportation of samples to the laboratory in cooler boxes. Other amendments involve the documentation and implementation of measures which are not currently being carried out correctly. For example, documenting the correct type of sampling container(s) to be used, the preparation and cleaning of sampling containers, the volume of sample that is to be collected for the various parameters, the filling and sealing of sample containers, details on when the sampling of surface films is required and when it should be avoided and the safety precautions required when sampling. As this information is readily available, both in ISO 5667 and Standard Methods (Anon., 1998) this corrective action can be implemented in the short term at a low cost to the laboratory.

C.A. No. 5 deals with the amendments that are required to SOP No.47 (sampling of surface water for abstraction of waters intended for human consumption) with regard to microbiological sampling. The amendments required include documentation of the type of sample container to be used and preparation of same and also details on how microbiological samples are to be taken. As this corrective action involves the amendment of an existing SOP to include procedures which are currently being carried out it can be implemented in the short term at a low cost to the laboratory.

C.A. No. 6 requires that an appropriate field report sheet be developed as per ISO 5667 for sampling rivers and also for sampling surface waters used for the abstraction of drinking water.

This involves the amendment of the current river sampling field report sheet and the development of an appropriate field report sheet for sampling of surface water used for abstraction of drinking water. This corrective action can be implemented in the short term at a low cost to the laboratory.

C.A. No. 7 deals with the requirement to filter/centrifuge samples at the time of taking the sample or immediately afterwards. This C.A. has been dealt with previously in Section 3.2.4.

C.A. No. 8 requires that procedures be documented and implemented with regard to the selection of effective samplers and sampling containers. Laboratory personnel responsible for purchasing laboratory goods should be aware of the sampler and container types to be purchased. Firstly, this involves identifying the correct type of samplers and sampling containers that have to be purchased and then documenting the findings. As this information is readily available, this corrective action can be implemented in the short term at a low cost to the laboratory.

C.A. No. 9 requires that abnormal sampling situations are identified e.g. flood conditions in a river or times of an algal bloom. Once identified, an SOP detailing the procedure for sampling during these conditions shall have to be documented. This would be best documented in a separate SOP with a reference made to it in SOP No. 8 and 47. The SOP must include details regarding the reporting of results obtained during abnormal sampling conditions. Abnormal sampling situations can be identified and an appropriate SOP documented in the short term however, the implementation time of this C.A will be dependant on the sampling equipment and the analysis required. If the facilities are available in-house the procedures can be documented in the short term.

C.A. No. 10 deals with determining whether an accurate determination of the D.O. level in a river is required i.e. a measurement of D.O. taken directly in the water-body as opposed to the current practice of measuring D.O. in the sampling bucket. In most situations, the accuracy of the D.O. measurement required will be stated in relevant legislation. If the precision required is high then an accurate determination of D.O. will have to be carried out unless it can be proved that the current practice meets the required precision. This would involve measuring D.O. in a large number of samples, both in-situ and in the sampling bucket and carrying out subsequent statistical analysis. If required, new D.O. probes, with extra long cables to extend the D.O. probe from bridge into the flowing water, would have to be purchased thereby incurring a

high cost on the laboratory. The rate of sampling would also be slowed down as it would take longer to measure the D.O. directly in the water-body as the D.O. probe particularly when extending the D.O. probe from large bridges

The time-of-travel of pollutants will primarily depend on the type of pollutant, the characteristics of the water body and the mixing conditions. Determining the time-of-travel of pollutants involves the use of tracers or measurement of flow with knowledge of cross-sectional areas. C.A. No. 11 deals with the need to assess whether the time-of-travel of pollutants in rivers needs to be ascertained. This may be necessary where certain constituents or pollutants are being traced through a system or where the rate of change of unstable constituents is being investigated (e.g. in the self-purification of a water body the time-of-travel can provide information on kinetic rate co-efficients). As in-house expertise is not available to determine the above, external consultants would be required thereby incurring a high cost.

C.A. No. 12 deals with the need to determine the possibility of a non-homogeneous distribution of the determinands of interest at the various sampling sites. As in-house expertise are not available to determine this, external consultants would be required thereby incurring a high cost particularly as each sampling site shall have to be assessed. If a non-homogeneous distribution of the determinands of interest is identified a method shall have to be developed and documented to take this into account. Again, external consultants would be required to develop the most appropriate method. Bearing these factors in mind, this corrective action could only be implemented in the long term.

C.A. No. 13 requires that SOP No. 43 is amended to include details on the maximum time allowable for sample storage for each of the parameters of interest. Details regarding maximum sample storage can be obtained from Standard Methods (Anon. 1998).

3.2.6 Wastewater sampling

Table 3.7 outlines twenty-two corrective actions necessary in order to bring LCC's wastewater sampling procedures in line with the requirements of ISO 5667, namely Parts 1, 2, 3, 10 and 14.

Table 3.7: An assessment of the ability of Limerick County Council's Environmental Laboratory to implement the proposed corrective actions in relation to wastewater sampling.

Corrective Action (Standard Ref.)	Are the facilities/ resources available	Proposed time scale for implementation: Short/Medium/ Long term.	Cost of implementation: High/Medium/ Low	Staff training on-site/ off-site?	Comments
1. a) Review wastewater sampling locations to ensure sufficient turbulence is present at all sites. *(ISO 5667-1:1980 Section 2 (8.9)), (ISO 5667-10:1992 (5.1.2))* b) Identify sampling points where incomplete mixing of wastewaters exists due to low flow rates or mixing of wastewaters from different sources. *(ISO 5667-1:1980 Section 2 (12.1.1))*	**No**	Long	High	N/A	- The implementation of this Corrective Action would require external expertise to determine whether there is sufficient turbulence at the various sampling locations.
2. Identify, document and implement measures to overcome or minimize heterogeneity caused by suspended solids and/or thermal stratification in wastewater streams. *(ISO 5667-10:1992 (5.1.3))*	No	Long	High	N/A	- The implementation of this CA would require external expertise to identify, document and implement the appropriate measures.
3. Identify and document when and how emulsified and floating material are to be sampled. *(ISO 5667-10:1992 (5.1.4), ISO 5667-1:1980 Section 2 (12.1.1))*	Yes	Short	Low	On-site	- Purchase the required sampling equipment and containers, if required.
4. Identify and document exact sampling points used;					

Table 3.7 (ctd.)

Corrective Action (Standard Ref.)	Are the facilities/ resources available	Proposed time scale for implementation: Short/Medium/ Long term.	Cost of implementation: High/Medium/ Low	Staff training on-site/ off-site?	Comments
4. (ctd.) a) for influent and effluent at all wastewater plants routinely sampled. *(ISO 5667-10:1992 (5.1.3)), (ISO 5667-1:1980 Section 2 (12.1.1))* b) to extract samples from aeration tanks in a wastewater treatment plant. *(ISO 5667-1:1980 Section 3 (19.2))*	Yes	Short	Low	On-site	- Train sampling personnel to ensure samples are always taken at the exact same location.
5. Develop, document and implement system for frequently reviewing the plant's sampling locations. *(ISO 5667-10:1992 (5.1.3))*	Yes	Short	Low	On-site	- Document the reviews carried out on the plant's sampling locations
6. Prepare SOP for sampling of storm sewage and surface run-off taking into account the guidelines provided in *ISO 5667-1:1980 Section 2 (13).*	Yes	Short	Low	On-site	
7. Amend SOPs 10 & 11 to include details on: a) Calibration/checking of field meters prior to sampling. *(ISO 5667-14:1998 (5.1))* b) Cleaning/preparation of the sampling containers and equipment. *(ISO 5667-3:1994 (3.2.3.1) (3.2.3.2) (3.2.3.3), ISO 5667-10:1992 (4.2.1))* c) sample container type to be used for various analyses. *(ISO 5667-2:1991*					

Table 3.7 (ctd.)

Corrective Action (Standard Ref.)	Are the facilities/ resources available	Proposed time scale for implementation: Short/Medium/ Long term	Cost of implementation: High/Medium/ Low	Staff training on-site/ off-site?	Comments
7. (ctd.) *(6.1.1)), (ISO 5667-3:1994 (3.2.2), (3.2.3.2), (3.2.3.3)), (ISO 5667-10:1992 (4.1))* d) taking of samples and filling of sampling containers *(ISO 5667-3:1994 (3.2.1), (3.2.2), (ISO 5667-10:1992 (4.2.1))* e) sample volume required for the various analyses.*(ISO 5667-2:1991 (6.3.1)) (ISO 5667-10:1992 (4.2.1))* f) the depth at which the samples should be taken e.g. one-third of the effluent water depth below the surface of the water. *(ISO 5667-10:1992 (5.1.2))* g) handling corrosive or abrasive liquids. *(ISO 5667-1:1980 Section 2 (8.7))* h) parameters measured on site. *(ISO 5667-2:1991 (4.1)), (ISO 5667-3;1994 (3.1)), (ISO 5667-14:1998 (6))* i) preservation and storage of samples. *(ISO 5667-10:1992 (5.4))* j) taking, preservation and analyses of blank samples. *(ISO 5667-3:1994 (3.2.2)* k) the requirement to complete field sheet *(ISO 5667-2:1991 (7.1)), (ISO 5667-3:1994 (4).*	Yes	Short	Low	On-site	

Table 3.7 (ctd.)

Corrective Action (Standard Ref.)	Are the facilities/ resources available	Proposed time scale for implementation: Short/Medium/ Long term.	Cost of implementation: High/Medium/ Low	Staff training on-site/ off-site?	Comments
7. (ctd.) l) the sealing and transportation of samples to the laboratory *(ISO 5667-2:1991 (6.2.4), ISO 5667-3:1994 (3.1), (3.2.4), (5), ISO 5667-14:1998 (5.1),(6),* m) storage of samples in a refrigerator, on arrival to the laboratory, where immediate analyses is not being carried out *(ISO 5667-3:1994 (6)).* n) safety precautions necessary (include details from Laboratory Safety Statement *(ISO 5667-1:1980 Section 2(7.1))*					
8. Develop, document and implement sampling report form for STP and industrial wastewater sampling as per ISO 5667. *(ISO 5667-1:1980 Section 2 (8.13), ISO 5667-2:1991 (7.2), ISO 5667-3:1994 (4)), (ISO 5667-10:1992 (7))*	Yes	Short	Low	On-site	
9. Identify and document whether sampling locations require to be cleaned (to remove scale, sludge, bacterial film etc. from the walls) prior to sampling and detail how cleaning is to be carried out. *(ISO 5667-10:1992 (5.1.2))*	No	Medium	Low	On-site	The implementation of this corrective action would require; - Reassessment of each sampling location to be reassessed - Identification of an effective method of

Table 3.7 (ctd.)

Corrective Action (Standard Ref.)	Are the facilities/ resources available	Proposed time scale for implementation: Short/Medium/ Long term	Cost of implementation: High/Medium/ Low	Staff training on-site/ off-site?	Comments
9. (ctd.)					cleaning be identified - Access to a water supply - Documentation of cleaning procedure
10. Assess the need to use a flexible inert tube, to deliver liquid to the bottom of the sampling bottle, when sampling from a tap or pump outlet. *(ISO 5667-2:1991 (6.7))*	Yes	Medium	Low	On-site	- Assessment would have to be based on a large number of samples. - The possibility of cross contamination by repeat use of the tube would have to be addressed.
11. Identify the samples which require to be filtered/centrifuged at the time of taking the sample or immediately afterwards. Implement a procedure for the filtration/ centrifuging of these samples. *(ISO 5667-3:1994 (3.2.5).*	Yes	Medium	Medium	On-site	- Document the samples which require to be filtered/ centrifuged. - Document method for filtering and centrifuging. - Purchase the required consumables. - Document, which samples are filtered/centrifuged and how it was carried out ie type of filter and filter pore size.

Table 3.7 (ctd.)

Corrective Action (Standard Ref.)	Are the facilities/ resources available	Proposed time scale for implementation: Short/Medium/ Long term.	Cost of implementation: High/Medium/ Low	Staff training on-site/ off-site?	Comments
12. Develop, document and implement a procedure for the freezing and thawing of samples. *(ISO 5667-3:1994 (3.2.4))*	Yes	Short	Low	On-site	
13. Amend SOP No. 43 to include details on the max. length of sample storage for the various analyses, making reference to guidelines in Standard Methods (Anon. 1998). *(ISO 5667-3:1994 (3.1))*	Yes	Short	Low	On-site	
14. Document and implement procedures for the selection of effective samplers *(ISO 5667-2:1991 (6.3.1))* and the selection and purchase of sampling containers, including details on the cap types to be used for the various parameters. *(ISO 5667-2:1991 (6.1.1), (6.2.1), (6.2.3), (6.2.4), (6.5)), (ISO 5667-10:1992 (4.1)).*	Yes	Short	Low	N/A	- Ensure personnel responsible for purchasing laboratory goods are aware of the sampling container and sampler types to be purchased.
15. Document criteria for the selection of automatic sampling equipment, taking into account the features and attributes stated in *ISO 5667-10:1992 (4.2.2).*	Yes	Short	Low	N/A	- The use(s) of the automatic sampler will dictate the criteria for selection. All specifications in ISO 5667 may not be required. The criteria of importance will have to be documented.

Table 3.7 (ctd.)

Corrective Action (Standard Ref.)	Are the facilities/ resources available	Proposed time scale for implementation: Short/Medium/ Long term.	Cost of implementation: High/Medium/ Low	Staff training on-site/ off-site?	Comments
15. (ctd.)					- The cost of implementing this requirement may be high if current samplers do not meet requirements.
16. Develop, document and implement a method for selecting the period over which a composite sample is to be taken, taking the objective of the sampling programme and the stability of the sample into account. *(ISO 5667-10:1992 (5.2.4))*	Yes	Long	Medium		- The objectives of the sampling programme must be firstly documented and the stability of the various parameters determined as per ISO 5667.
17. Statistically determine the number of samples to be taken during each composite sample. *(ISO 5667-10:1992 (5.2.2))*	Yes	Long	Medium	Both	- Identify the situations where composite samples are to be taken. - Document the number of samples required and the statistical method used to determine this number. - Some off-site statistical training may be required
18. Identify and document the parameters that can only be determined on spot or composite samples. *(ISO 5667-10:1992 (5.3.1.1))*	Yes	Short	Low	On-site	

Table 3.7 (ctd.)

Corrective Action (Standard Ref.)	Are the facilities/ resources available	Proposed time scale for implementation: Short/Medium/ Long term.	Cost of implementation: High/Medium/ Low	Staff training on-site/ off-site?	Comments
19. Develop and document procedure for the taking of composite samples, including the type of composite sample and details on the volumes to be taken. *(ISO 5667-10:1992 (5.3.1.2))*	Yes	Long	Low	On-site	- Shall depend on outcome of Points 16-18 above.
20. Implement a procedure for: - dealing with samples of anomalous material - identifying hazardous materials *(ISO 5667-3:1994 (4))*	Yes	Medium	High		- Need to identify what anomalous material may arise and document procedure for dealing with same. - Identify protocol for dealing with hazardous material, if need arises.
21. a) Identify areas where a site inspection may be necessary in order to ensure the locations of the sewers and path of the waste stream correspond to the site map drawings and the selected location is representative for sampling purpose. *b)* Develop a system of carrying out site inspections using chemical tracer studies or other approved method. Develop an appropriate method to document results of same. *(ISO 5667-10:1992 (5.1.1))*	No	Long	High	Off-site	- Applicable for licensed discharges to sewers - Would have to form part of licence review process

Table 3.7 (ctd.)

Corrective Action (Standard Ref.)	Are the facilities/ resources available	Proposed time scale for implementation: Short/Medium/ Long term.	Cost of implementation: High/Medium/ Low	Staff training on-site/ off-site?	Comments
22. Develop, document and implement procedure for noting and recording conditions inside a licensed industrial plant prior to sampling *(ISO 5667-10:1992 (5.1.2))*	Yes	Short	Low	On-site	- The implementation of this corrective action would require communication with relevant industrial personnel at the time of sampling.

C.A. No. 1 requires that current wastewater sampling locations be reviewed in order to ensure sufficient turbulence is present at all sites. Incomplete mixing of wastewaters may occur due to low flow rates or mixing of wastewaters from different sources. This could be a particular problem in the case of influent where wastewater may be contained in large cross-sectional channels that slow down the rate of flow. Locations where incomplete mixing of wastewater occurs should be identified. As in-house expertise is not available to determine whether sufficient turbulence exists at the sampling locations, external consultants would be required. This would incur a high cost especially as there are a large number of sites to be assessed. Additional cost would also be incurred if any of the assessed sites had to be altered to ensure sufficient turbulence is present.

C.A. No. 2 requires that measures be identified, documented and implemented to overcome or minimize the heterogeneity caused by suspended solids and/or thermal stratification in wastewater streams. Sampling sites, where heterogeneity is likely to occur, must first be identified before appropriate measures could be identified to promote the mixing of such streams before sampling. As in-house expertise is not available to determine the above, external consultants would be required. This would incur a high cost especially if measures to overcome heterogeneity had to be implemented. Therefore, the full implementation of this would be very long-term.

C.A. No. 3 requires the identification of situations where emulsified and floating material is to be sampled. Sampling for emulsified and floating material, such as oil and grease, is a qualitative sampling procedure as it involves skimming the sample surface. An appropriate method must be documented for same. Additional sampling equipment and containers may need to be purchased e.g wide mouth jars. The cost incurred here would be low and so this corrective action could be implemented in the short term.

C.A. No. 4 requires the identification and documentation of exact sampling points at the influent, effluent and aeration tanks of all wastewater plants routinely sampled within the County. It is important that the wastewater samples are always taken at the exact same sampling location in order to allow comparisons to be made between the various results over time. C.A. No. 5 requires that a system be developed, documented and implemented for frequently reviewing the plant's sampling locations (as stated in C.A. No. 4). Both C.A's No. 4 and 5 can be implemented in the short term at a low cost.

C.A. No. 6 requires that an SOP be prepared with regard to the sampling of storm sewage and surface water run-off. LCC does not currently sample storm sewage or surface run-off on a regular basis, therefore this procedure would be best documented as a separate SOP with a reference made to it in both SOP No's. 10 and 11. This procedure should take into account the guidelines provided in ISO 5667-1:1980 Section 2 (13). This can be implemented in the short term at a low cost.

C.A. No. 7 deals with the amendments which are required to the current laboratory wastewater sampling SOPs (SOP No. 10 and 11) in order to meet the requirements of ISO 5667. A significant number of these amendments involve the documentation of procedures, which are currently being carried out. For example, the calibration and checking of field meters prior to sampling, the monitoring of parameters *in-situ*, the recording of monitoring results and sample details on a field sheet and the transportation of samples to the laboratory in cooler boxes. Other amendments involve the documentation and implementation of procedures that are already in place but do not comply fully with ISO 5667 requirements e.g. procedures relating to the use of correct sampling equipment and containers, the preparation and cleaning of sample containers, the filling and sealing of sampling containers (including detail on the correct sample volume to be collected for each parameter), the handling of corrosive or abrasive liquids and the use of safety precautions. An extensive body of information exists regarding these details, therefore these procedures could be easily incorporated into SOP No. 10 in the short term. Some of the amendments required shall involve the documentation and implementation of new procedures, e.g. the preservation of samples at the time of sampling and the taking, preservation and analyses of blank samples. The above amendments can be documented and implemented in the short term at a low cost to the laboratory.

C.A. No. 8 requires that an appropriate field report sheet be developed for sampling wastewaters as per ISO 5667. LCC laboratory does not currently have an appropriate field report sheet however this can be rectified in the short term at a low cost to the laboratory.

C.A. No. 9 deals with identifying whether the walls of the various wastewater sampling locations need to be cleaned prior to sampling in order to remove scale, sludge, bacterial film, etc. If this is necessary then a procedure should be documented detailing how cleaning is to be carried out. This C.A. could take a considerable period of time to implement since each sampling location

would have to be assessed and an effective method of cleaning identified and documented. Cleaning procedures undertaken at the sampling location would slow down the rate of sampling, particularly if the location is difficult to clean or if a readily available source of water cannot be identified.

C.A. No. 10 deals with assessing the need to use a flexible inert tube to deliver liquid to the bottom of the sampling bottle when sampling from a tap or pump outlet. This C.A. has been dealt with previously in Section 3.2.4.

C.A. No. 11 deals with the requirement to filter/centrifuge samples at the time of taking the sample or immediately afterwards. This C.A. has been dealt with previously in Section 3.2.4.

C.A. No. 12 requires that a procedure be developed, documented and implemented with regard to the freezing and thawing of samples. This can be carried out in the short term at no additional cost to the laboratory.

C.A. No. 13 requires that SOP No. 43 is amended to include details on the maximum time allowable for sample storage for each of the parameters of interest. These details, which can readily be obtained from Standard Methods (Anon. 1998), can be incorporated into the appropriate SOP in the short term at a low cost to the laboratory.

C.A. No. 14 requires that procedures be documented and implemented with regard to the selection of effective samplers and sampling containers for wastewater sampling. As this involves the documentation of existing procedures, the C.A. can be implemented in the short term at no additional cost to the laboratory.

C.A. No. 15 requires that the criteria for the selection of automatic sampling equipment be documented. The criteria stated must take into account the relevant features and attributes stated in ISO 5667-10:1992 (4.2.2). The criteria selected shall depend on the intended use(s) of the automatic sampler. Current automatic samplers can then be assessed for their suitability. If the current samplers do not meet the necessary requirements, the cost of implementing this C.A. may be high.

C.A. No. 16 requires that a method be documented and implemented for selecting the period over which a composite sample is to be taken. The period selected should take into account the objective of the sampling programme and the stability of the sample. This will result in a long time-scale for implementation.

C.A. No. 17 deals with statistically determining the number of samples to be taken during each composite sampling period. In order to do this correctly, off-site statistical training may be required thereby increasing the cost of implementation and the length of time to achieve full implementation.

Certain parameters can only be measured on spot samples because of the instability of the parameter e.g. temperature and pH. C.A. No. 18 requires that parameters to be determined on spot samples only be identified and documented. This can easily be implemented at no additional cost to the laboratory.

C.A. No. 19 requires that a method be documented and implemented with regard to the taking of composite samples. This should include details on the type of composite sample (i.e. time-weighted or flow-weighted samples) and the volumes to be taken. As this procedure is dependent on C.A. No.'s 16-18 being fully implemented, the time-scale for implementation would be long-term.

C.A. No. 20 deals with the requirement to implement a procedure for identifying hazardous materials and dealing with samples of anomalous material. This would involve a considerable amount of work and time to document accurately as firstly the various types of anomalous and hazardous material would have to be identified and only then could an appropriate procedure be documented

C.A. No. 21 requires identification of those areas where a site inspection may be necessary in order to ensure that (a) the locations of the sewers and path of the waste stream correspond to the site map drawings and (b) the selected location is representative for sampling purpose. A system for carrying out these site inspections must be developed and may consist of chemical tracer studies or other approved methods. The results of all such inspections should be documented. This requirement is particularly applicable to licensed discharges to sewers and would have to

form part of licence review process. The time-scale for implementation would therefore be long-term and a high cost may be incurred, particularly for larger and older premises.

C.A. No. 22 requires that a procedure be developed and implemented for noting and recording conditions inside a licensed industrial plant prior to sampling the effluent discharge. This would require communication with the relevant industrial personnel at the time of sampling. This could be implemented in the short term by amending the relevant sampling SOP (SOP No. 11) and associated field report sheet.

4.0 DISCUSSION

4.1 RESULTS OBTAINED FROM THE QUESTIONNAIRE

There was an excellent response rate to the questionnaires forwarded to Local Authority (LA) and EPA laboratories with values of 72% and 100%, obtained respectively. Such a high response rate allows significant conclusions to be drawn regarding water sampling practices in these sectors. Unfortunately, the response rate from independent laboratories was very low, with just four of the 11 laboratories responding to the questionnaire. As only three of these laboratories carry out routine water quality sampling, the replies received cannot be considered representative of the entire private laboratory sector. They are therefore not discussed as part of this dissertation but included for the readers information in Appendix C (Table C3). A reason for the low response rate received from private laboratories could not be ascertained as each of the laboratories were contacted by telephone and most agreed to complete and return the questionnaire. The low response rate may indicate a reluctance by private laboratories to disclose this information to a potential customer(s) for fear of negative publicity.

4.1.1 Laboratories Involvement in Water Sampling

Most EPA laboratories (80%) have personnel designated solely for sampling (Table 3.1, Figure 3.1). LA laboratories seem to operate differently in that only 11% of those which responded have personnel designated solely for sampling. This trend is probably due to LA laboratories covering smaller geographical areas than EPA laboratories and subsequently having lower laboratory staffing rates where it would be impractical to have dedicated samplers.

72% of LA laboratory respondents routinely sample rivers (Figure 3.2). A higher percentage was expected since all LAs are required to regularly monitor rivers in their catchment area in order to assess compliance with the Local Government (Water Pollution) Act, 1977 (Water Quality Standards for Phosphorus) Regulations, 1998. The lower percentage of LAs actually involved in river sampling may be due to the fact that some rivers are monitored as part of specific projects e.g. the Three Rivers project and the Lough Ree/ Lough Derg project. This monitoring is carried out by designated laboratories set up by the LA responsible for the project. The number of LA laboratories involved in river sampling is likely to decrease further in the near future because of the implementation of the Water Framework Directive. Under this Directive river basin districts are being designated and associated laboratories are likely to be set up.

72% of the LA laboratories, which responded, routinely sample STPs (Figure 3.2). Again a higher percentage would have been expected as LA's are required to regularly monitor STPs in order to assess their compliance with the Environmental Protection Agency Act, 1992 (Urban Waste Water Treatment) Regulations, 1994. This lower than expected percentage may be due to the fact that in a number of STPs, dedicated LA staff are responsible for the required monitoring at the plant. These staff are assigned solely to the STP and do not form part of the main laboratories monitoring programme, which were the focus of the questionnaire.

67% of LA's routinely sample industrial wastewaters (Figure 3.2). This figure would be expected to vary between LA's depending on the number of licensed industries under the Local Government (Water Pollution) Acts 1977 and 1990. Monitoring is carried out to assess if the effluent being discharged complies with the specified licence limits.

Just 61% of LA laboratories, which responded, routinely sample drinking waters (Figure 3.2). Again a higher percentage would have been expected as LAs are required to regularly monitor drinking waters within their catchment area in order to assess compliance with the European Communities (Quality of Water Intended for Human Consumption) Regulations, 2000. The lower percentage revealed in the questionnaire may be due to fact that the local Health Board carry out the required monitoring in some counties.

The results obtained from the questionnaire indicate that all EPA laboratories routinely sample industrial wastewaters and rivers (Table 3.1 and Figure 3.2) therefore indicating that the EPA is fulfilling its regulatory roles and its role in monitoring the quality of the environment. 60% of EPA laboratories monitor sewage treatment plants and drinking water (Figure 3.2). The percentage of EPA laboratories sampling STPs and drinking waters is quite high as this monitoring is generally carried out by LAs and Health Boards who subsequently submit results to the EPA.

4.1.2 Sampling Procedures

Each laboratory must produce a sampling manual which includes the procedures and precautions to be adopted for each parameter or group of parameters to be sampled/ analysed in that laboratory (ISO 5667, Flanagan *et al*, 2003, CITAC and EURACHEM, 2002 and Barron, 2001). As part of the questionnaire, a number of questions were asked regarding the documentation of

sampling procedures in the laboratory. Of the laboratories, which replied to the questionnaire, only 74% of LA and 60% of EPA laboratories have documented sampling procedures (Table 3.1 and Figure 3.3). Documented sampling procedures in EPA laboratories seem to be more detailed than those in LA laboratories, particularly with regard to the type of sampling container used and the types of samples which are to be preserved. The fact that not all laboratories have documented sampling procedures in place is of concern and raises questions with regard to how sampling is carried out and whether there is continuity in procedures between sampling staff.

4.1.3 Guides used in Preparing Sampling Programmes and Procedures

Results obtained from the questionnaire indicate that Standard Methods is the most common guide used for preparing sampling programmes and procedures (Figure 3.4). 83% of LA and 60% of laboratories, which responded, use Standard Methods as a guide when preparing sampling programmes and procedures (Figure 3.4).

11% of LA and 20% of the EPA laboratory respondents, use ISO 5667 as a guide when preparing sampling programmes and procedures. Although 16% of LA and 40% of the EPA respondents have considered accreditation specifically to ISO 5667 (Figure 3.12) a much lower percentage, of these laboratories use the standard when preparing sampling procedures. This may indicate that the standard is too comprehensive or onerous to use or it may also indicate that these laboratories are at the initial stages of considering accreditation to the standard and have not begun to use the standard to prepare sampling programmes and procedures.

LA implementation handbooks are published by either the EPA or the Department of the Environment to give guidance to LAs with regard to the implementation of specific legislation. Details with regard to sampling procedures are often stated. 56% of the LA laboratory respondents, use these guides when preparing sampling programmes and procedures. This low percentage is of concern as these publications often state specific requirements with regard to type of sample, sampling location, etc. For example, the 1996 EPA Implementation Handbook, published to accompany the Environmental Protection Agency Act, 1992 (Urban Waste Water Treatment) Regulations, 1994, strongly recommends the use of flow-proportional samplers for wastewater samples. This direction is more specific than the Regulations themselves which state that either flow-proportional or time-based 24-hour samples can be taken. Similarly the implementation handbook for the European Communities (Drinking Water) Regulations, 2000,

Flanagan *et al.* 2003 state that drinking water samples taken in order to assess compliance with the Regulations should not be taken from outside taps. The Regulations do not state this.

Only 20% of EPA laboratories use implementation handbooks when preparing sampling programmes and procedures (Figure 3.3). As these handbooks are very specific to the implementation of specific legislation by LAs they would not, in most cases, be applicable to EPA sampling programmes.

4.1.4 Training of Sampling Personnel

Flanagan *et al*, 2003 states that in order for sampling procedures to be effectively implemented and correctly carried out, staff training must be provided. All laboratories, which responded to the questionnaire, carry out in-house training of sampling personnel, however, only 32% of LA and 20% of EPA laboratory respondents, have documented sampling training procedures in place (Figure 3.5). Similarly the maintenance of sampling training records is quite poor with just 11% of LA laboratories and 40% of EPA laboratories maintaining these records (Table 3.1 and Figure 3.5). These low percentages are of concern because assurance is not demonstrated to external parties, that the sampling procedure is carried out correctly or that there is continuity within a laboratory with regard to how samples are taken or that sampling staff have obtained proper training.

4.1.5 On-site analysis of water pollutants

The question relating to parameters routinely monitored at the sampling locations was misunderstood by most of the laboratories that responded. Most interpreted the question as meaning all the parameters that are monitored both in the field and in the laboratory during drinking water, river and wastewater sampling.

On-site analysis is recommended for pH, chlorine, dissolved oxygen, conductivity and temperature (Anon., 1998 and ISO 5667. Of the five laboratories, which interpreted the question correctly, all measure D.O, chlorine and temperature on-site, however, only two measure pH and conductivity on-site. The failure to monitor pH on site is of particular concern especially in the case of samples with a low pH. These samples continually absorb carbon dioxide from the atmosphere thereby resulting in a continual increase in pH during storage and/or transit (Anon., 1998).

4.1.6 Calibration and checking of *in-situ* monitoring equipment

In order to ensure accurate readings are taken in field the field meters used should be calibrated/checked prior to sampling (NSAI, 1994). All laboratories, which responded to the questionnaire, check/calibrate their field meters prior to use in the field. However, just 63% of LA and 50% of EPA laboratories maintain a record of this check/calibration (Table 3.1 and Figure 3.6). Failure to record the above information reduces the traceability of the results obtained as it could not be subsequently proved that the particular parameter measured was done so using a properly calibrated/checked instrument.

4.1.7 Sampling Containers Used for Sampling

The choice of sampling container affects the integrity of the determinand (Anon., 1998) glass containers should be used for phosphate and oil and grease; plastic containers should be used for fluoride and glass or plastic containers can be used for microbiology and metal analysis. (Flanagan *et al*, 2003; Anon., 1998 and Crosby and Patel, 1995).

In the questionnaire, the laboratories were asked about the type of sampling container used to sample for microbiological, fluoride, oil/grease, phosphate and metals. All laboratories, which replied to the questionnaire, use the correct type of sampling containers when sampling for fluoride, metals and microbiological samples (Figure 3.7). All EPA laboratories use the correct container i.e glass, when sampling for oil and grease, however, only 63% of LA laboratories use the correct type of sampling containers. The remainder of LA laboratories incorrectly use plastic sampling containers. The sample result(s) obtained from these laboratories may not be accurate as oil and grease is absorbed into the walls of plastic containers (Anon., 1998). This would be of particular concern when measuring low levels of oil and grease.

All laboratories, which replied to the questionnaire, use the incorrect type of sampling container i.e. plastic containers, when sampling for phosphate (Table 3.1 and Figure 3.7). Phosphate is absorbed into the walls of plastic containers thereby resulting in false low readings, particularly where low levels are being detected (Anon., 1998). The Local Government (Water Pollution) Act, 1977 (Water Quality Standards for Phosphorus) Regulations, 1998 cite a concentration of 0.07mg/l PO_4-P as being indicative of seriously polluted. This is a very low level in analytical terms and hence the absorption of phosphate into the sampling container may have significant consequences. Bearing this in mind, questions may be posed regarding the accuracy of phosphate monitoring in Irish rivers by LA and EPA laboratories.

4.1.8 Sample Preservation

Sample preservation is required to ensure the integrity of a sample for a number of determinands. When the interval between sample collection and analysis is long enough to produce changes in either the concentration or the physical state of the constituent to be measured, the samples should be preserved (Crosby and Patel 1995 and Flanagan, 1990*b*). Samples undergoing analysis for ammonia or trace metals should be analysed as soon as possible or acidified to pH <2. Samples undergoing phosphate analysis should be refrigerated and analysed within 48 hours (Crosby and Patel 1995; Flanagan, 1990 and Anon., 1998).

67% of EPA laboratories chemically preserve samples for ammonia analysis, in contrast only 5% of the LA laboratory respondents preserve for ammonia (Table 3.1 and Figure 3.8). This is of concern as ammonia once in contact with air is immediately oxidised to nitrite and nitrate. If the sample is not preserved or analysed immediately the ammonia level measured may not be representative of the sample taken.

All EPA laboratories chemically preserve samples taken for oil and grease analysis, however, none of the LA laboratory respondents, preserve for oil and grease. This may have a significant effect on sample results particularly where low levels of oil and grease are being measured as the oil and grease may be broken down by bacteria present in the sample.

All EPA laboratories chemically preserve samples taken for metal analysis. A high percentage of the LA laboratories (60%) also preserve these samples (Figure 3.8).

Of the laboratories that responded to the questionnaire, one LA and one EPA laboratory chemically preserves for phosphate. This is not required in Standard Methods.

64% of LA and 80% of EPA laboratories document which samples are to be preserved (Figure 3.3), however, a lot fewer (45% and 40% respectively) maintain records of the type of preservation which is carried out or record details of the preservative used. This is of particular concern if the sampler does not carry out the laboratory analyses as the type of preservative used would be unknown to the analyst.

4.1.9 Quality Control

It is recommended that a quality control (QC) programme be implemented with regard to sampling (ISO5667-5:1999 (9), ISO 5667-6:1990 (5.5) and ISO 5667-14:1998(E)). Among the QC procedures recommended in ISO 5667 are the use of field blanks and also the use of QC tests on the preservatives used. Field blanks are used to establish whether the sample container or the sampling process is a source of contamination. A QC test on the preservative procedure will establish if the preservative used is a source of contamination (i.e. if it contains the analyte of interest or leaches the analyte of interest from the sample container).

Most of the EPA laboratories carry out these quality control procedures, i.e. 60% analyse field blanks and 80% carry out a quality control test on the preservatives used (Table 3.1 and Figure 3.9). A significantly lower percentage of the LA laboratory respondents use these procedures i.e. 27% analyse field blanks and 18% carry out a QC test on the preservatives used. These results indicate a lack of quality control over sampling procedures in LA laboratories. This could be significant if, on the implementation of these procedures, it was found that the sample container or the preservative used were having a significant effect on the result obtained.

4.1.10 Labelling of Sampling Containers

Q28 of the questionnaire asked, "Is information regarding sample location and on-site analysis written on the sampling bottle or on a field log-sheet?" 42% of the laboratories, which responded, answered the question incorrectly by replying "Yes". Of the laboratories, which answered the question correctly, 43% record the information on the sampling bottle, 36% record the information on a field sheet and 21% use both. Detailed information should be recorded with regard to the various sample types (ISO 5667, Standard Methods (Anon, 1998) and the Drinking Water Regulation 2000 implementation handbook). A field sheet or logbook is necessary in order to record all this information accurately. Since 43% of the laboratories, which responded correctly to this question, record information on the sampling bottle this would indicate that there is insufficient information being recorded in relation to sampling location or *in-situ* analysis at the time of sampling. This may affect the traceability of the results obtained.

4.1.11 Transportation of Samples

In general, samples should be protected from direct sunlight and be held in a cool environment (Flanagan *et al*, 2003; Flanagan *et al*, 2002; Anon., 1998; Crosby and Patel 1995; NSAI, 1996; ISO, 1990; and Galal-Gorchev and Lewis, 1984). 32% of LA laboratory respondents and 40%

of EPA laboratory respondents do not transport samples in a cooled environment (Table 3.1). This is of concern particularly during warmer weather since specific parameters of interest e.g. microbiological, BOD and ammonia, may be significantly altered during sample transit due to the increase in temperature.

4.1.12 Use of Chain-of-Custody Forms

Chain-of-custody forms are used to trace sample history from collection to final reporting. Anyone taking possession of samples during transport is technically part of the chain-of-custody and may need to account for the samples whilst they are under their immediate control (Treble and Nicholson, 2000 and Anon., 1998). This process is essential when the data is to be used for litigation purposes.

All EPA laboratories use chain-of-custody forms for various types of samples i.e. those taken by laboratory personnel, by non-laboratory personnel and for prosecution cases (Table 3.1 and Figure 3.10). In contrast, LA laboratory respondents rarely use chain-of-custody forms. Only 25% use the form for samples taken by the laboratory personnel, 36% use the forms for samples taken for prosecution cases and 47% use the forms for samples taken by non-laboratory personnel. This may become a significant issue, particularly for legal cases, if the sampler does not subsequently analyse the sample or if the sample is sub-contracted to an external laboratory for specific analyses.

4.1.13 Samples used as Evidence in Court Cases

Water samples, particularly those taken by LA's and the EPA, are sometimes required as evidence in a court-of-law, where a prosecution is pending, in relation to pollution of a waterbody. As part of the questionnaire, laboratories were asked firstly if samples taken were used as evidence in court and secondly if the sampling procedure had ever been questioned in court.

Results from the questionnaire indicate that all EPA laboratories use the results from samples analysed, as evidence in court (Table 3.1 and Figure 3.11). In contrast, only 47% of LA laboratory respondents use the results from samples analysed as evidence in court. This indicates that the EPA is more likely to be involved in prosecution cases than LA's. In a court-of-law it would be extremely difficult to prove the impact of a pollution incident on a watercourse without presenting analytical analysis. The results of the questionnaire therefore

indicates that LAs are not using their enforcement powers fully under the Local Government (Water Pollution) Acts, 1977 and 1990.

Just 16% of LA and 25% of EPA laboratories, which responded, have had their sampling procedures questioned in a court-of-law. Details regarding the areas cross-examined in court were not requested in the questionnaire. This low percentage indicates that defending solicitors are currently not questioning the manner in which water/wastewater samples are taken. This may be linked to the reason why no laboratory is currently accredited or in the process of accreditation to ISO 5667. It may also account for the low percentage of laboratories documenting sampling training procedures and maintaining sampling training records.

4.1.14 Accreditation of laboratories

The two main standards to which analytical laboratories may be accredited to in Ireland are ISO17025:1999 (General requirements for the competence of testing and calibration laboratories) which deals primarily with the analyses of the samples and ISO 5667 which is a water quality sampling standard. Most EPA laboratories are either accredited to ISO 17025 or in the process of accreditation to this standard (Figure 3.12). Although none of the LA laboratories, which replied to the questionnaire, are presently accredited to ISO 17025, 48% are currently considering attaining accreditation to this standard. This trend is probably due to increasing pressures from third parties for results to come from an accredited laboratory e.g. the EPA has repeatedly stated in guidance documents that results should come from accredited laboratories (EPA, 1996 and Flanagan *et al*, 2003).

There are currently no laboratories in Ireland accredited to the ISO 5667 standard 60% of EPA laboratory respondents and 16% of LA laboratory respondents have considered accreditation to this standard. The high percentage of EPA laboratories having considered accreditation to ISO5667 may be linked to the regulatory and leadership role with which this organisation has over LAs and private industry.

4.1.15 Limerick County Council v's other Environmental Laboratories

Results obtained from the questionnaire indicate that practices and procedures in Limerick County Council (LCC) are similar, in a number of areas, to other environmental laboratories in Ireland. LCC, in common with all other laboratories calibrate/check field meters prior to field analysis and use the correct type of sampling container when sampling for microbiological,

fluoride and metals. Similarly, LCC have documented sampling procedures in place, transport samples in a cooled environment and use chain-of-custody forms when samples are taken by non-laboratory personnel. This is also the situation in most other laboratories questioned. LCC do not, however, use the correct type of sampling container when sampling for phosphate nor do they document sampling training procedures or maintain records of staff training. This malpractice was also reflected in most other environmental laboratories questioned.

In general, LCC shares more practices and procedures in common with other LA laboratories than with EPA laboratories. For example, LCC do not preserve samples for oil and grease or ammonia nor do they analyse quality control blanks. This is the situation in most other LA laboratories but not in most EPA laboratories.

LCC do, however, share some practices in common with EPA laboratories that are not common in LA laboratories. For example, LCC maintain sampling training records, have standard field log-sheets for the sampling of various water bodies and has been questioned in court regarding sampling procedures. In addition, LCC has considered obtaining accreditation specifically to the ISO 5667 standard.

4.2 RESULTS OBTAINED FROM THE GAP ANALYSIS

Current water sampling procedures and practices employed at the environmental laboratory of LCC were used, as a case study, to determine the level of work required to achieve ISO 5667 accreditation. A gap analysis was undertaken to examine in detail the requirements of the standard versus current practice and procedures in the laboratory. From this gap analysis the corrective actions necessary to comply with ISO 5667 were identified thereby indicating the level of work required for accreditation.

The gap analysis revealed links between the various parts of the ISO 5667 standard. These were subdivided into a number of key areas and included general requirements with regard to the:

- information provided for in the sampling programme
- quality control procedures
- preservation of samples
- information provided for in standard operating procedures (SOPs)

The discussion, which follows, gives details of the required corrective actions under the above sub-headings.

4.2.1 Sampling Programme

A sampling programme gives details on the position of sampling sites, frequency of sampling, duration of sampling and sampling procedures (NSAI, 1994). LCC has prepared a number of sampling programmes in relation to water/wastewater sampling. These include a sampling programme for drinking water, river water and urban/industrial wastewater sampling.

The gap analysis undertaken between the various sampling programmes of LCC and ISO 5667 revealed that the sampling programmes of the environmental laboratory of LCC are, in general, lacking in specific detail, particularly, in relation to the objectives of the sampling programme, sampling locations, sampling times, frequency of sampling, numbers of samples required and the precision adequate for analytical field results (Table 3.2- C.A 1-10; Table 3.5- C.A 1 and Table 3.7-C.A 4). Information on the above can be incorporated into LCC's existing sampling programmes in a relatively short period of time, at a low cost using existing resources. The reason for this being that the bulk of water sampling carried out by the laboratory is done in accordance with relevant legislation which specifies the above information. In relation to the precision of analytical field results, the relevant specifications must be extracted from the appropriate legislation and compared to the precision of current analytical field results. The precision of a current analytical field method is determined by measuring the parameter of interest a number of times on a particular sample. The standard deviation of these results is then used to calculate precision. If the required precision is not being obtained this indicates that the current meter is not capable of meeting the required specification. The meter and/or the probe may then need to be re-calibrated, serviced by the manufacturer or replaced by a more precise meter.

The gap analysis undertaken between the current sampling programmes at LCC and ISO 5667 revealed that records do not exist in LCC's drinking water, river water or urban/industrial wastewaters sampling programmes as to how sampling locations are selected. This is required under ISO 5667 in order to ensure that the samples taken at these locations are representative.

LCC's drinking water sampling programme lists all of the drinking water supplies (public and group water schemes) monitored within the county and states the frequency of monitoring required for these under the European Communities (Drinking Water) Regulations, 2000. The selection and mapping of sampling locations is currently underway following which an annual sampling programme will be documented. The sampling locations are selected randomly throughout the distribution system, however, this is not stated in the sampling programme as is required in ISO 5667 (Table 3.5- C.A. 1). This can easily be rectified in the short term.

LCC's river water sampling programme identifies and maps river sampling locations and also sampling locations for surface waters used for the abstraction of drinking water. There are no records, however, with regard to how these locations were selected. Surface water sampling locations must be representative of the whole aquatic system (Clesceri *et al*, 1998; Crosby and Patel, 1995; NSAI, 1994 and Galal-Gorchev and Lewis, 1984) and therefore the surface water sampling locations used by LCC staff must be reassessed to ensure that they are indeed providing representative samples. This reassessment must take into account *inter alia*, locations where marked quality changes are likely to occur, locations where there are important river uses and also the presence of EPA flow stations (Table 3.6- C.A 1). This can only be done in the long term as the river sampling programme for the current year has already been initiated. Any additional points selected must be assessed to ensure they are accessible all year round. The cost of implementation of this measure would be low provided any additional sampling required could be carried out using existing resources.

LCC's wastewater sampling programme identifies and maps all LA urban wastewater treatment plants (WWTPs) in the county and details the frequency of monitoring for each plant. The sampling programme also lists the industries licensed under the Local Government (Water Pollution) Act, 1977-1990. Sampling times for both urban and industrial WWTPs are spread evenly throughout the year based on the requirements of the above legislation. This is documented on a wall planner prepared at the beginning of each calendar year. The location of sampling points at LA WWTPs and industrial discharge points is not stated in the sampling programme (Table 3.2- C.A. 1)

ISO 5667 requires the identification and documentation of an exact sampling point at the influent, effluent and aeration tank(s) of all WWTPs routinely sampled (Table 3.7- C.A. 4). The reason for this being to ensure that variations detected in pollutant concentration are due to

wastewater quality changes rather than the use of different sampling points e.g. samples taken from an influent stream before screening will yield different values to those taken of the same influent stream after screening. The sampling locations at each of the urban and industrial WWTPs could be identified and included in the sampling programme in the short term at a low cost to the laboratory.

ISO 5667-10 requires that a system be implemented in the sampling programme for frequently reviewing the sampling locations chosen. This would involve assessing each sampling site to ensure there is sufficient turbulence and mixing of the wastewaters. Insufficient mixing may result in unrepresentative samples being obtained. As the expertise necessary to carry out such a study is not available in LCC, implementation would be expensive and time consuming (Table 3.7-C.A. 1).

With regard to licensed discharges to sewers, ISO 5667-10 requires identification of those areas where a site inspection may be necessary in order to ensure that the locations of the sewers and path of the waste stream correspond to the site map drawings and that the selected location is representative for sampling purpose (Table 3.7-C.A 21). A system for carrying out these site inspections must be developed and may consist of chemical tracer studies or other approved methods. The results of all such inspections should be documented. This requirement would have to form part of licence review process. The time-scale for implementation would therefore be long-term and a high cost may be incurred, particularly for larger and older premises.

4.2.2 Quality Control

Quality control (QC) is a set of measures taken within a sample analysis methodology to assure that the process is in control (Clesceri *et al.*, 1998). The environmental laboratory at LCC has a number of QC measures in place with regard to sampling. These include monitoring of unstable parameters *in-situ* using calibrated field meters, transportation of samples in cooler boxes, use of sterilised bottles for microbiological sampling, use of disposable plastic sampling containers for physical/chemical samples and in-house training of new members of staff.

In order to comply fully with the requirements of ISO 5667 a number of additional QC measures must be introduced (Table 3.3). These corrective actions can be implemented using existing resources, however, the time scale and cost of implementation of the proposed corrective actions vary. For example, the documentation of sampling training procedures, training of sampling

personnel and development of detailed training records can be readily implemented within a short period of time and at a relatively low cost. On the other hand, the development, documentation and implementation of a complete analytical QC programme for periodically testing sampling methods used would take considerable time and expense to implement fully. The reason for this being that such a programme would require the use of field blanks, samples with added determinands and/or duplicate samples in order to identify possible sources of error in the sampling method. The implementation of these techniques would also result in an increased workload for both the sampler and the analyst. The introduction of an adequate preservation programme, to ensure that the concentration or physical state of the determinand of interest is not altered during storage, would also be time consuming and expensive to implement fully (see Section 4.2.3)

4.2.3 Preservation

Samples should be preserved when the interval between sample collection and analysis is long enough to produce changes in either the concentration or the physical state of the constituent to be measured (Crosby and Patel 1995 and Flanagan, 1990*b*). Aside from the preservation of microbiological samples (by the addition of sodium thiosulphate prior to sterilisation), staff of the environmental laboratory at LCC do not carry out preservation of any physical/chemical samples at the sampling site. Laboratory staff do, however, monitor a number of unstable parameters at the sampling site. The parameters measured *in situ* are temperature, pH, dissolved oxygen and chlorine.

From the results obtained from the questionnaire, it is apparent that, similar to LCC laboratory, most LAs do not preserve samples. Figure 3.8 (page 38) shows that no LA laboratory preserves for oil and grease while a mere 5% preserve for ammonia. EPA laboratories do, however, generally preserve samples. All EPA laboratories preserve samples taken for oil and grease and metals, while 67% preserve samples for ammonia.

The requirement to preserve samples, during sampling or immediately afterwards, is stated in each part of ISO 5667 audited. Other workers have also stressed the importance of preservation. (Flanagan *et al.*, 2003; Clesceri *et al.*, 1998 and Bartram *et al.*, 1996) This highlights the importance of sample preservation in maintaining the integrity of a sample during transport and storage.

A number of corrective actions in relation to sample preservation emerged from the gap analysis undertaken between ISO 5667 and current LCC sample preservation practices (Table 3.4). Some of these corrective actions can be implemented in the medium term at a low/medium cost using existing laboratory facilities and resources e.g. the preservation method(s) required for the various samples could be readily identified and documented. The implementation of these sampling procedures in the field, however, will require extra resources. These resources are mainly associated with the increased workload associated with an efficient preservation programme. For example, the preservation of samples on-site would result in an increased pre-sampling preparation time and also an increased sampling time as more sample containers may be required to be labelled and filled. The keeping of adequate records of all preservation steps, as required under ISO 5667, will also be time consuming.

ISO 5667 –3 and ISO 5667-14 state that the preservation method used must not result in dilution of the analyte or interfere with the subsequent analysis thereby influencing the final result. In order to comply with this requirement an appropriate QC procedure must be developed, documented and implemented. Although this may result in a significant increase in the laboratory analysts' workload it should not result in a significant increase in the sampler's workload, as no additional sampling is required. This corrective action could therefore be implemented in the medium term at a medium cost (Table 3.4).

Composite samplers are currently used by LCC staff to sample wastewaters. These samples are analysed for BOD, COD, suspended solids and nutrients. ISO 5667 –10 requires that when composite samples are collected over extended periods, preservation should be an integral part of the sampling operation. The EPA recommend the use of automatic samplers with built-in refrigeration when sampling wastewater treatment plants, however, they have stated that an acceptable compromise would be to protect the sampling equipment from direct sunlight (EPA 1996). Preservation is required for a number of parameters analysed in composite wastewater samples taken by LCC environmental staff e.g. samples undergoing analyses for BOD and phosphate require preservation by refrigeration; samples analysed for ammonia must be preserved by acidification. Composite samplers that incorporate preservation facilities are extremely expensive and may not be necessary i.e. due to the high levels of the above pollutants present in most wastewater samples the non-preservation of the sample may not significantly affect the result obtained. This can only be ascertained by determining the stability of the parameters of interest using a large number of representative wastewater samples.

4.2.4 Sampling procedures

4.2.4.1 Drinking Water sampling

The European Communities (Drinking Water) Regulations, 2000, came into force in Ireland on 1st January, 2004. As a result of this, the EPA has published a draft implementation handbook for sanitary authorities entitled *'European Communities (Drinking Water) Regulations, 2000 – A handbook on implementation for sanitary authorities Draft'* (Flanagan *et al.*, 2003). The requirements of this handbook are very similar to those of ISO 5667-5 (e.g. both require sampling procedures to be documented, sampling locations to be pre-determined and mapped and correct and immediate sample preservation and storage)

The results of the gap analysis carried out between ISO 5667- Parts 1, 2, 3, 5 and 14 and the current drinking water sampling procedures at LCC revealed that a number of the requirements of ISO 5667-5 are already being met by the laboratory. Nevertheless, a significant number of requirements remain to be implemented (Table 3.5).

Each laboratory should produce a sampling manual (ISO 5667; Flanagan *et al.*, 2003; Barron, 2001 and Clesceri *et al.*, 1998). This manual should include the procedures and precautions to be adopted for each parameter or group of parameters. Sampling manuals of the environmental laboratory at LCC are in the form of documented standard operating procedures (SOP) as shown in Appendix B.

SOP No. 6 relates to the sampling of drinking water from consumer taps. This SOP gives details on the sampling equipment required, the need to sterilise and run the tap prior to sampling and the requirement to test for chlorine on-site. SOP No. 6 is not sufficiently comprehensive, however, to meet the requirements of ISO 5667, and in particular, Parts 1, 2, 3 and 5. A number of amendments must be made to SOP No. 6 in order to rectify this situation. These amendments cover such areas as the nature of sampling taps, sampling containers, field meters, sample volumes, filling, preservation and sealing of samples, sampling in low flow areas, QC measures, sample storage and transportation, field records and safety precautions (Table 3.5 –C.A.2)

Some of the amendments required of SOP no. 6 are currently being carried out by LCC staff, however, they fall short of ISO 5667 requirements because they are not documented in the appropriate SOP. For example, current drinking water sampling practice at LCC is to;

-measure a number of parameters *in-situ* (using field equipment that has been checked/calibrated);
-fill sample into sample container and seal;
-record results and other information into the appropriate field report sheet; and
-transport samples back to the laboratory in cooler boxes.

This information is not, however, documented in SOP No. 6. To do so, would require little effort and expense as outlined in Table 3.5-C.A.2.

Comprehensive details must be included in SOP No. 6 in relation to the selection of sampling containers and the cleaning/preparation/sterilisation of same. All physical/chemical drinking water samples taken by LCC environmental staff are currently collected in high-density polyethylene (HDPE) bottles. Although this practice was sufficient for the analysis of most of the physical/chemical parameters under the now revoked European Communities (Drinking Water) Regulations, 1988, the new European Communities (Drinking Water) Regulations, 2000 (which came into force in January 2004) requires a wider range of parameters to be monitored and many of these require the use of specific containers for sample storage (e.g. pesticides and trihalomethanes). Therefore, the issue of sampling containers needs to be urgently addressed. This can be done in short term, however, the cost incurred may be low/medium as the sampling time per sample will increase due to a larger number of bottles requiring labelling and filling.

SOP No. 6 does not include details in relation to a number of requirements of ISO 5667. For example, SOP No. 6 does not include details on the selection of sampling taps, the volume of sample to be collected, parameters to be measured on-site, taking of samples, sealing of sample bottles, preservation of samples for various parameters, storage of samples and safety considerations. This information is readily available in ISO 5667 and other publications (Flanagan *et al.*, 2003 and Anon, 1998) and therefore could be easily included in SOP No. 6 in the short term at a low cost (Table 3.5- C.A. 2). Other details absent from SOP No. 6 (and that are required under ISO 5667) include procedures for sampling at different locations (e.g. from reservoirs, water treatment plants and hydrants), procedures for sampling in areas of low flow (to avoid disturbance of sedimentary material) and procedures for taking QC samples. This information is also readily available in ISO 5667 and other publications (Flanagan *et al.*, 2003 and Anon, 1998) and therefore could be easily included in SOP No. 6 in the short term at a low cost (Table 3.5- C.A. 2).

Results from the questionnaire revealed that, like LCC, most LA laboratories have documented procedures in place for sampling drinking water. The level of detail included in these procedures, however, would appear to fall short of ISO 5667 and EPA requirements particularly in relation to sampling container, sample labelling and preservation of samples. EPA laboratories generally seem to have more detailed documented procedures with regard to the above (Section 3.1.2). The use of the incorrect container type may affect the accuracy of the result obtained. For some analytes desorption of constituents from the sample container would result in artificially elevated results, while for others the adsorption of constituents of the sample onto the container would result in artificially reduced results. If the samples are not preserved or not preserved correctly, the concentrations determined may be different from those existing at the time of sampling. (Flanagan *et al.*, 2003, Clesceri *et al.*, 1998, NSAI, 1996, ISO 1987 and Department of Environment, 1981). The above may have a significant affect on the sample results obtained and subsequently reported to members of the public. If it were found that previous results reported as complying were in fact in breach of legislation limits public confidence in drinking water quality would be seriously impacted on.

Certain requirements of ISO 5667 require further investigation before details of same can be incorporated in SOP No. 6. For example, the need to monitor taste on-site at a time when the microbiological quality of the water sample is unknown and the requirement to disinfect using a chlorine solution instead of alcohol (which is currently being used). This could be assessed in the short term at low cost by referencing relevant documentation e.g. Flanagan *et al.*, 2003 and Anon, 1998. Furthermore, ISO 5667 requires that a method be developed and incorporated into the sampling programme for investigating the dissolution of materials (e.g. lead) from pipework or the growth of microorganisms within the pipework (e.g. due to lack of scouring). Either of the above may have a significant effect on water quality if present in excessive amounts. As information with regard to the above is not readily available, a complete investigation would have to be carried out. This could take a considerable period of time and resources.

The requirement to record relevant drinking water field data on a field sheet is not only stated in ISO 5667-5 but also by other workers (Flanagan *et al,* 2003; Clesceri *et al,* 1998; Bartram *et al,* 1996 and Crosby and Patel, 1995). LCC laboratory has a designated drinking water field sheet, however, this is not sufficiently comprehensive to meet the requirements of ISO 5667-5. The drinking water field sheet used by LCC environmental staff needs to be amended to include

details on weather conditions, unusual observations and information on samples taken for specific reasons (Table 3.5- C.A.11).

In summary, all of the corrective actions with regard to drinking water sampling can be implemented using existing resources in a medium/short period of time and at a relatively low cost. Obtaining accreditation for drinking water sampling (i.e. to ISO 5667-5) would be particularly beneficial, as it would increase consumer confidence in the results obtained.

4.2.4.2 River sampling

Monitoring of river water quality is required in order to assess compliance with a number of pieces of legislation including the Local Government (Water Pollution) Act, 1977 (Water Quality Standards for Phosphorus) Regulations, 1998 and European Communities (Quality of Surface Water Intended for the Abstraction of Drinking Water) Regulations, 1989. All river quality data is submitted to the EPA on an annual basis where it is subsequently used in the preparation of State of the Environment Reports. LCC laboratory staff sample a number of river catchments on a monthly basis at pre-determined sampling points. Surface waters used for the abstraction of drinking water are sampled on a quarterly basis.

A gap analysis undertaken between ISO 5667- Parts 1, 2, 3, 6 and 14 and the current river water sampling procedures at LCC revealed that while some of the requirements are currently being met a significant number of non conformances still exist. The corrective actions required to remedy this situation are shown in Table 3.6.

SOP No. 8 relates to the sampling of river water while SOP No. 47 relates to the sampling of surface waters used for the abstraction of drinking water (Appendix B). SOP No. 8 gives details on the sampling equipment required, the need to measure dissolved oxygen and temperature at the sampling site and the need to fill sampling bottles to overflow. SOP No. 47 also gives details on the sampling equipment required, where samples should be taken and sample transportation. The details included in SOP No.'s 8 and 47 are not sufficient to satisfy the requirements of ISO 5667. The details that are lacking are similar to those missing in SOP No. 6 for drinking water. For example, details with regard to sampling containers, sampling equipment, calibration of field meters, volume of sample required, the filling of the sample container and the preservation of samples (Table 3.6-C.A. 4).

The amendments required to SOP No.'s 8 and 47, in order to comply with ISO 5667, can be sub-divided into those amendments that can be achieved in the short term using existing resources, those that can be achieved in the long term using existing resources and those that cannot be achieved using existing resources thereby necessitating a long time scale for full implementation.

Short-term amendments relate to the inclusion into the SOP of details which are readily available in literature (and in particular ISO 5667) or are currently being carried out at LCC but not documented. For example, current river water quality monitoring practice is to;
-check/calibrate field meters prior to and during sampling
-measure a number of parameters *in situ* e.g. dissolved oxygen, temperature, pH and conductivity;
-record results on an appropriate field sheet;
-take samples in cleaned/pre-rinsed sample containers;
-seal samples;
-transport these back to the laboratory in cooler boxes.

The above practices are, however, not documented in SOP No.'s 8 or 47. This could be remedied in the short term at relatively little expense.

As mentioned previously, some of the detail lacking in SOP No.'s 8 and 47 is readily available in literature and its inclusion merely necessitates the review of this literature, the incorporation of the relevant detail into the SOP and its implementation in current sampling practice. For example, SOP No.'s 8 and 47 does not include details in relation to sampling containers and how these are to be prepared prior to use. ISO 5667 contains a vast amount of information on sampling containers and also on the preparation of such containers. Information in relation to sampling containers is also contained in Anon, 1998. The appropriate information could easily be incorporated into SOP No.'s 8 and 47 from these sources.

Results of the questionnaire revealed that 71% of respondents document the type of sampling container to be used in their SOP. However, it appears that on some occasions the details included in the SOP are incorrect i.e. not one LA or EPA laboratory use glass bottles for phosphate analysis. This highlights the need to document correctly the type of sampling container to be used. This could easily be incorporated into SOP No.'s 8 and 47 in the short term at relatively little expense.

Other information lacking in SOP No.'s 8 and 47 include details on sampling equipment, volume of sample to be collected for various parameters, filling and sealing of sample containers and sample storage/transportation. This information is readily available in literature and could be documented in SOP No. 8 in the short term at relatively little expense.

The gap analysis also revealed that SOP No. 8 does not include sufficient detail in relation to sampling during abnormal conditions i.e. under flood conditions or during algal blooms (Table 3.6-C.A. 9). If sampling is not carried out correctly under these conditions then the results obtained will not be representative. In order to rectify this situation, possible abnormal conditions must be identified and sampling requirements prepared for each of these conditions. This could be achieved in the short term, however, a medium cost may be incurred as additional sampling equipment may have to be purchased.

Similar to the drinking water field report sheet, the report sheet used for river sampling does not provide for the recording of all the necessary information specified in ISO 5667-6. LCC does not have a specific report sheet for sampling surface waters used for abstraction of drinking water. This must be developed as per ISO 5667-6. This could be achieved in the short term at a relatively low cost to the laboratory.

Some of the corrective actions identified in the gap analysis may prove to be expensive and time consuming to implement. For example, if an accurate measurement of dissolved oxygen (D.O.) is required (i.e. a measurement of D.O. taken directly in the water-body as opposed to the current approximate measurement of D.O. in the sampling bucket) then the existing short probes would have to be replaced by long probes, thereby incurring a high cost (Table 3.6 – C.A.10).

Some of the proposed corrective actions required in order to fully comply with ISO 5667 are beyond the scope and capability of the laboratory and therefore appropriate external consultants would have to be engaged. Some examples are given below.

Pollutants present in a waterbody may be distributed uniformly throughout or they may, for various reasons, be concentrated in a particular section (ISO, 1990). If a waterbody displays non-homogenous distribution of pollutants then this will greatly affect the results obtained as the sample taken may not be representative of the major part of the water body. ISO 5667 requires a

determination of the type of distribution of the pollutants of interest in a waterbody (i.e. homogenous or non-homogenous) to be ascertained. The expertise necessary to carry out such a study is not available in LCC and therefore implementation would be expensive and time consuming.

'If significant streaming or stratification exists at the sampling point a series of transverse and depth samples should be collected to determine the nature and extent of any streaming or stratification' (ISO 5667-1- Section 2.9.3.1). This would firstly involve identifying a method to assess stratification and then an assessment of each river sampling site. Stratification is important because it means that pollutants can be isolated in discrete areas of a waterbody. Sampling from stratified waterways may miss pollutants altogether or result in exaggerated pollutant concentrations.

In order to determine the impact of a discharge (wastewater or adjoining tributary) on a river, upstream and downstream sampling points must be accurately determined (NSAI 1994, ISO,1990). The location of the downstream point is dependent on the particular river, the time of travel of pollutants and the degree of vertical, lateral and longitudinal mixing in the waterbody. ISO 5667-6 (5.1.1.1) recommends the use of tracer techniques and conductivity measurements to determine the degree of mixing in a river system. The expertise necessary to carry out such a study is not available in LCC and therefore implementation would be expensive and time consuming.

4.2.4.3 Wastewater

Staff of LCC's environmental laboratory monitor all LA Urban wastewater treatment plants in the county in order to assess their operational efficiency as required under the Environmental Protection Agency Act, 1992 (Urban Waste Water Treatment) Regulations, 1994. Industrial discharges (to both water and sewer) licensed under the Local Government (Water Pollution) Act, 1977-1990 are also monitored.

The gap analysis undertaken between ISO 5667 - Parts 1, 2, 3, 10 and 14 and the current wastewater sampling procedures at LCC revealed that while some of the ISO 5667 requirements in relation to wastewater sampling are currently being met a significant number of requirements

have yet to be addressed. Table 3.7 details the corrective actions required in order to comply with ISO 5667 with regard to wastewater sampling.

SOP No. 10 relates to sampling from urban WWTPs while SOP No. 11 relates to industrial effluent sampling (Appendix B). SOPs No.'s 10 and 11 make reference to personal safety, give details on the sampling equipment required and list the sampling locations. SOP No. 10 also lists the parameters to be measured on-site The details included in SOPs No.'s 10 and 11 are not sufficient to fulfil all of the requirements of ISO 5667. The amendments required to rectify this are similar in nature to those required for drinking water and river water.

SOP No.'s 10 and 11 do not document a number of wastewater sampling practices and procedures already in place at LCC. For example, it is standard practice for LCC's environmental staff to attach a container to a long armed sampling device to avoid contamination of sampling containers. In addition, sampling containers are not reused. These practices are not documented in the appropriate SOPs. Temperature, pH and conductivity are monitored *in-situ* during industrial effluent sampling, using calibrated field meters. Again, this is not documented in the appropriate SOPs. As these procedures are currently being carried out the inclusion of such details in the appropriate SOPs could take place in the short term.

As was observed in the SOPs for drinking water and river water sampling, details regarding the type of sampling container(s) to be used, the volume of sample(s) required and sample preservation are not included in the wastewater SOPs. This situation could be rectified in the short term as the information required is readily available. In fact, if a comprehensive SOP was prepared for drinking water, river or wastewater sampling it could be used as a template for the other sampling SOP's as the type of information required is very similar in all situations.

The gap analysis undertaken between LCC's current wastewater sampling procedures and ISO 5667-10 revealed that additional documented procedures are required in LCC's wastewater sampling SOPs in order to comply with ISO 5667. These procedures (which relate to the selection and purchase of effective samplers and sampling containers, the freezing and thawing of samples and sampling of storm sewage and surface run-off) must first be prepared using the guidelines provided in ISO 5667. As the information regarding the above is readily available these procedures could be documented in the short term at a low cost to the laboratory.

LCC do not, at present, have a specific field report form for sampling wastewaters. Such a report form is necessary to comply with the requirements of ISO 5667, which also includes details of the information to be included in these forms (ISO 5667-10:1992 (E-7). The requirement to complete this field report sheet must be included in SOP No.'s 10 and 11. SOP No. 11 must also include a requirement to note the operating procedures inside the plant at the time of sampling. This information is necessary to allow the sample results obtained to be compared with the activity at the time of sampling. The above corrective actions can be implemented using existing resources over a relatively short time scale and at a relatively low cost.

The requirement to prepare specific field report forms has been highlighted in the gap analyses undertaken for drinking water, river water and wastewater sampling. The questionnaire also revealed the lack of use of specific field report sheet in other LA laboratories. Only 33% of LA laboratories, which responded to the questionnaire, have specific field report sheets. This is in contrast to EPA laboratories, all of whom have specific field report forms.

Under the EPA Act, 1992 (Urban Waste Water Treatment) Regulations, 1994, 24 hour composite samples are required when sampling WWTP's. In LCC these composite samplers are purchased and operated by the relevant County Council area offices. There are no documented procedures, within LCC, with regard to the purchasing of such composite samplers or the taking of composite samples. The procedure for purchasing composite samplers should take into account the specifications given in ISO 5667-10, which are applicable to the specific use(s) of the sampler. In order to fulfil the requirements of ISO 5667, the procedure for taking of composite samples must include details on the type of composite sample required, the number of samples to be taken (which must be determined statistically) and the period over which the samples are to be taken. Details of the parameters which cannot be measured in a composite sample (e.g. temperature and pH) must also be included. Although all of the above corrective actions can be implemented in-house, the period for implementation may be long-term if it is found that the current composite samplers do not meet the relevant specifications stated in ISO 5667. The purchase of replacement composite samplers would be very expensive.

5.0 CONCLUSIONS

5.1 Questionnaire

From the questionnaire, it was concluded that:

1. No laboratory in Ireland is currently accredited to ISO 5667 nor are any of the laboratories, which responded, in the process of attaining accreditation to this standard. 26% of laboratories, which responded, have considered accreditation to ISO 5667 however most of these have found it to be very complex and currently have it as part of their long-term plan.

2. The sampling procedure used by environmental laboratories is not generally questioned during legal proceedings. This may be one of the reasons why no laboratory is accredited to ISO 5667.

3. Of the laboratories, which replied to the questionnaire, only 74% of Local Authority (LA) and 60% of EPA laboratories have documented sampling procedures. The documented sampling procedures in EPA laboratories seems to be more detailed than those in LA laboratories, particularly with regard to the type of sampling container to be used and the samples which are to be preserved.

4. The questionnaire indicated similar trends within the various laboratory sectors. For example, LA laboratories generally do not preserve samples i.e. none preserve for oil and grease with very few (5%) preserving for ammonia. Similarly very few (27 %) analyse quality control field blanks or have considered obtaining accreditation specifically to ISO 5667. The trends in EPA laboratories are somewhat different, from those in LA laboratories, in that all EPA laboratories preserve samples for oil and grease and most (67%) preserve for ammonia. A higher percentage (60%) also carry out quality control field blanks and have considered obtaining accreditation specifically to ISO 5667.

5. Results of the questionnaire revealed that all laboratories questioned use the incorrect type of sampling container for water samples used for phosphate analysis. The Local Government (Water Pollution) Act, 1977 (Water Quality Standards for Phosphorus) Regulations, 1998 specifies that phosphate levels >0.07mg/l are indicative of a seriously

polluted river. This is a very low level in analytical terms and hence the impact of absorption of phosphate into the sampling container may be significant if the incorrect type of container is used.

5.2 Gap Analysis

From the gap analysis, it was concluded that:

1. The gap analysis undertaken between ISO 5667 and current practices and procedures at Limerick County Council environmental laboratory has highlighted the need for;
   - Comprehensive sampling programmes which details the objectives of the sampling programme, sampling locations, sampling times, frequency of sampling, numbers of samples required and the precision adequate for analytical field results thereby providing representative samples of the waterbody, drinking water or wastewater being monitored. This information can be obtained from relevant leglisation and associated implementation handbooks.
   - Comprehensive sampling procedures containing detailed information in relation to sampling equipment (including sample containers and field meters), sample volumes required, filling of samples, sample preservation, sample storage, sample transportation, maintenance of records, quality control measures and safety precautions. This information can be obtained from Standard Methods (A.P.H.A 1998), relevant legislation and associated implementation handbooks.

2. The requirements of ISO 5667 with regard to the detail required in the various sampling SOPS for river water, drinking water and wastewater sampling are similar to one another. If a comprehensive SOP was prepared for the sampling of one of these water bodies it could be used as a template for the other sampling SOP's. The situation is similar for field report forms.

3. Approximately 80% of the corrective actions required to bring LCC current sampling procedure in line with ISO 5667 requirements could be implemented using current laboratory resources and facilities. The time scale for implementation of these corrective actions varies. Total compliance with all the relevant requirements of ISO 5667 is currently beyond the scope of the environmental laboratory at LCC. This is due to the lack of relevant in-house expertise and financial constraints with regard to such areas as

assessing sampling sites for stratification, ensuring sufficient turbulence in the waterbody being sampled and implementing measures to overcome or minimize heterogeneity.

4. The costs incurred in fully implementing ISO 5667 include;
   - administration costs with regard to the documentation of sampling programmes and sampling procedures;
   - labour cost with regard to the implementation of new procedures (e.g. preserving samples and carrying out quality control checks);
   - purchasing costs with regard to the required materials; and
   - external consultant fees.

   The measures, which can be implemented in-house, could probably be met by using the current annual budget provided adequate staff time is allocated. External consultants fees could not be paid for from this budget since external consultant fees would very quickly reach tens of thousands of euros.

5. The requirements with regard to the correct sampling and preservation of samples are becoming more significant. This has been particularly noticeably in the EPA's draft handbook on the implementation of the European Communities (Drinking Water) Regulations, 2000 for sanitary authorities, which was published in 2003. Several of the requirements specified are similar to those of ISO 5667-5.

6.0 RECOMMENDATIONS

1. The questionnaire return rate from the independent laboratory sector was very low (36%) and was therefore not truly representative of water sampling practices in this sector. More representative information regarding the independent laboratory sector therefore needs to be obtained.

2. The questionnaire has highlighted significant gaps in relation to sampling by LA and EPA laboratories. The areas of sampling that require immediate attention are;
   - documentation of sampling training procedures
   - maintaining sampling training records
   - using the correct container type when sampling for phosphate
   - preservation of samples (in particular LA laboratories) and maintaining records of same
   - carrying out quality control checks on the sampling procedures.

   The EPA, as part of their regulatory role, should ensure that these procedures are in place.

3. The Local Government (Water Pollution) Act, 1977 (Water Quality Standards for Phosphorus) Regulations, 1998 required LAs to prepare and present to the EPA, a Phosphate Measures Report by July 1999 and Implementation Reports every two years thereafter. These reports incorporate results of the monitoring of phosphate levels in specified waterbodies together with details of phosphate reduction programmes. As no laboratory, which responded to the questionnaire, use the correct type of sampling containers when sampling for phosphate it needs to be firstly determined if the phosphate levels currently being measured by LA and EPA laboratories are accurate. If it were found that the phosphate levels have been underestimated a review of the phosphate reduction programmes would then have to be undertaken.

4. Under EU and Irish legislation all LA Laboratories are required to carry out similar water quality monitoring programmes. From the questionnaire, it became apparent that the sampling procedures and practices in LCC are similar to those in other LA laboratories. Therefore, the gap analysis carried out as part of this dissertation could be used as a

template in assessing the work required by other LA laboratories in obtaining accreditation to ISO 5667.

5. The gap analysis undertaken between practices and procedures carried out at LCC's environmental laboratory and ISO 5667 indicated that several of the requirements of this standard could be implemented in-house using existing facilities. Implementation of these measures would be a positive step towards accreditation and would prepare sampling staff towards working to full accreditation.

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APPENDIX A

THE DISTRICT COURT

THE DISTRICT COURT AREA OF RATHKEALE DISTRICT COURT NO. 13.

BETWEEN/

THE COUNTY COUNCIL OF THE COUNTY OF LIMERICK

Complainant.

AND/

A.I.B.P. LIMITED

Accused.

RATHKEALE DISTRICT COURT - 14th JULY 1997.

1. **BACKGROUND:**

The above entitled Prosecution under Section 3 of the Local Government (Water Pollution) Act 1977 as amended by the Local Government (Water Pollution) (Amendment) Act 1990 was dismissed by the District Court Judge and the consequential Application under Section 10 was refused. The Court awarded Costs to the accused to follow the event on both matters.

In my opinion the learned District Judge was correct to dismiss the prosecution as there were serious flaws with the evidence adduced by and on behalf of the prosecution which I outline below.

2. **PROBLEMS WITH THE PROSECUTION EVIDENCE:**

1. The samples were not taken properly.

The evidence before the Court was that the samples were acquired using a jug and long-handled scoop which had been used previously by the Officer in question and which was stored in the back of his car. There were further problems in that the samples of water obtained were stored in plastic bottles instead of appropriately

cleaned glass bottles. The samples were kept in a questionable storage environment and there was imprecise labelling and record keeping of the samples.

2. The samples were not taken from the proper location. In the opinion of the District Court Judge the Prosecution should have acquired samples from the river water both upstream, downstream and at the location of the out-fall pipe in question as well as obtaining samples from the Defendant's plant.

3. None of the dead fish were analysed for a cause of death to establish a fish kill caused by toxic pollutant.

4. The chain of evidence with regard to the handling of the samples was not established. The evidence under this heading was particularly unsatisfactory. There was no proper labelling of record-keeping as to what happened the samples. The dates, times and locations as to when the samples were handed over were not maintained. There was no evidence from D.H.L. Couriers who transferred the samples from B.H.P. to A.E.S. in England.

5. The handling of the samples left it open to the question of possible contamination.

The evidence was that having obtained the sample the relevant Officer placed it in a plastic bottle for that purpose and labelled it. It is unclear as to whether he sealed the top of the bottle in any manner. It subsequently transpired that the relevant Officer opened the samples in Limerick Laboratory before sending them on to B.H.P. for analysis.

When B.H.P. acquired the samples the records were not satisfactory and again it transpired that the sample was taken from the plastic bottle and placed into a glass bottle of some description but again there was

no precise evidence as to the conditions under which this was done nor as to whether the glass bottle was fully filled or properly sealed. Furthermore, it transpired that B.H.P. did not disclose to the relevant Officer of Limerick County Council that they intended to " farm out " the relevant analysis to a Laboratory in England rather than doing it themselves.

B.H.P. then handed the sample to D.H.L. Couriers for transportation to the A.E.S. Laboratory in England, again there was no evidence as to the storage conditions under which the samples were transported or maintained and it also transpired that B.H.P. sent the relevant sample as part of a batch of other samples from Syntex in Clarecastle.

D.H.L. delivered the sample to A.E.S. and again there is no evidence as to proper record-keeping of the handling of the sample.

3. **THE ANALYSIS REPORTS:**

The Analysis Reports were unsatisfactory in that it transpired that the B.H.P. Report furnished by B.H.P. to Limerick County Council was less than candid in that it did not disclose that the analysis had been carried out by Doctor Ian Barnabas of A.E.S. in England but rather it, to quote the Judge, plagarised Doctor Barnabas's Report by summarising his findings. Furthermore, the B.H.P. Report failed to give the result of the analysis carried out by the B.H.P. on the other two samples. Furthermore, the Report was insufficient as regards the details of labelling, handling and storage of the samples and the methods of analysis etc.

4. **COMMENT:**

At the hearing of this Prosecution it became quite evident that the people involved in the taking and

handling of the samples had little or no knowledge of the type of forensic requirements that a Court of Law would need to satisfy it beyond all reasonable doubt as to the integrity and accuracy of the sampling procedure and the manner in which that sample was handled. Furthermore there was insufficient record-keeping as to the identity, labelling and handling of samples, the conditions under which samples were stored, and the particulars of analysis.

Nothing further occurs to me at present.

ated this the 15th day of July 1997.

MICHAEL FINBARR COLLINS,
BARRISTER-AT-LAW.

APPENDIX B

Limerick Countr Council Laboratory
Standard Operating Procedure No.6

Routine Drinking Water Supply Samples.

- Prepare a list of supplies to be sampled.

- Obtain the following:
  Pre - sterilised thiosulphate containing glass bottles.
  Clean plastic bottles.
  Chlorine meter with powder pillows for total and free Clorineand cuvettes.
  Alcohol.
  Indelible marker.

- If possible obtain the sample from a shop / Co-op / Co. Council Office et.....

- Identify yourself and state that you work for Limerick Co. Council.

- Inform them that you are taking a water sample as part of a routine sampling programme to assure water quality and request permission to take a sample.

- Run tap of for approx., two minutes before sampling.

- Enquire if there have been any problems with the water quality in the recent past.

- Run chlorine test as per HACH method.

- Label bottles with:
  Name of supply
  Date
  Chlorine level - total, free
  Temp. for C3.

- Soak mouth of tap in alcohol and run tap again.

  Fill sterile bottle with water using aseptic technique. Rinse out plastic bottle and fill to overflowing.Thank supply user for their help, and clean your work area

- Return Equipment and samples to car, putting sterile bottle in cooler.

- Return to laboratory before 16:00 hours to facilitate bacteriological analysis and sample logging

Signed: _____ Date: 9-7-98

Co signed: _____

Limerick County Council Laboratory
Standard Operating Procedures No.8
Routine River Sampling.

- *At all times have regard to your personal safety.*
- Obtain a map of your sampling route with location codes.
- Take the following:
  Reflective coat
  Clean sample bottles
  Calibrated D.O. meter
  Indelible marker
  Sampler on a rope, or a long armed sampler
  Map
  Gloves.
- Park safely at sampling point.
- Drop D.O. meter probe into moving water and allow reading to settle.
- Mark bottle with location , D.O. (%), temp. (Deg C), and note anything unusual with the river quality, height, weather et....
- Rinse sampler and sample bottle. Fill sample bottle to overflow. Leave no air spaces.
- Move to next location.
- Return to laboratory by 16:15 hours, and log samples and record pH.

Signed: _____ Date: 9.7.98

Co signed: _____

Limerick County Council laboratory
Standard Operating Procedure No.10

Sewage Treatment Plant Sampling.

- *At all times have regard to your own personal safety.*
- Observe the **strictest hygiene measures** through out the day.
- Where a composite sampler is available, contact the STP caretaker the evening before, sampling and requesting him / her to set the sampler in motion.
- Request that the sampling container is cleaned out carefully prior to the sampler being set in motion.
- Inform someone at your base, of the route you are taking.
- Take the following with you:
  Clean bottles
  Marker
  Long armed sampler
  D.O. meter
  Master keys
  Heavy duty gloves
- Clearly mark bottles giving the plant name , and the type of sample.
- Where access is possible take samples from the influent and effluent.
- Where composite sampler is available take composite sample
- Where composite sampler is unavailable take a grab from the middle channel.
- Where access is difficult use the long armed sampler, ensuring that it is rinsed out well before each sample is taken.
- Where time allows or where the effluent looks poor take both upstream and downstream samples.
- At activated sludge plants where time allows take a mixed liquor sample and measure the oxygen in the tank.
- Record this information on the sample bottle.

- Where possible rinse all equipment before returning to car.
- Return to the laboratory by 16:15 hours, log samples put on C.O.D. tests and store samples.

Signed: C. [illegible] Date: 9.7.98

Co signed: B. Coo[illegible]

Limerick Countr Council laboratory
Standard Operating Procedures No.11

Industrial Effluent Sampling

- *At all times have regard for your own personal safety.*
- Observe the **strictest hygiene measures** through out the day.
- Obtain a list of industries to be sampled.
- Inform someone at your base of the route you are about to take.
- Inform yourself as to the nature of the discharge and whether the industry is discharging to a sewer or to waters.
- Take the following with you:
  Clean sample bottles
  Long armed sampler
  Marker
  Heavy duty gloves
  Man hole keys.
- Call to reception at the industry and show your identification.
- Inform them that you are from the Co. Council and that you are there to take a sample of their industrial discharge. Ask if there is anyone from the company who would like to accompany you.
- Take a grab sample of the discharge from the location indicated in the discharge licence. Offer a split sample to the company.
- In the event of having to lift a manhole, ask for help.
  Do not attempt to lift a manhole on your own.
- Rinse the sampler and bottle out with the effluent before taking the sample.
- Mark the bottle with the name of the company and the nature of the sample.
- Return the laboratory before 16:15 hours to log samples and set up C.O.D.s' and record pH

Signed: _____ Date: 9.2.98

Co signed: _____

Limerick County Council
Environment Laboratory
Ballykeeffe

Standard Operating Procedure	*Page 1 of 1*
No. 43	*Issue No. 1*
	17/12/01

Procedure for handling of test samples or items:

A: System for identifying test samples:

1. On arrival to the laboratory record test sample details on the appropriate pre-prepared result sheet.
2. Obtain a unique identification code for each test sample from the 'samlog' database (available on the computer network) recording sample details, receipt date and sampler.
3. Record this identification code:
   (a) with the relevant details, on the result sheet
   (b) on the sample bottle.
4. Use the identification code:
   (a) to record results in the results book.
   (b) if the sample or part of it are to be sub-contractor to an outside laboratory.

B: System for identifying items for calibration:

1. Obtain a unique identification code for all prepared and purchased calibration and AQC standards in the appropriate logbook in the laboratory.
2. Record details regarding standard concentration, source, expiry date and analyst in the logbook (for the appropriate code)
3. Record standard concentration, identification code and expiry date on the standard solution bottle.

C: Storage, handling and preparation of test items:

1. Wear the appropriate personal protective equipment and observe safety rules while sampling.
2. Store collected samples in an appropriate cooler box (i.e. there are separate cooler boxes for drinking water samples) while transporting to the laboratory.
3. When analysis are not been carried out on the test sample store in the appropriate fridge (i.e. there is a separate fridge for drinking water samples).
4. Wear appropriate personal protective equipment, where necessary, when handling samples for analysis.
5. When analysis is complete, as required on the appropriate result sheet, dispose of the sample in a safe manner.

Note: Samples which are not taken by laboratory personnel are only accepted, for analysis, with the approval of the Technical Manager and if taken and transported in a timely manner.

Signed: Carol Sweetman Date: 17/12/01

Co-Signed: [signature] Date: 17.12.01

SI 294 – Surface Waters for Abstraction of Waters Intended for Human Consumption

Sampling Procedure

1. Notify the sub-contracting laboratory prior to sampling Cryptosporidium. Outline that raw and treated samples will be delivered for each sampling location. State that only the samples marked as raw water are to be analysed. Treated samples are to be put on standby. State that in the event of a positive result for Crypto in a raw sample, the corresponding treated sample is to be analysed immediately. State that positive results must be phoned to the Environment Laboratory immediately.

2. Notify the sub-contracting laboratory prior to sampling Salmonella Outline that raw and treated samples will be delivered for each location. State that all samples are to be analysed. State that positive results must be phoned to the Environment Laboratory immediately.

The following sample bottles must be taken for each site:

1. 2 No. 250ml sterile glass bottles (One for Total and Faecal Coliforms and Streptococci and one for Clostridium). Samples to be taken of raw water only.
2. 2 No. 500 ml sterile glass bottles (For Salmonella analysis on raw water and treated water)
3. 2 No. 10 litre sterile plastic bottles (One for Cryptosporidium on raw water and one for Cryptosporidium on treated water)
4. 2 No. 1 litre plastic bottles (For chemical analysis including sub sampling on raw water)

All raw water samples should be taken at the abstraction point or if this is not feasible, at the closest point to abstraction. All bacteriological samples will be taken aseptically and all samples will be transported in cooler boxes containing ice packs.

The sampler will return to base by 4pm to allow bacteriology analysis. Total and Faecal Coliforms, Streptococci and Clostridium analysis should be carried out immediately.

Log all samples in the *Samlog* system. Arrange for all sub contract work to be collected/delivered.

Signed: _____ Date: 22.2.02

Co. Signed: Carol Sweetman

APPENDIX C

Table C-1: Summary of Local Authority Laboratory replies to questionnaire.

Q. No.	Question:	% Yes	% No
1.	Does the laboratory carry out its own sampling?	68	32
2.	Does the laboratory have personnel designated solely for sampling?	11	89
3.	Are sampling procedures documented?	74	26
4.	Are there documented procedures for the training of personnel involved in sampling?	32	68
5.	Is the above training carried out in-house or by an independent outside body? ***Answer:*** *9 replied 'in-house' none replied 'independent outside body'*		
6.	Are sampling training records maintained?	11	89
7.	Has the laboratory ever considered obtaining accreditation specifically for sampling work carried out by the laboratory?	16	84
8.	If **YES** to Q7please give brief details: ***Answers included:*** ➢ *As part of MSc. project* ➢ *As part of overall accreditation* ➢ *More cost effective to contract out most work*		
9.	Does the laboratory use any of the following as a guide when preparing sampling programmes and procedures? ISO 5667 □ LA Implementation handbooks □ Standard Methods (A.P.H.A) □	 11 56 83	 89 44 17
10.	Are samples taken/analysed by the laboratory used as evidence in court?	47	53
11.	Have laboratory sampling procedures used by your laboratory ever been questioned in court?	16	84
12.	Which of the following samples are routinely sampled by your laboratory: (Please tick) River water: □ Wastewater – Industrial effluent: □ Wastewater – Sewage treatment plants: □ Drinking water: □	 72 67 72 61	 28 33 28 39

Table C-1 (ctd.)

Q. No.	Question:	% Yes	% No
13.	Please list the parameters which are routinely monitored at the following sampling locations; (a) Drinking water: *Answers included:* ➢ *Total & free chlorine and temperature* ➢ *pH, temperature, conductivity, total and residual chlorine* ➢ *Total & free chlorine, odour and taste* (b) River water: *Answers included:* ➢ *Dissolved oxygen and temperature* ➢ *pH, temperature, conductivity and dissolved oxygen* ➢ *Dissolved oxygen and temperature* (c) Wastewater (Industrial effluent): *Answers included:* ➢ *pH, temperature, conductivity and dissolved oxygen* ➢ *Flow* (d) Wastewater (Sewage treatment plants): *Answers included:* ➢ *Dissolved oxygen* ➢ *Flow*		
14.	Are field meters calibrated/checked prior to sampling?	100	0
15.	Is the above recorded?	63	37
16.	Are chain of custody forms used in any of the following situations: a) Samples taken by laboratory personnel: □ b) Samples taken by non-laboratory personnel: □ c) Samples taken for prosecution cases: □	a) 25 b) 47 c) 36	a) 75 b) 53 c) 64
17.	What type of sampling containers does the laboratory use to sample the following: ***% use the correct sampling container.*** a) Microbiological : *100% use sterile glass/plastic containers.* b) Fluoride : *100% use plastic sampling containers.* c) Oil and grease : *63% use glass sampling containers.* d) Phosphate : *0% use glass sampling containers.* e) Metals : *100% use glass/plastic sampling containers.*		
18.	Do the method(s) document what type of sampling container is to be used?	56	44
19.	Are field blanks analysed for each sample run?	27	73

Table C-1 (ctd.)

Q. No.	Question:	% Yes	% No
20.	Are any of the following samples chemically preserved prior to analysis: ***Answers:*** a) Ammonia: ☐ *5% chemically preserve for ammonia.* b) Phosphate: ☐ *6% chemically preserve for phosphate* c) Total Phosphorus: ☐ *6% chemically preserve for total phosphorus* d) Metals: ☐ *53% chemically preserve for metals* e) Oil and grease: ☐ *0% chemically preserve for oil and grease*		
21.	If **YES** to Q20 – How soon after sampling are samples preserved? ***Answers included:*** a) Ammonia: *same day* b) Phosphate: *same day* c) Total Phosphorus: *same day* d) Metals: *same day, immediately, on receipt to lab,* e) Oil and grease: *within 24hrs, within 5 days.*		
22.	Do the laboratory procedures document which samples are to be preserved?	64	36
23.	Are records maintained of the preservation carried out?	45	55
24.	Are quality control tests carried out in order to ensure that the preservatives used do not interfere with subsequent determinations? If **YES** please give brief details: ***Answers included:*** ➢ *Yes, by sub-contract laboratory.* ➢ *Field blanks have been used.* ➢ *Blank with preservative added is carried through analysis.*	18	82
25.	Is sodium thiosulphate (or similar chemical) added to drinking water sampling bottles prior to sterilisation, in order to neutralise the effects of chlorine?	100	0
26.	Are samples transported from the sampling site to the laboratory in a refrigerated van or cooler box?	68	32
27.	Are there documented procedures with regard to the labelling of samples?	53	47
28.	Is information regarding sample location and on-site analysis written on the sampling bottle or on a field log-sheet? ***Answers included:*** ➢ *6 labs replied- on the sampling bottle* ➢ *3 labs replied - on a field sheet.* ➢ *3 labs replied - both* ➢ *7 labs replied - yes*		
29.	Are there standard field log-sheets for the various water bodies being sampled?	33	67

Table C-1 (ctd.)

Q. No.	Question:	% Yes	% No
30.	Is the laboratory accredited to ISO 17025?	0	100
31.	If **YES** to Q30 how many tests is the laboratory accredited for? *0% **YES** to Q30*		
32.	If **NO** to Q30 is the laboratory in the process of attaining accreditation to ISO 17025?	50	50

Table C-2: Summary of EPA Laboratory replies to questionnaire.

Q. No.	Question:	% Yes	% No
1.	Does the laboratory carry out its own sampling?	83	17
2.	Does the laboratory have personnel designated solely for sampling?	80	20
3.	Are sampling procedures documented?	60	40
4.	Are there documented procedures for the training of personnel involved in sampling?	20	80
5.	Is the above training carried out in-house or by an independent outside body? ***Answer:*** *All laboratories replied 'in-house'*		
6.	Are sampling training records maintained?	40	60
7.	Has the laboratory ever considered obtaining accreditation specifically for sampling work carried out by the laboratory?	60	40
8.	If **YES** to Q7 please give brief details: ***Answers included:*** ➢ *Long term plan but will probably not proceed with it for several years.* ➢ *Considered it but decided not to apply.* ➢ *Accredited for a number of tests but did not include sampling as it is more complex and would require more time.*		
9.	Does the laboratory use any of the following as a guide when preparing sampling programmes and procedures? ISO 5667 ☐ LA Implementation handbooks ☐ Standard Methods (A.P.H.A) ☐	 20 20 60	 80 80 40
10.	Are samples taken/analysed by the laboratory used as evidence in court?	100	0
11.	Have laboratory sampling procedures used by your laboratory ever been questioned in court?	25	75
12.	Which of the following samples are routinely sampled by your laboratory: (Please tick) River water: ☐ Wastewater – Industrial effluent: ☐ Wastewater – Sewage treatment plants: ☐ Drinking water: ☐	 100 100 60 40	 0 0 40 60

Table C-2 (ctd.)

Q. No.	Question:	% Yes	% No
13.	Please list the parameters which are routinely monitored at the following sampling locations; (e) Drinking water: ***Answers included:*** ➢ *Free chlorine and temperature* (f) River water: ***Answers included:*** ➢ *Dissolved oxygen and temperature* (g) Wastewater (Industrial effluent): ***Answers included:*** ➢ *Temperature and flow* (h) Wastewater (Sewage treatment plants): ***Answers included:*** ➢ *Temperature*		
14.	Are field meters calibrated/checked prior to sampling?	100	0
15.	Is the above recorded?	50	50
16.	Are chain-of-custody forms used in any of the following situations: a) Samples taken by laboratory personnel: ☐ b) Samples taken by non-laboratory personnel: ☐ c) Samples taken for prosecution cases: ☐	 a) 100 b) 100 c) 100	 a) 0 b) 0 c) 0
17.	What type of sampling containers does the laboratory use to sample the following: ***% use the correct sampling container.*** a) Microbiological : *100% use sterile glass/plastic containers.* b) Fluoride : *100% use plastic sampling containers.* c) Oil and grease : *100% use glass sampling containers.* d) Phosphate : *0% use glass sampling containers.* e) Metals : *100% use glass/plastic sampling containers.*		
18.	Do the method(s) document what type of sampling container is to be used?	100	0
19.	Are field blanks analysed for each sample run?	60	40
20.	Are any of the following samples chemically preserved prior to analysis: ***Answers:*** a) Ammonia: ☐ *67% chemically preserve for ammonia.* b) Phosphate: ☐ *33% chemically preserve for phosphate* c) Total Phosphorus: ☐ *33% chemically preserve for total phosphorus* d) Metals: ☐*100% chemically preserve for metals* e) Oil and grease: ☐ *100% chemically preserve for oil and grease*		

Table C-2 (ctd.)

Q. No.	Question:	% Yes	% No
21.	If **YES** to Q20 – How soon after sampling are samples preserved? ***Answers included:*** a) Ammonia: *On receipt at lab.* b) Phosphate: *On receipt at lab.* c) Total Phosphorus: *On receipt at lab.* d) Metals: *On receipt at lab and immediately.* e) Oil and grease: *On receipt at lab and immediately.*		
22.	Does the laboratory procedures document which samples are to be preserved?	80	20
23.	Are records maintained of the preservation carried out?	40	60
24.	Are quality control tests carried out in order to ensure that the preservatives used do not interfere with subsequent determinations? If **YES** please give brief details: ***Answers included:*** ➢ *Using field blanks.*	80	20
25.	Is sodium thiosulphate (or similar chemical) added to drinking water sampling bottles prior to sterilisation, in order to neutralise the effects of chlorine?	75	25
26.	Are samples transported from the sampling site to the laboratory in a refrigerated van or cooler box?	60	40
27.	Are there documented procedures with regard to the labelling of samples?	60	40
28.	Is information regarding sample location and on-site analysis written on the sampling bottle or on a field log-sheet? ***Answers included:*** ➢ *2 labs replied - on a field sheet.* ➢ *3 labs replied - yes*		
29.	Are there standard field log-sheets for the various water bodies being sampled?	100	0
30.	Is the laboratory accredited to ISO 17025?	60	40
31.	If **YES** to Q30 how many tests is the laboratory accredited for? ***Answers included:*** ➢ *18 tests* ➢ *20 tests* ➢ *22 tests*		
32.	If **NO** to Q30 is the laboratory in the process of attaining accreditation to ISO 17025?	50	50

Table C-3: Summary of Independent Laboratory replies to questionnaire.

Q. No.	Question:	% Yes	% No
1.	Does the laboratory carry out its own sampling?	75	25
2.	Does the laboratory have personnel designated solely for sampling?	100	0
3.	Are sampling procedures documented?	100	0
4.	Are there documented procedures for the training of personnel involved in sampling?	33	67
5.	Is the above training carried out in-house or by an independent outside body? ***Answer:*** *Two laboratories replied 'in-house' the remainder did not reply to the question.*		
6.	Are sampling training records maintained?	50	50
7.	Has the laboratory ever considered obtaining accreditation specifically for sampling work carried out by the laboratory?	33	67
8.	If **YES** to Q7please give brief details: ***Answers included:*** ➢ *To ISO 5667*		
9.	Does the laboratory use any of the following as a guide when preparing sampling programmes and procedures? ISO 5667 ☐ LA Implementation handbooks ☐ Standard Methods (A.P.H.A) ☐	 0 0 100	 100 100 0
10.	Are samples taken/analysed by the laboratory used as evidence in court?	100	0
11.	Have laboratory sampling procedures used by your laboratory ever been questioned in court?	0	100
12.	Which of the following samples are routinely sampled by your laboratory: (Please tick) River water: ☐ Wastewater – Industrial effluent: ☐ Wastewater – Sewage treatment plants: ☐ Drinking water: ☐	 67 100 67 67	 33 0 33 33

Table C-3 (ctd.)

Q. No.	Question:	% Yes	% No
13.	Please list the parameters which are routinely monitored at the following sampling locations; (i) Drinking water: ***Answers included:*** ➢ *Free chlorine and dissolved oxygen* (j) River water: ***Answers included:*** ➢ *pH, temperature, conductivity, depth and flow* (k) Wastewater (Industrial effluent): ***Answers included:*** ➢ *Temperature and colour* (l) Wastewater (Sewage treatment plants): ***Answers included:*** ➢ *pH, temperature and DO*		
14.	Are field meters calibrated/checked prior to sampling?	100	0
15.	Is the above recorded?	50	50
16.	Are chain-of-custody forms used in any of the following situations: a) Samples taken by laboratory personnel: ☐ b) Samples taken by non-laboratory personnel: ☐ c) Samples taken for prosecution cases: ☐	a) 50 b) 50 c) 50	a) 50 b) 50 c) 50
17.	What type of sampling containers does the laboratory use to sample the following: ***% use the correct sampling container.*** a) Microbiological : *100% use sterile glass/plastic containers.* b) Fluoride : *100% use plastic sampling containers.* c) Oil and grease : *100% use glass sampling containers.* d) Phosphate : *0% use glass sampling containers.* e) Metals : *100% use glass/plastic sampling containers.*		
18.	Do the method(s) document what type of sampling container is to be used?	100	0
19.	Are field blanks analysed for each sample run?	67	33
20.	Are any of the following samples chemically preserved prior to analysis: ***Answers:*** f) Ammonia: ☐ *33% chemically preserve for ammonia.* g) Phosphate: ☐ *0% chemically preserve for phosphate* h) Total Phosphorus: ☐ *0% chemically preserve for total phosphorus* i) Metals: ☐*67% chemically preserve for metals* j) Oil and grease: ☐ *33% chemically preserve for oil and grease*		

Table C-3 (ctd.)

Q. No.	Question:	% Yes	% No
21.	If **YES** to Q20 – How soon after sampling are samples preserved? ***Answers included:*** f) Ammonia: *On receipt at lab* g) Phosphate: *0% chemically preserve for phosphate* h) Total Phosphorus: *0% chemically preserve for total phosphorus* i) Metals: *On receipt at lab, when subcontracting to ICP.* j) Oil and grease: *On receipt at lab.*		
22.	Do the laboratory procedures document which samples are to be preserved?	100	0
23.	Are records maintained of the preservation carried out?	0	100
24.	Are quality control tests carried out in order to ensure that the preservatives used do not interfere with subsequent determinations? If **YES** please give brief details: ***Answers included:*** ➢ *Preservation is performed as per Standard Methods.*	33	67
25.	Is sodium thiosulphate (or similar chemical) added to drinking water sampling bottles prior to sterilisation, in order to neutralise the effects of chlorine?	100	0
26.	Are samples transported from the sampling site to the laboratory in a refrigerated van or cooler box?	100	0
27.	Are there documented procedures with regard to the labelling of samples?	100	0
28.	Is information regarding sample location and on-site analysis written on the sampling bottle or on a field log-sheet? ***Answers included:*** ➢ *1 lab replied – mostly on the bottle.* ➢ *1 lab replied – yes* ➢ *1 lab replied – both*		
29.	Are there standard field log-sheets for the various water bodies being sampled?	33	67
30.	Is the laboratory accredited to ISO 17025?	67	33
31.	If **YES** to Q30 how many tests is the laboratory accredited for? ***Answers included:*** ➢ *37 tests* ➢ *40 tests*		
32.	If **NO** to Q30 is the laboratory in the process of attaining accreditation to ISO 17025?	0	100

APPENDIX D

DOCUMENT No. 1:

Gap Analysis results for *I.S. EN 25667-1:1994 Water Quality – Sampling – Part 1: Guidance on the design of sampling programmes (ISO 5667-1:1980).*

1. **Scope and field of application:** Not applicable to gap analysis
2. **References:** Not applicable to gap analysis

SECTION 1: DEFINITION OF OBJECTIVES

3. Introduction:

'The samples collected should be as fully representative as possible of the whole to be characterized'

Findings	Non-Conformance	Corrective Action
1. River and UWWTP sampling locations are mapped in the sampling programme 2. Industrial sampling locations are identified in the appropriate discharge licence.	1. Drinking water locations not mapped.	1. Map drinking water locations

'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'

Findings	Non-Conformance	Corrective Action
1. Collected samples are transported to laboratory in cooler boxes. 2. No chemical preservation of samples is undertaken.	1. As per finding No. 2.	1. Identify and document the preservation method(s) required for various samples. 2. Implement preservation methods where required.

'Before any sampling programme is devised, it is very important that the objectives be established'

Findings	Non-Conformance	Corrective Action
1. The objectives of sampling are primarily determined by legislative requirements, however these objectives are not stated in the sampling programme.	1. As per finding No. 1.	1. State the objectives of the sampling programmes.

3. Introduction (ctd..):

'Some consideration should also be given to the degree of detail and precision that will be adequate.'

Findings	Non-Conformance	Corrective Action
1. The laboratory has calculated the precision, trueness and bias for various analytical procedures. 2. Various Regulations state the precision, trueness and bias required e.g. European Communities (Drinking Water) Regulations, 2000, European Communities (Quality of Surface Water Intended for the Abstraction of Drinking Water) Regulations, 1989.	1. The degree of detail and precision required under legislation is not compared with what the laboratory is capable of achieving.	1. Compare requirements of relevant legislation with laboratories capability.

'Some consideration should also be given to ..... the manner in which the results are to be expressed and presented e.g. max, min, median values, load'

Findings	Non-Conformance	Corrective Action
1. Max, min and median annual values are reported for river and wastewater results. 2. % annual compliance is reported for drinking water results. 3. The sampling programme does not detail how results are to be presented.	1. As per finding No. 3.	1. Amend sampling programme to include in detail how results are to be presented.

'Additionally a list of parameters of interest should be compiled and the relevant analytical procedure consulted since these will usually give guidance on precautions to be observed during sampling and subsequent handling'

Findings	Non-Conformance	Corrective Action
1. Specific result sheets exist for the various types of samples (e.g. wastewater, river water, drinking water) and these state the parameters to be monitored. 2. The sampling programme does not list the parameters to be monitored.	1. As per finding No. 2.	1. Compile a list of the parameters of interest for each sample type e.g wastewater, etc, with reference to the relevant analytical procedure.

3. Introduction (ctd..):

'It may often be necessary to carry out a preliminary sampling and analysis programme before the final objectives can be defined.'

Findings	Non-Conformance	Corrective Action
1. The objectives of the sampling programmes undertaken are determined primarily by legislation, therefore the above is not applicable.	N/A	N/A

4. Requirements:

Not applicable to gap analysis

5. Special Considerations in Relation to Variability

5.1

'Sampling should be avoided at or near boundaries of systems unless conditions are of special interest'

Findings	Non-Conformance	Corrective Action
1. SOP 6, 8, 10, 11 or 'sampling programme manual' do not state anything regarding the above	1. As per finding	1. Assess the above for the various sampling situations and amend SOPs where required.

5.3

'Care should be taken to eliminate or minimize any changes in the concentration of determinands of interest that may be produced by the sampling process itself and to ensure that changes during the period between sampling and analysis are avoided or minimized'

Findings	Non-Conformance	Corrective Action
1. Sampling bottles are not reused 2. The sampling bottle is attached to the long-arm sampler. 3. A bucket is used for sampling river locations. 4. Samples are transported to the laboratory in a cooler box. 5. Samples are not chemically preserved prior to analysis.	1. Findings 1-4 are not documented in the relevant SOPs. 2. No samples are chemically preserved	1. Amend sampling SOP's to include NC No. 1 2. Identify and document which samples require to be chemically preserved. 3. Implement system of chemical preservation. 4. Train sampling personnel with regard to chemical preservation.

SECTION 2: IDENTIFICATION OF SAMPLING SITUATIONS

6. Introduction: Not applicable to gap analysis

7. General Safety Precautions.

7.1

'Personnel responsible for the design of sampling programmes and for carrying out sampling operations must ensure that the requirements of relevant safety regulations are taken into account and that sampling personnel are informed of the necessary precautions to be taken in sampling operations'.

Findings	Non-Conformance	Corrective Action
1. SOP No.8,10 and 11 state 'At all times have regard for your own personal safety' 2. SOP No. 8 re-river sampling states ' Park safely at sampling point' 3. SOP's No. 5 or 47 do not cover or refer to the area of safety. 4. The ancillary safety statement for the environment section details the hazards and controls related to fieldwork. Staff who have read the safety statement sign off to confirm they have done so.	1. SOP No.8, 10 and 11 do not refer to the safety statement for the environment section. 2. As per finding No. 3	1. Amend SOP No.8, 9,10 and 11 to include reference to the safety statement for the environment section. 2. Amend SOP No. 5 and 47 to include general reference with regard to safety and reference to the safety statement for the environment section.

7.2

'Weather conditions should be considered in order to ensure the safety of personnel and equipment.'

Findings	Non-Conformance	Corrective Action
1. The ancillary safety statement for the environment section details the hazards and controls related to fieldwork. Under the control section it is stated 'suitable clothing for prevailing and likely weather conditions must be worn.' 2. Staff who have read the safety statement sign off to confrom they have done so.	None	None

7.3
Not applicable to gap analysis.

7.4
'Sampling from unsafe sites, such as unsafe banks, should be avoided if possible. If this is unavoidable the operation should be conducted by a team using appropriate precautions rather than one operator. Sampling from bridges should be used when appropriate.'

Findings	Non-Conformance	Corrective Action
1. Routine river samples are always taken from bridges 2. SOP No. 8 states 'park safely at the sampling point'.	1. None	1. None

7.5
'Reasonable access in all weather is important and it is essential for frequent routine sampling.'

Findings	Non-Conformance	Corrective Action
1. Access to sampling sites has been considered for routine sampling points e.g river samples are taken at bridges. This is not documented in the sampling programme	1. As per finding No. 1	1. Amend sampling programme stating that routine river samples are taken at bridges.

7.6
Not applicable to gap analysis.

7.7
Many other situations arise during the sampling of water when special precautions have to be taken to avoid accidents. For example, some industrial effluents may be corrosive or may contain toxic or flammable materials. The dangers associated with sewage should not be overlooked; these may be gaseous, microbiological, virological or zoological, such as from amoebae or helminths.

Findings	Non-Conformance	Corrective Action
1. The ancillary safety statement for the environment section details the hazards and controls related to hazardous chemicals, Weils disease and infectious diseases. Staff who have read the safety statement sign off to confirm they have done so.	None	None

7.8
Not applicable to gap analysis.

7.9
Not applicable to gap analysis.

7.10
Not applicable to gap analysis.

7.11
Not applicable to gap analysis.

8. Special Considerations in Sampling

8.1 Design of sampling programmes

'In designing quality sampling networks it is usual to make provision for the measurement of flow at key stations.'

Findings	Non-Conformance	Corrective Action
1. Some of the river sites selected have EPA flow gauges located at them.	1. No reference in laboratory sampling manual with regard to the above.	1. Reassess sampling locations to take flow stations into account.

8.2 Identifying the sampling location

'Identifying the sampling location enables comparative samples to be taken at other times.'

Findings	Non-Conformance	Corrective Action
1. All river sample locations are at easily accessible bridges. 2. All river sample locations are mapped. 3. UWWTP plants are mapped. 4. Industry discharge sampling locations are identified in Local Authority licence for the facility. 5. Drinking water locations not identified.	1. As per finding No. 5	1. Identify and map drinking water locations.

8.3 Character of flow

'Ideally samples should be taken from turbulent, well-mixed liquids and whenever possible turbulence should be induced in flows that are streamlined.'

Findings	Non-Conformance	Corrective Action
1. SOP No. 8, 10, 11 and 47 do not make provision for sampling from turbulent, well-mixed liquids.	1. As per finding No. 1	1. Review sampling locations to ensure samples are taken from turbulent, well-mixed liquids. 2. If possible induce turbulence in flows that are streamlined. 3. Amend sampling locations if required.

8.4 Change in flow characteristics with time.

Not applicable to gap analysis.

8.5 Change of liquid composition with time.

Not applicable to gap analysis.

8.6 Sampling from pipes

'Liquids should be pumped through pipes of adequate size at linear velocities high enough to maintain turbulent flow characteristics'

Findings	Non-Conformance	Corrective Action
1. SOP No. 8 states 'run tap for approx. 2 minutes before sampling'	None	None

8.7 Nature of liquid

'The liquid may be corrosive or abrasive. Resistance to these conditions should be considered.'

Findings	Non-Conformance	Corrective Action
1. Not considered in SOP 10 or 11.	1. As per finding No. 1	1. Review and amend relevant SOP's to include details on handling corrosive or abrasive liquids e.g. wearing PPE, using the correct sampling container, etc. 2. Train sampling personnel with regard to handling corrosive or abrasive liquids.

8.8 Temperature changes occurring in sampling systems.

Not applicable to gap analysis

8.9 Sampling for determination of suspended solids

'Solids may be distributed anywhere throughout the depth of a liquid. Adequate mixing should be carried out, if possible, by maintaining turbulent conditions. Ideally, the linear velocity should be sufficient to induce turbulence and samples should be taken under isokinetic conditions. If this is not possible, a series of samples should be taken across a full cross-section of the flow.'

Findings	Non-Conformance	Corrective Action
1. Suspended solids analysis is carried out as part of STP and industry sampling programmes. 2. SOP No. 10 and 11 do not take the above into account.	1. As per finding No. 2	1. Review STP sampling locations to ensure there is adequate turbulence at each site. 2. Identify sites where there is insufficient turbulence and document method for taking a series of samples across a full cross-section of the flow. 3. Train sampling personnel with regard to sampling across a full cross-section of the flow.

8.10 Sampling for volatile compounds content.

Not applicable to gap analysis

8.11 Mixtures of waters of different densities.

Not applicable to gap analysis

8.12 Hazardous liquids

'It is necessary to consider the possibility of the presence of toxic liquids or fumes or both and the possible build up of explosive vapours.'

Findings	Non-Conformance	Corrective Action
1. The ancillary safety statement for the environment section details the hazards and controls related to confined space entry. Staff who have read the safety statement sign off to confirm they have done so.	None	None

8.13 Effect of meteorological conditions

'Changes in meteorological conditions may induce marked variations in water quality; such changes should be noted and allowance made for them when interpreting results.'

Findings	Non-Conformance	Corrective Action
1. SOP No. 8 states that the weather conditions should be noted and this is recorded in the river sampling field sheet. 2. Not considered in SOP No.6, 10, 11 or 47 and not recorded on relevant field sheet.	1. As per finding No. 2	1. Review and amend relevant SOP's and field sheets to include requirement to note the meteorological conditions.

9. Individual sampling situations – Natural waters

9.1 Precipitation

Not applicable to gap analysis.

9.2 Estuaries, coastal waters, seas and oceans.

Not applicable to gap analysis.

9.3 Rivers and Streams.

9.3.1 Mixing

'If significant streaming or stratification exists at the sampling point, a series of transverse and depth samples should be collected to determine the nature and extent of any streaming or stratification.'

Findings	Non-Conformance	Corrective Action
1. The river sampling points have not been assessed with regard to the existence of significant streaming or stratification	1. As per finding No. 1	1. Identify appropriate method to assess stratification. 2. Assess each sampling location for stratification. 3. Take appropriate measures following assessment.

9.3.2 Selection of sites.

' Sites should be selected so as to provide representative samples, preferably where marked quality changes are likely to occur or where there are important river uses, for example confluences, major discharges or abstractions. Weirs or small discharges which are only very local in effect should generally be avoided. Sites should preferably be chosen where flow data is available.'

Findings	Non-Conformance	Corrective Action
1. The sampling programme does not state how the river sampling sites were selected. 2. Some of the river sites selected have EPA flow gauges located at them.	1. As per finding No. 1	1. Review river sampling locations taking the above requirements into account.

' If sampling is intended to monitor the effects of a discharge, sampling both upstream and downstream should be carried out, but careful consideration should be given to the mixing of the discharge and receiving water and its effects on the downstream samples. Sampling should extend for an appropriate distance downstream to assess the effects on the river.'

Findings	Non-Conformance	Corrective Action
1. SOP No. 10 requires monitoring of the effects of urban wastewater discharge.	1. No details in SOP No. 10 regarding where exactly the u/s and d/s samples should be taken.	1. Identify appropriate method to assess the effects of a point source discharge on a river. 2. Document method. 3. Train sampling personnel.

9.4 Canals

Not applicable to gap analysis.

9.5 Storage reservoirs and lakes

' Sampling should be carried out at all available draw-off points and draw-off depths in addition to inputs.'

Findings	Non-Conformance	Corrective Action
1. No SOP with regard to sampling from storage reservoirs	1. As per finding No. 1	1. Prepare SOP with regard to sampling from storage reservoirs. 2. Train sampling personnel.

9.6 Groundwaters

Not applicable to gap analysis.

9.7 Bottom deposits in rivers, estuaries and the sea, lakes and reservoirs.

Not applicable to gap analysis.

9.8 Drinking water

9.8.1 Water being pumped into supply

' The sampling point should be selected so as to permit monitoring of residual disinfecting agents befo any loss occurs but after all reactions are completed.'

Findings	Non-Conformance	Corrective Action
1. The sampling programme does not detail how the drinking water sampling points are selected.	1. As per finding No. 1.	1. Amend sampling programme detailing how the drinking water sampling points are selected.

'Sampling for routine bacteriological examination is also required and suitable precautions, including any national safety regulations, should be observed.'

Findings	Non-Conformance	Corrective Action
1. SOP No.6 states 'soak mouth of tap in alcohol and run tap.	None	None

9.8.1 Water being pumped into supply (ctd..)

'Sampling tap should have no attachments and should be suitable for sterilization by flaming. The material of the sample pipe shall be carefully chosen in relation to the test requirements.'

Findings	Non-Conformance	Corrective Action
1. Attachments are removed from the tap prior to sampling, however this is not stated in SOP No. 6. 2. Taps are not flamed because a lot of taps are plastic. Instead the mouth of the tap is soaked in alcohol, as per SOP No.6 3. SOP No.6 does not include details with regard to the material of the sample pipe.	1. As per findings No. 1 and 3.	1. Amend SOP No.6 to include the requirement to remove attachments prior to sampling. 2. Identify the aspects which have to be considered with regard to the sample pipe and include findings in SOP No. 6.

'In order to make sure that the sample is drawn directly from the tap into the container, the sample container should be placed immediately below the tap but not connected to it, nor in direct contact with it.'

Findings	Non-Conformance	Corrective Action
1. SOP 6 states 'fill sterile bottle using aseptic technique'	1. Not sufficient detail regarding aseptic technique	1. Amend SOP 6 to give details regarding aseptic technique.

9.8.2 Service Reservoirs

'Samples should be taken from a tap fitted to the outlet main as close as possible to the reservoir.....Ensure the reservoir is emptying at the time of taking the sample (if filling and emptying through same main).

Findings	Non-Conformance	Corrective Action
1. No details in method regarding sampling from reservoirs	1. As per finding No. 1	1. Assess the above with regard to current reservoirs. 2. Detail sampling requirements and location in appropriate SOP. 3. Train sampling personnel.

9.8.3 Water in the distribution system

'Anti-splash or similar devices should be removed before sampling; mixer taps are not recommended for sampling.'

Findings	Non-Conformance	Corrective Action
1. The above is not stated in SOP No. 6.	1. As per finding No. 1	1. Amend SOP No. 6 to include the above. 2. Train sampling personnel.

'Special precautions are necessary for sampling for bacteriological examination.'

Findings	Non-Conformance	Corrective Action
1. SOP 6 states 'fill sterile bottle using aseptic technique'	None	None

9.8.4 Sludges derived from drinking water treatment.
Not applicable to gap analysis.

9.9 Bathing places
Not applicable to gap analysis.

10. Sampling Situations in Industry.

10.1 Inlet water.
Not applicable to gap analysis.

10.2 Boiler system water
Not applicable to gap analysis.

11 Trade Effluents.

11.1 Sites

'The sampling of industrial effluents has to be considered in relation to the nature and location of each individual effluent'
'The possibility of domestic sewage from the factory being contained in the sample should also be considered and the site should be chosen to exclude such wastes, if necessary'
'If the effluent discharge is to a lagoon or holding tank, then the sampling situation becomes similar to that for lakes.'

Findings	Non-Conformance	Corrective Action
1. The industrial effluents sampled are licensed points and are detailed as part of licence conditions. – details given in SOP No. 11	None	None

11.1 Sites (ctd..)

'With manhole sampling, it is preferable, for safety reasons, that the manhole should be designed so as to permit sampling to take place without entry.'

Findings	Non-Conformance	Corrective Action
1. The accessibility of the effluent sampling points is required as part of licence conditions. 2. SOP No. 11 states 'do not attempt to lift a manhole on your own.'	None	None

11.2 Nature of the effluent

'When effluents from a variety of processes discharge into a common main, adequate mixing is required in order to obtain satisfactory sample.'

Findings	Non-Conformance	Corrective Action
1. Industrial effluents are sampled at the location(s) identified in the discharge licence, issued by the Local Authority.	None	None

11.3 Industrial water and effluent treatment sludges.

Not applicable to gap analysis.

12 Sewage and Sewage Effluents.

12.1 Selection of sampling sites.

12.1.1 Liquid effluents

' Sewage may be contained in culverts of large cross-section and its composition may vary with depth and across the diameter of the culvert. Incomplete mixing of sewage from different sources may also occur and at low flow rates suspended material may settle. Before selecting a site, a preliminary sampling programme to establish these variations should be conducted and the location of the routine sampling point determined. In many cases it will be necessary to take two or three routine samples at different points and to mix these to give a composite sample. '

Findings	Non-Conformance	Corrective Action
1. The variation in sewage composition, due to low flow rates or due to the sewage being contained in culverts of large cross-section, has not been taken into account.	1. As per finding No. 1	1. Conduct a preliminary sampling programme to establish whether these variations exist. 2. Amend SOP No. 10 if required.

'Floating material, such as oil and grease, cannot be sampled representatively on a routine basis and samples should generally be taken from below the surface. '

Findings	Non-Conformance	Corrective Action
1. SOP No. 10 or 11 do not detail how samples for oil and grease should be taken.	1. As per finding No. 1	1. Amend relevant SOPs to include sampling for floating material. 2. Train sampling personnel.

12.1.1 Liquid effluents (ctd.)

'Crude sewage samples are frequently taken after the preliminary screening and comminution processes so that adventitious inclusion of large particles in the sample is avoided.'
'In selecting a sampling site for crude sewage at the treatment plant, the inclusion of recirculated liquors within the plant should be considered. Ideally two samples, one including all liquors representing the total load on the plant and one excluding recirculated liquor to give a measure of the loading from external sources, may be necessary'

Findings	Non-Conformance	Corrective Action
1. SOP No. 10 does not clearly state where exactly an influent sample should be taken.	1. As per finding No. 1	1. Ascertain if an influent sample can be taken which includes all liquors and one which excludes the recirculated liquor for each relevant STP. 2. Amend SOP No. 10 stating where the influent sample is to be taken. 3. Train sampling personnel to ensure the correct sampling point(s) is selected.

12.1.1 Sewage treatment sludges
Not applicable to gap analysis.

13 Storm Sewage and Surface Run-off

'Automatic sampling devices that collect samples at regular intervals and which start at a prescribed flow offer many advantages. This equipment should be installed in a permanent state of readiness. In many instances, flow-proportional sampling will be desirable.
Relevant precipitation and air temperature data should be collected throughout the period of investigation.'

Findings	Non-Conformance	Corrective Action
1. Storm sewage and surface run-off are not sampled on a routine basis.	1. The above requirements are not taken into account.	1. Prepare SOP for sampling of storm sewage and surface run-off taking the above into account. 2. Train sampling personnel with regard to sampling storm sewage and surface run-off.

SECTION 3 TIME AND FREQUENCY OF SAMPLING

14. Introduction
Not applicable to gap analysis.

15. Types of sampling programme.
Not applicable to gap analysis.

16. Statistical considerations

16.1 Establishment of sampling programmes

'The times and frequency of sampling in any programme can be properly decided only after detailed preliminary work, in which a high sampling frequency is necessary to provide the information to which statistical techniques are applied.
'Once the frequency of sampling has been decided, the data obtained should be reviewed regularly so that changes can be made as required.'

Findings	Non-Conformance	Corrective Action
1. The frequency of sampling is stated either in the relevant legislation or as required by the EPA. This is not clearly stated in the sampling programme.	1. As per finding No. 1	1. Amend sampling programme to clearly identify the source used to calculate the frequency of analysis.

16.2 Confidence interval
Definition - Not applicable to gap analysis.

16.3 Confidence level
Definition - Not applicable to gap analysis.

16.4 Determination of confidence interval and number of samples

Findings	Non-Conformance	Corrective Action
1. No statistical analysis has been carried out to determine the confidence interval or if the number of samples currently being taken is sufficient at a particular confidence level of interest.	1. As per finding No. 1	1. Assess the need to statistically determine the confidence interval and determine if the correct number of samples is being taken at the particular confidence level of interest. 2. If necessary, carry out statistical analysis, document results and amend sampling programme if required.

16.5 Random and systematic variations of water quality.

Findings	Non-Conformance	Corrective Action
1. The water bodies sampled have not been identified as either having random or systematic variations in quality. 2. The number of samples take at a particular location and frequency of sampling have not been determined statistically.	1. As per findings No. 1 and 2.	1. Identify whether the water bodies sampled have random or systematic variations in quality. 2. Determine statistically the number and times of sampling required.

17. Abnormal Variability.

' It may be necessary to increase sampling frequency while abnormal conditions persist. In calculating long-term trends, results obtained from these samples should be used only if allowance is made for the increased frequency. '

Findings	Non-Conformance	Corrective Action
1. No mention in sampling programme regarding sampling in rivers, of wastewater during abnormal conditions or the subsequent reporting of this. 2. Drinking water samples taken during abnormal conditions are not used in calculating long-term trends – this fact is not documented in SOP No. 49.	1. As per findings No. 1 and 2.	1. Prepare SOP detailing the procedure for sampling of rivers, etc, during abnormal conditions. 2. Amend SOP No. 47 to include details on the reporting of the results from sampling during abnormal conditions. 3. Train sampling personnel.

18. Duration of sampling occasion and composite samples.

' If only the average quality during the period is of interest, and provided the determinand is stable, it may be useful for the duration of collection of samples to be long and preferably the same as the period of interest. '

Findings	Non-Conformance	Corrective Action
1. Composite sampling is generally only required during STP monitoring. 2. Flow-proportional or time-based 24-hour samples are required to be collected under the EC (Urban Wastewater Treatment) Regulations, 1994, therefore 24 hour composite samples are collected at the plants which shall come under the requirements of this Regulation in 2005.	None	None

SECTION 4 FLOW MEASUREMENTS AND SITUATIONS JUSTIFYING FLOW MEASUREMENTS FOR WATER QUALITY PURPOSES.

19 Introduction

19.1 General

Not applicable to gap analysis.

19.2 Direction of flow

'In treatment processes, the pattern of water movement in tanks affects the mixing of the contents and the settling of suspended matter and should be considered to ensure representative samples are collected.'

Findings	Non-Conformance	Corrective Action
1. Sampling of mixed liquor from aeration tanks is not considered in SOP 10.	1. As per finding No. 1	1. Amend SOP 10 to include sampling location from treatment aeration tanks. 2. Train sampling personnel to ensure samples from the aeration tank are taken at the correct location.

19.3 Velocity of flow

'Current velocity is of importance:

a) In calculating the discharge rate

b) In calculating the mean velocity or time of travel – time required for a given body of water to move through a given distance.

c) In assessing the effect of turbulence and the mixing of a water body.'

Findings	Non-Conformance	Corrective Action
1. A number of river sampling locations have EPA staff gauges. These are monitored by the EPA. 2. The current velocity values are not used by the laboratory.	None	None

19.4 Discharge rate.

'Information on mean and extreme rates of discharge is essential for the design and operation of effluent, sewage and water treatment plants and for setting rational quality limits to safeguard natural watercourses.'

Findings	Non-Conformance	Corrective Action
1. Daily discharge is calculated in the larger STP plants.	None	None

20. Justification for flow measurements in water quality control.

20.1 Treatment plant loads
Not applicable to gap analysis.

20.2 Dilution effects
Not applicable to gap analysis.

20.3 Mass flow calculations
Not applicable to gap analysis.

20.4 Transport of pollutants and rates of recovery

' A sampling programme for a river or estuary should attempt to sample the same body of water as it moves along the watercourse.'

Findings	Non-Conformance	Corrective Action
1. Each river catchment is sampled at a number of locations along its length	None	None

20.5 Flow-related determinands
Not applicable to gap analysis.

20.6 Groundwaters
Not applicable to gap analysis.

21. Methods available for flow measurement
Not applicable to gap analysis.

DOUCMENT No. 2:

Summary of the Corrective Actions required in order to comply with:

I.S. EN 25667-1:1994 Water Quality – Sampling – Part 1: Guidance on the design of sampling programmes (ISO 5667-1:1980).

Note: *For the corrective actions to be implemented effectively staff training shall have to be paramount in all cases.*

1. Identify and document the preservation method(s) required for the various samples. Implement preservation methods where required *(ISO 5667-1:1980 Section 1 (3)).*

2. Map drinking water locations *(ISO 5667-1:1980 Section 1 (3), Section 2 (8.2)).*

3. State the objectives of the sampling programmes *(ISO 5667-1:1980 Section 1 (3)).*

4. Identify and document the degree of detail and precision that will be adequate for analytical field results. Outline the manner in which the results are to be expressed and presented. as part of the sampling programme *(ISO 5667-1:1980 Section 1 (3)).*

5. Compile list of parameters of interest with reference to the relevant analytical procedure *(ISO 5667-1:1980 Section 1 (3)).*

6. *'Sampling should be avoided at or near boundaries of systems unless conditions are of special interest'* -Assess the above for the various sampling situations and amend SOPs where required *(ISO 5667-1:1980 Section 1 (5.1)).*

7. Amend sampling SOPs to include measures taken to eliminate or minimize any changes in the concentration of determinands of interest that may be produced by the sampling process itself e.g.
   a) Sampling bottles are not reused
   b) The sampling bottle is attached to the long-arm sampler.
   c) Samples are transported to the laboratory in a cooler box
   (ISO 5667-1:1980 Section 1 (5.3)).

8. Identify and document which samples are required to be chemically preserved. Implement system of chemical preservation *(ISO 5667-1:1980 Section 1 (5.3)).*

9. Implement system of chemical preservation *(ISO 5667-1:1980 Section 1 (5.3)).*

10. Amend SOP No.'s 8, 9,10 and 11 to include reference to the safety statement for the environment section *(ISO 5667-1:1980 Section 2 (7.1)).*

11. Amend SOP No. 5 and 47 to include general reference with regard to safety and reference to the safety statement for the environment section *(ISO 5667-1:1980 Section 2 (7.1)).*

12. Amend sampling programme to include how sampling sites were selected e.g. access in all weather *(ISO 5667-1:1980 Section 2 (7.5)).*

13. Reassess river sampling locations to take flow stations into account *(ISO 5667-1:1980 Section 2 (8.1)).*

14. Review and amend, if required SOP No.'s 8, 10, 11, and 47 with regard to ensuring samples are taken from turbulent, well-mixed liquids *(ISO 5667-1:1980 Section 2 (8.3)).*

15. Review and amend SOP No.'s 10 and 11 to include details on how to handle liquids that may be corrosive or abrasive *(ISO 5667-1:1980 Section 2 (8.7)).*

16. Review wastewater sampling locations to ensure sufficient turbulence is present at all sites. Identify the sites where there is not sufficient turbulence. Develop and document method for taking samples across the full cross-section of the flow at these sites. Amend, if required, SOP No.'s 10 and11 *(ISO 5667-1:1980 Section 2 (8.9)).*

17. Review and amend SOP No.'s 6, 10, 11 or 47 and the field sheets to include requirement to note meteorological conditions *(ISO 5667-1:1980 Section 2 (8.13)).*

18. Identify appropriate method to assess stratification at a river sampling location. Assess each river sampling location for stratification. Take appropriate measures following the results of the assessment *(ISO 5667-1:1980 Section 2 (9.3.1)).*

19. Assess each river sampling location for stratification *(ISO 5667-1:1980 Section 2 (9.3.1)).* Take appropriate measures following the results of the assessment *(ISO 5667-1:1980 Section 2 (9.3.1)).*

20. Review river sampling locations selected to ensure they provide representative samples i.e. where marked quality changes are likely to occur or where there are important river uses. Amend sampling programmes accordingly *(ISO 5667-1:1980 Section 2 (9.3.2)).*

21. Identify an appropriate method to assess the effects of a discharge on a river i.e. the selection of both upstream and downstream points. Document method *(ISO 5667-1:1980 Section 2 (9.3.2), (9.8.2)).*

22. Prepare SOP detailing how samples are to be taken from storage reservoirs *(ISO 5667-1:1980 Section 2 (9.5)).*

23. Amend sampling programme detailing how the drinking water sampling points are selected *(ISO 5667-1:1980 Section 2 (9.8.1)).*

24. Amend SOP No.6 to include details regarding selection of drinking water sampling taps *(ISO 5667-1:1980 Section 2 (9.8.1)).*

25. Identify the aspects which have to be considered with regard to the sample pipe and include findings in SOP No. 6 *(ISO 5667-1:1980 Section 2 (9.8.1)).*

26. Amend SOP No.6 to give precise details on the aseptic technique to be used when taking microbiological samples *(ISO 5667-1:1980 Section 2 (9.8.1)).*

27. Include statement in SOP No. 6 stating that anti-splash devices should be removed before sampling and that mixer taps are not recommended for sampling *(ISO 5667-1:1980 Section 2 (9.8.3)).*

28. Conduct a preliminary investigation to establish whether there is:
    a) Incomplete mixing of sewage from different sources: and
    b) Settlement of suspended material.
    Amend SOP No. 10 if required *(ISO 5667-1:1980 Section 2 (12.1.1)).*

29. Amend SOP No. 10 clearly stating exact location where an influent sample should be taken *(ISO 5667-1:1980 Section 2 (12.1.1)).*

30. Prepare SOP for sampling of storm sewage and surface run-off taking the requirements of ISO 5667-1:1980 Section 2 (13) into account.

31. Amend sampling programme to clearly identify the source used to calculate the frequency of analysis *(ISO 5667-1:1980 Section 3 (16.1)).*

32. Ascertain the need to statistically determine the number of samples required for a given confidence interval. If required carry out statistical analysis, document results and amend sampling programme as required *(ISO 5667-1:1980 Section 3 (16.4)).*

33. Identify whether the water bodies sampled have random or systematic variations in quality. Determine statistically the number and times of sampling
    (ISO 5667-1:1980 Section 3 (16.5)).

34. Prepare SOP detailing the procedure for sampling during abnormal conditions *(ISO 5667-1:1980 Section 3 (17)).*

35. Amend SOP No. 49 to include details on the reporting of the results from sampling during abnormal conditions *(ISO 5667-1:1980 Section 3 (17)).*

36. Amend SOP No.10 to include details on the exact sampling location from treatment aeration tanks *(ISO 5667-1:1980 Section 3 (19.2)).*

DOCUMENT No. 3:

Gap Analysis results for *I.S. EN 25667-2:1994 Water quality – Sampling- Part 2: Guidance on sampling techniques (ISO 5667-2:1991).*

1. **Scope:** Not applicable to gap analysis.
2. **Normative References:** Not applicable to gap analysis.
3. **Definitions:** Not applicable to gap analysis.

4. **Types of sample :**

4.1 General

'Certain parameters, such as the concentration of dissolved gases, should be measured in situ if possible, to obtain accurate results.'

Findings	Non-Conformance	Corrective Action
1. A number of parameters are measured *in situ* i.e. DO, pH, temperature, conductivity, and chlorine. 2. The relevant SOPs do not specifically state which parameters are to be measured *in situ*.	1. As per finding No. 2	1. Amend the relevant SOPs to include list of parameters which are measured on-site.

' It is recommended that separate samples be used for chemical, microbiological and biological analyses.'

Findings	Non-Conformance	Corrective Action
1. Relevant SOPs state that separate samples be used for chemical and microbiological samples	None	None

4.2 Spot samples

'Spot samples are recommended if the flow of the water to be sampled is not uniform, if the values of the parameters of interest are not constant and if the use of composite sample would obscure differences between individual samples due to reaction between them.

Findings	Non-Conformance	Corrective Action
1. The sampling programme does not give details on the type of sample to be taken.	1. As per finding No.1	1. Amend sampling programme to include details on when spot samples must be taken.

4.3 Periodic samples (discontinuous)

Not applicable to gap analysis.

4.4 Continuous samples
Not applicable to gap analysis.

4.5 Series sampling
Not applicable to gap analysis.

4.6 Composite samples.
'Composite samples provide average compositional data. Consequently before combining samples it should be verified that such data are desired or that the parameter(s) of interest do(es) not vary significantly during the sampling period.

Composite samples are valuable in cases when compliance with a limit is based on the average water quality.'

Findings	Non-Conformance	Corrective Action
1. The sampling programme does not give details on the type of sample to be taken i.e. spot or composite 2. No assessment carried out to determine whether the parameters of interest vary significantly during the composite sampling period.	1. As per findings No. 1 and 2	1. Amend sampling programme to include details on when composite samples are to be taken. 2. Develop, document and implement method to determine whether the parameters of interest vary significantly during the composite sampling period.

4.7 Large volume samples
'Some methods of analysis for certain determinands require the sampling of a large volume, namely from 50 litres to several cubic metres. Such large samples are necessary, for example, when analysing for pesticides or micro-organisms that cannot be cultured.'

Findings	Non-Conformance	Corrective Action
1. SOP No. 47 requires 10 litres of sample for *Cryptosporidium*. 2. SOP No. 6 does not include instructions regarding sampling for *Cryptosporidium* or pesticides	1. As per finding No. 2	1. Amend relevant SOPs with regard to sampling large volumes of water.

5. Types of sampling

' There are many sampling situations, some of which can be satisfied by taking simple spot samples whereas others may require sophisticated instrumental sampling equipment.'

Findings	Non-Conformance	Corrective Action
1. The sampling programme does not give details on the type of sample to be taken.	1. As per finding No. 1	1. Amend sampling programme to include details on the types of samples to be taken.

6. Sampling equipment.

6.1 Materials.

6.1.1 General

'The sample container has to preserve the composition of the sample from losses due to adsorption and volatilization, or from contamination by foreign substances.'

Findings	Non-Conformance	Corrective Action
1. All analysis carried out in the laboratory is as per 'Standard Methods (20th Edition)'which details the sample container type to be used for the various analyses. 2. The type of container is not documented in laboratory SOP or sampling programme. 3. No record is maintained with regard to what type of sampling bottle is used for the various analyses.	1. As per findings No. 2, 3	1. Document in relevant SOP the correct type of sampling container to be used for various analytes. 2. Record the type of sample container used. 3. Train sampling personnel to ensure that the correct sample container is used.

'The sample container used to collect and store the sample should be chosen after considering, for example, resistance to temperature extremes, resistance to breakage, ease of good sealing and reopening, size, shape, mass, availability, cost, potential for cleaning and re-use, etc.'

Findings	Non-Conformance	Corrective Action
1. No procedure in place with regard to the selection of sampling container.	1. As per finding No. 1	1. Develop and implement system for selection and purchase of sampling containers

6.1.1 General (ctd..)

'High density polyethylene is recommend for silica, sodium, total alkalinity, chloride, specific conductance, pH and hardness determinations in water.'

Findings	Non-Conformance	Corrective Action
1. High density polyethylene bottles are used for sampling the above.	None	None

'For light sensitive materials, light absorbent glass should be used'

Findings	Non-Conformance	Corrective Action
1. The use of light absorbent glass for sampling is not documented and they are not used on a routine basis for light sensitive materials.	1. As per finding No. 1	1. Identify and document the parameters, which are light sensitive. 2. Implement system to ensure the correct containers are used for sampling these. 3. Train sampling personnel with regard to using the correct type of container.

'Stainless steel should be considered for samples of high temperature and or pressure or when sampling for trace concentrations of organic material. Glass bottles are suitable for organic chemical compounds and biological species.

The sample containers used to collect and store the samples should be selected by taking into account the following predominant criteria:

a) Minimisation of contamination of the water sample by the material of which the container or its stopper is made.

b) Ability to clean and treat the walls of the containers, to reduce surface contamination by trace constituents such as heavy metals.

c) Chemical and biological inertness of the material of which the container is made, in order to prevent or minimize reaction between constituents of the sample and the container.

d) Sample containers may also cause errors by adsorption of determinands. Trace metals are particularly liable to this effect but other determinands (eg detergents, pesticides, phosphate) may also be subject to error.'

Findings	Non-Conformance	Corrective Action
1. No documented procedure with regard to selection of sampling container.	1. As per finding No. 1	1. Document procedure for the selection of sampling container for various analyses, taking into account the factors listed above.

6.1.2 Sampling lines

'The guidelines for the selection of materials for sample containers also apply to sampling lines.'

Findings	Non-Conformance	Corrective Action
1. No documented procedure with regard to selection of sampling lines.	1. As per finding No. 1	1. Document procedure for the selection of sampling lines.

6.2 Types of sample container

6.2.1 General

'Polyethylene and borosilicate glass bottles are suitable for conventional sampling for the determination of physical and chemical parameters of natural waters.
Screw cap, narrow-mouthed and wide-mouthed bottles should be fitted with inert plastics stoppers/caps or ground glass stoppers.
If the samples are transported in a case to a laboratory for analysis, the lid of the case should be constructed to prevent loosening of the stopper which could result in spilling and/or contamination of the sample.'

Findings	Non-Conformance	Corrective Action
1. No documented procedure with regard to selection of sampling container. 2. Sampling bottles are fitted with plastic caps. This is not documented in relevant SOPs. 3. Plastic caps used have a tamper proof seal. This is not documented in relevant SOPs.	1. As per findings No. 1-3	1. Document procedure with regard to the selection of sampling container, including details on correct caps to be used.

6.2.2 Special sample containers

' The collection and analysis of samples containing dissolved gases or constituents that would be altered by aeration poses a specific problem. The narrow mouthed BOD bottles should be fitted with pointed glass stoppers to minimize air occlusion and thus require special provision for sealing during transportation.'

Findings	Non-Conformance	Corrective Action
1. The sampling bottles used for river and wastewater samples are filled to overflow. This requirement is only stated in SOP No. 8 (re river sampling) 2. The BOD test is carried out in the laboratory as per 'Standard Methods (20th Edition)'. Bottles are filled and fitted with pointed glass stoppers.	1. As per finding No. 1	1. Amend relevant sampling SOPs to include details with regard to filling the sample bottle.

6.2.3 Trace organic contaminants

' The sample bottles should be made of glass as virtually all plastics containers interfere with the highly sensitive analysis. The closure should be of glass or polytetrafluoroethylene '.

Findings	Non-Conformance	Corrective Action
1. No documented procedure exists with regard to the selection of sampling container for trace organic contaminants. 2. No record is maintained to indicate what type of sample bottle was used.	1. As per findings No. 1 and 2	1. Document in relevant SOP which sampling container is to be used for trace organic contaminants analyses. 2. Record which sample container is used. 3. Train sampling personnel with regard to the correct sample container to be used.

6.2.4 Sample containers for microbiological examination

'Sample containers for microbiological examination should be able to withstand the high temperatures, which occur during sterilization. During sterilization or sample storage the materials should not produce or release chemicals, which could inhibit microbiological viability, release toxic chemicals or encourage growth.
Sample bottles should be of good quality glass or plastics material and free from toxic substances.
Bottles should be fitted with grounded glass stoppers or screw caps fitted.'

Findings	Non-Conformance	Corrective Action
1. No documented procedure exists with regard to the selection of sampling containers for microbiological examination.	1. As per finding No. 1.	1. Document procedure for the selection of sampling containers for microbiological examination.

'The samples should remain sealed until opened in the laboratory and should be covered to prevent contamination.'

Findings	Non-Conformance	Corrective Action
1. All samples are sealed with a tamper-proof cap, which is not opened until it reaches the laboratory. 2. The sampling SOPs do not give details regarding the sealing of the bottle.	1. As per finding No. 2.	1. Amend SOP No.'s 6, 8, 10, 11 and 47 to include details regarding the sealing of sampling bottle.

6.3 Sampling equipment for physical or chemical characteristics.

6.3.1 Introduction

' The volume of sample collected should be sufficient for the required analyses and for any repeat analyses. '

Findings	Non-Conformance	Corrective Action
1. The sample volume collected depends on the type and number of parameters which are being analysed. 2. SOP No.'s 6, 8, 10 and 11 make no reference with regard to what volume of sample should be collected.	1. As per findings No. 1.	1. Amend relevant SOP's to include details with regard to what volume of sample is to be collected. 2. Train sampling personnel to ensure the correct volume of sample is collected.

'Effective samplers should:

a) Minimize the contact time between the sample and the sampler

b) Use materials such that no sample contamination occurs.

c) Be simply designed to ensure ease of cleaning

d) Be designed after considering the system suitability in relation to the required water sample (i.e. chemical, microbiological)'

Findings	Non-Conformance	Corrective Action
1. No SOP with regard to selection of effective samplers. 2. Drinking water samples are collected directly from tap into sample container (SOP No. 6). 3. STP and industrial effluent samples are collected directly into the sampling container using a long arm sampler onto which the sampling container can be attached. (not stated in SOP No.'s 10 and 11) 4. River samples are collected using a bucket, which is rinsed prior to use (SOP No. 8)	1. As per finding No. 1	1. Document a procedure for the selection of effective samplers.

6.3.2 Equipment for spot sampling

6.3.2.1 General
The simplest equipment for taking surface samples is a bucket or wide mouthed bottle dropped into a body of water and hauled out after sampling.

Findings	Non-Conformance	Corrective Action
1. River samples are taken using a bucket.	None	None

6.3.2.2 Equipment for spot sampling at selected depths.
Not applicable to gap analysis.

6.3.2.3 Grabs or dredges for sampling sediments.
Not applicable to gap analysis.

6.3.2.4 Clam-shell buckets.
Not applicable to gap analysis.

6.3.2.5 Core samplers.
Not applicable to gap analysis.

6.3.3 Automatic sampling equipment.
Not applicable to gap analysis.

6.4 Equipment for biological sampling
Not applicable to gap analysis.

6.5 Sampling equipment for microbiological characteristics.
'For the majority of samples, sterilised glass or plastic bottles are suitable. All apparatus used, including the pumps and pumping equipment, has to be free from contamination (e.g. by flushing) and should not introduce new microorganisms.'

Findings	Non-Conformance	Corrective Action
1. No documented procedure exists with regard to the selection of sampling containers for microbiological examination. 2. SOP No.6 states 'run tap for approx. 2 mins' and 'soak mouth of tap in alcohol'	1. As per finding No. 1.	1. Document procedure for the selection of sampling containers for microbiological examination.

6.6 Sampling equipment for radioactivity characteristics.
Not applicable to gap analysis.

6.7 Equipment for sampling of dissolved gases (and volatile materials)

'Samples suitable for accurate determinations of dissolved gases should only be obtained with equipment which collects a sample by displacement of water, rather than air, from the sampler. If pumping systems are used for the collection of dissolved gas samples, it is essential that the water be pumped in such a way that the pressure applied to it does not drop significantly below atmospheric pressure. The sample should be pumped directly into the storage or analysis bottle, which should be flushed by an amount equal to at least 3 times its volume before starting analysis or stoppering the bottle.

If approximate results are acceptable, samples for dissolved oxygen determinations may be collected using a bottle or a bucket. The error introduced into these determinations by contact between the sample and the air varies with the degree of saturation of the gas in the water.'

Findings	Non-Conformance	Corrective Action
1. Samples for dissolved oxygen determinations are collected using a bucket. 2. The acceptable of approximate results has not been determined.	1. As per finding No. 2	1. Assess whether an accurate determination of dissolved gases is required. 2. Implement appropriate method if required.

'Where samples are collected in a bottle from a tap or pump outlet, a flexible inert tube which delivers liquid to the bottom of the bottle is recommended to ensure that liquid is displaced from the bottom of the bottle and that minimal aeration occurs.'

Findings	Non-Conformance	Corrective Action
1. Flexible inert tubes are not used to fill bottles from taps or pumps.	1. As per finding No. 1	1. Develop, document and implement method with regard to the correct filling of bottles from taps or pumps. 2. Train relevant personnel.

7 Identification and records

7.1 General

'The source of the sample and the conditions under which it was collected should be recorded and attached to the bottle immediately after filling.
The results of any on-site analyses carried out should also be included in a report with the sample. Labels and forms should always be completed at the time of sample collection.'

Findings	Non-Conformance	Corrective Action
1. All bottles are labelled at time of sampling as required under SOP No.'s 6, 8, 10 and 11. 2. SOP No. 47 does not include any details with regard to labelling of sample bottles. 3. Results of on-site analyses are included in a field report. There are pre-prepared sample report forms for the various sample bodies. 4. No reference in SOP No.'s 6, 8, 10, 11 or 47 with regard to recording on-site analyses on a sample report form.	1. As per findings No. 2 and 4.	1. Amend SOP No. 47 to include details with regard to labelling of sample bottles and completion of a sample report form. 2. Amend SOP No. 6, 8, 10 and 11 to include details with regard to recording on-site analyses on a sample report form.

7.2 Reports.

'At least the following information should be included in the sampling report:
a) Location (and name) of sampling site, with coordinates and any other relevant locational information.
b) Details of the sampling point
c) Date of collection
d) Method of collection
e) Time of collection
f) Name of collector
g) Weather conditions
h) Nature of pretreatment
i) Preservative or stabiliser added
j) Data generated in the field'

Findings	Non-Conformance	Corrective Action
1. The following are not included in the laboratory sampling report: - Coordinates of sampling site - Details of the sampling point - Method of collection - Time of collection - Weather conditions (drinking water sampling report) - Nature of pretreatment - Preservative or stabiliser added	1. As per finding No. 1	1. Amend sample report forms to include all of the above. 2. Train sampling personnel in order to ensure all relevant information is recorded.

DOCUMENT No.4:

Summary of the Corrective Actions required in order to comply with: ***I.S. EN 25667-2:1994 Water quality – Sampling- Part 2: Guidance on sampling techniques (ISO 5667-2:1991).***

Note: *For the corrective actions to be implemented effectively staff training shall have to be paramount in all cases.*

1. Amend the relevant sampling SOPs to include details on the parameters to be measured *in situ (ISO 5667-2:1991 (4.1)).*

2. Amend sampling programme to include details on when spot samples are to be taken *(ISO 5667-2:1991 (4.2), (5)).*

3. Amend sampling programme to include details on when composite samples are to be taken *(ISO 5667-2:1991 (4.6), (5)).*

4. Develop, document and implement method to determine whether the parameters of interest vary significantly during the composite sampling period *(ISO 5667-2:1991 (4.6)).*

5. Amend SOP No. 6 to include details with regard to sampling large volumes e.g. for *Cryptosporidium* analysis *(ISO 5667-2:1991 (4.7)).*

6. Document in the relevant sampling SOPs the sampling container to be used for various analyses and record the type of container used *(ISO 5667-2:1991 (6.1.1)).*

7. Develop and implement system for selection and purchase of sampling containers, including details on caps to be used for the various analyses *(ISO 5667-2:1991 (6.1.1), (6.2.1), (6.2.3), (6.5)).*

8. Identify and document the analytes which are light sensitive. Implement system to ensure the correct containers are used for sampling these analytes *(ISO 5667-2:1991 (6.1.1)).*

9. Document procedure for the selection of sampling lines *(ISO 5667-2:1991 (6.1.2)).*

10. Amend relevant sampling SOPs to include details with regard to filling the sample bottle *(ISO 5667-2:1991 (6.2.2)).*

11. Document procedure for the selection of sampling containers for microbiological examination *(ISO 5667-2:1991 (6.2.4)).*

12. Amend SOP No.'s 6, 8, 10, 11 and 47 to include details on sealing the sample *(ISO 5667-2:1991 (6.2.4)).*

13. Amend SOP No's 6, 8, 10 and 11 to include details on the volume of sample(s) to be collected for the determination of various analytes *(ISO 5667-2:1991 (6.3.1)).*

14. Document a procedure for the selection of effective samplers *(ISO 5667-2:1991 (6.3.1)).*

15. Assess the accuracy required when determining dissolved gases. If the current *in-situ* analytical methods do not yield sufficient accuracy implement appropriate method *(ISO 5667-2:1991 (6.7))*.

16. Develop, document and implement method with regard to the correct filling of bottles from taps or pumps, using flexible inert tubes *(ISO 5667-2:1991 (6.7))*.

17. Amend SOP No. 47 to include details with regard to labelling of sample bottles and completion of sample report form *(ISO 5667-2:1991 (7.1))*.

18. Amend SOP No. 6, 8, 10 and 11 to include details with regard to completion of sample report forms *(ISO 5667-2:1991 (7.1))*.

19. Amend the field sample report forms to include the information specified in ISO 5667-2:1991 (7.2).

DOCUMENT No. 5:

ISO 5667-3:1994 Water quality – *Sampling- Part 3: Guidance on the preservation and handling of samples*

1. **Scope:** Not applicable to gap analysis.
2. **Normative References:** Not applicable to gap analysis.

3. Preservation of samples

3.1 General considerations

'Waters, particularly surface waters and above all waste waters are susceptible to being changed to differing extents as a result of physical, chemical or biological reactions which may take place between the time of sampling and the analysis.
It must be emphasised moreover that these variations are often sufficiently rapid to modify the sample considerably in the space of several hours. In all cases, it is therefore essential to take the necessary precautions to minimise these reactions and, in the case of many parameters, to analyse the sample with a minimum of delay.
It is generally necessary to choose, from the various possible methods of preservation, a method that does not introduce unacceptable contamination.'

Findings	Non-Conformance	Corrective Action
1. pH, temperature, conductivity, dissolved oxygen and chlorine are monitored at the sampling site. 2. The above is not stated in relevant SOPs. 3. No routine preservation of samples takes place.	1. As per findings No. 2 and 3.	1. Amend relevant SOPs to include the field analysis, which are currently carried out. 2. Assess the need to preserve samples and implement system if necessary. 3. Train sampling personnel with regard to preservation of samples.

3.1 General considerations (ctd..)

'In every case, the method of storage should be compatible with the various analytical techniques for which it will be used.'

Findings	Non-Conformance	Corrective Action
1. Samples are transported from sampling site to laboratory in cooler boxes. Not documented in SOP No.'s 8, 10 or 11. 2. SOP No. 43 states 'store samples in appropriate fridge'. No details are given as to length of storage for the various analyses. 3. Standard Methods (20th Ed.) is used to determine storage time, however no reference is made to this in any SOP/procedure.	1. As per findings No. 1, 2 and 3.	1. Amend SOP No.'s 8, 10 and 11 to include details on sample transportation from sampling site to laboratory in cooler boxes. 2. Amend SOP No. 43 to include details on the max. length of sample storage for the various analytes referencing Standard Methods (20th Ed.).

3.2 Feasible precautions

3.2.1 Filling the container:

'In the case of samples for the determination of physico-chemical parameters, one simple precaution, which is not however adequate in all cases, is to fill the flasks completely and stopper them in such a way that there is not air above the sample.
This limits interaction with the gas phase and agitation during transport i.e. iron has less tendency to be oxidized thus limiting colour variations.

Findings	Non-Conformance	Corrective Action
1. SOP No.'s 6 and 8 state 'fill sample bottle to overflow' for physico-chemical parameters. 2. SOP No.'s 10, 11 and 47 have no statement regarding filling of sample bottles for physico-chemical parameters.	1. As per finding No. 2.	1. Amend SOP No.'s 10, 11 and 47 detailing how the sample container is to be filled. 2. Train sampling personnel with regard to the correct filling of sample container.

3.2.1 Filling the container (ctd..):

'For microbiological examination, the sample container should not be filled to the brim so that an air space is left after insertion of the stopper. This aids mixing before examination and avoidance of accidental contamination.'

Findings	Non-Conformance	Corrective Action
1. SOP No. 6 does not state that the sample container should be filled to the brim.	1. As per finding No. 1	1. Amend SOP No. 6 detailing how the microbiological sample container is to be filled. 2. Train sampling personnel with regard to the correct filling of sample container.

3.2.2 Use of appropriate containers:

'It is essential that the container in which the sample is stored and the stopper should not:

- *be a cause of contamination*
- *Absorb or adsorb the constituents to be determined (for example traces of metals may be adsorbed on the surface of a glass container, which may be prevented by acidifying the sample).*
- *React with certain constituents in the sample (for example fluorides reacting with glass).'*

Findings	Non-Conformance	Corrective Action
1. All microbiological samples are taken in sterilized bottles (SOP No.'s 6 and 47). 2. HDPE sampling bottles are not re-used. This is not documented in SOP No.'s 6, 8, 10, 11 or 47. 3. SOP No.'s 6, 8, and 11 state 'rinse sample container'. 4. SOP No.'s 10 and 47 do not state that the sample container should be rinsed prior to filling. 5. There is no detail in SOPs with regard to what type of container should be used for a particular parameter.	1. As per findings No. 2, 4 and 5.	1. Amend SOP No.'s 6, 8, 10, 11 and 47 stating that HDPE sampling bottles are not re-used. 2. Amend SOP No.'s 10 and 47 stating that the sample container should be rinsed prior to filling. 3. Prepare SOP detailing what type of sampling container is to be used for a particular parameter. 4. Train sampling personnel with regard to use of correct container.

3.2.2 Use of appropriate containers (ctd..):

'It is preferable to reserve a set of containers for a particular determinand.'

Findings	Non-Conformance	Corrective Action
1. Disposable plastic containers are used for physico-chemical samples. 2. This is not stated in any sampling SOP	1. As per finding No. 2	1. Amend relevant SOPs stating that disposable plastic containers are used for physico-chemical samples.

'Blank samples containing distilled water should always be taken, preserved and analysed as a check on the suitability of the choice of container and cleaning procedure.'

Findings	Non-Conformance	Corrective Action
1. Blank samples are not analysed.	1. As per finding No. 1	1. Implement system for the taking and analysing of blank samples. 2. Amend relevant SOPs with regard to taking blank samples. 3. Train sampling personnel with regard to taking blank samples.

3.2.3 Preparation of containers:

3.2.3.1 For samples for chemical analysis

'For analysis of trace quantities of chemical constituents of surface or waste water, it is usual to clean new containers thoroughly in order to minimize possible contamination of the sample; the type of cleaner used and the container material vary according to the constituents to be analysed.'

Findings	Non-Conformance	Corrective Action
1. New containers are not cleaned prior to use, they are rinsed prior to filling with the sample.	1. As per finding No. 1	1. Implement system of cleaning for sample bottles. 2. Prepare SOP detailing how this is to be carried out. 3. Train sampling personnel, with regard to cleaning of sample bottles.

3.2.3.1 For samples for chemical analysis (ctd..)

'In general, new glassware should be rinsed with water containing a detergent in order to remove dust and residues of packing material, followed by through rinsing with distilled or deionized water.
For general trace analysis, the bottles should be filled with 1mol/l solution of nitric acid or hydrochloric acid and left to soak for at least one day, followed by rinsing with distilled or deionized water.
For the determination of phosphates, silicon, boron and surfactants, detergents should not be used for cleaning purposes.'

Findings	Non-Conformance	Corrective Action
1. New glassware is rinsed with water containing a detergent followed by thorough rinsing with distilled water. This is not documented in any SOP. 2. For trace analysis the bottles used are not filled with 1mol/l solution of nitric acid or hydrochloric acid and left to soak for at least one day. 3. Phosphate free detergents are used for cleaning purposes. However sample bottles for silicon, boron and surfactants are not washed in phosphate free detergent.	1. As per finding No. 1-3.	1. Prepare SOP detailing how sample bottles are to be cleaned for the various analytes. 2. Train sampling personnel, with regard to cleaning of sample bottles.

3.2.3.2 For samples for determination of pesticides, herbicides and their residues
'In general glass (preferably brown) containers should be used.
All containers should be cleaned with water and detergent, followed by through rinsing with distilled or deionized water, then oven dried at 105^{O}C for 2 hours and cooled before being rinsed with the extraction solvent used during the analysis. Finally they should be dried with a stream of carefully purified air or nitrogen.'

Findings	Non-Conformance	Corrective Action
1. The type of container to be used and the method of cleaning is not documented. 2. Containers used are not prepared as specified above.	1. As per findings No. 1 and 2.	1. Implement correct method for cleaning sample containers. 2. Document type of container and appropriate cleaning method. 3. Train sampling personnel, with regard to cleaning of sample bottles.

3.2.3.3 For samples for microbiological analysis

'The container should be able to withstand a sterilisation temperature of 175^{O}C for 1 hour and should not produce release at this temperature any chemicals which would either inhibit biological activity, induce mortality or encourage growth.'

Findings	Non-Conformance	Corrective Action
1. Pyrex bottles that can withstand a sterilization temperature of 140^{O}C are used for microbiological analysis. 2. There is no stated specification for the type of bottles which should be used.	1. As per finding No. 2.	1. Document container specification for microbiological analysis.

'It is essential that the containers be free of acidic, alkaline and toxic compounds. Glass containers should be cleaned with water and detergent followed by rinsing with distilled water. They should also be rinsed with nitric acid 10% (V/V) followed by rinsing with distilled water in order to remove any heavy metals or chromate residues.'

Findings	Non-Conformance	Corrective Action
1. Glass containers are washed with detergent, acid wash and rinsed with distilled water. 2. The above is not documented.	1. As per finding No. 2.	1. Document procedure for cleaning glass containers. 2. Train sampling personnel, with regard to cleaning of glass containers.

If the samples contain chlorine, sodium thiosulphate should be added before sterlization.'

Findings	Non-Conformance	Corrective Action
1. The above is carried out but not documented.	1. As per finding No. 1	1. Include the requirement to add sodium thiosulphate before sterlization in SOP re preparation of sampling containers.

3.2.4 Cooling or freezing of the samples

'The sample should be kept at a temperature lower than that during filling. Containers should be almost, but not completely, filled.
Cooling or freezing of samples is only truly effective if it is applied immediately after the collection of the samples.

Cooling cannot be considered as a means of long-term storage, particularly in the case of waste water samples.
In general, freezing allows an increase in the period of storage. Nevertheless, it is necessary to control the freezing and thawing technique fully in order to return the sample to its initial equilibrium after thawing.

Samples for microbiological analysis should not be frozen.'

Findings	Non-Conformance	Corrective Action
1. All samples are transported from sampling location to the laboratory in cooler boxes. 2. The requirement to store samples in cooler boxes is not documented in SOP No.'s 6, 8, 10 or 11. 3. STP samples are frozen following analysis in order that BODs can be repeated if necessary i.e. samples are not frozen immediately after collection. 4. There are no documented procedures with regard to the freezing and thawing of samples. 5. Microbiological samples are not frozen, this is not documented.	1. As per findings No. 2-5.	1. Amend SOP No.'s 6, 8, 10 and11 to include the requirement to store samples in cooler boxes during transit to laboratory. 2. Develop and implement a system to freeze samples, if required immediately after collection. 3. Document procedure for freezing and thawing of samples. 4. Train sampling personnel with regard to freezing ad thawing of samples.

3.2.5 Filtration or centrifuging of samples

'Suspended matter, sediment, algae and other micro-organisms may be removed, either at the time of taking the sample or immediately afterwards, by filtration of the samples, through filter paper or membrane filter or by centrifuging.'

Findings	Non-Conformance	Corrective Action
1. Suspended matter or sediment is not removed at the time of taking the sample or immediately afterwards.	1. As per finding No. 1	1. Identify and document which samples are to be filtered or centrifuged. 2. Develop, document and implement a system for filtration/ centrifuging of the relevant samples at the time of taking the sample or immediately afterwards. 3. Train sampling personnel with regard to filtration/ centrifuging of samples.

'It is essential that the filter is not a cause of contamination and is carefully washed before use, but in a manner consistent with the final method of analysis.
Membranes should be used with caution as various heavy metals and organic material may be adsorbed onto the membrane surface and soluble compounds within the membrane can be leached out into the sample.'

Findings	Non-Conformance	Corrective Action
1. No procedure exists to assess whether the filter is a cause of sample contamination.	1. As per finding No. 1	1. Develop, document and implement a procedure for assessing whether the filter is a cause of sample contamination.

3.2.6 Addition of preservatives

'Certain preservatives need to be used with caution, considering the danger involved in their handling. Operators should be warned of these dangers and the ways of protecting themselves from them.'

Findings	Non-Conformance	Corrective Action
1. The safety statement for the laboratory has a section on handling chemicals and requires that the necessary safety precautions be strictly adhered to. 2. Laboratory personnel who have read the safety statement have signed to certify this.	None	None

'It is essential that the preservatives used do not interfere during the determination; tests intended to check their compatibility are necessary in cases of doubt. Any dilution of the sample with added preservatives should be taken into account during the analysis and calculation of result.
It is preferable that the addition of preservatives be made using sufficiently concentrated solutions so that only small volumes are necessary.
The addition of these agents can also modify the chemical or physical nature of the constituents and it is therefore necessary that these modifications are not incompatible with the objectives of later determinations.

It is essential to carry out a blank test, particularly determinations of trace elements, to take into account possible introduction of an additional amount of the element to be determined.'

Findings	Non-Conformance	Corrective Action
1. No documented SOP/procedure with regard to preservation of samples. 2. The possible effect of dilution due to addition of preservatives is not taken into account. 3. Concentrated acid is used for preservation, this is not documented. 4. No blank test is carried out.	1. As per findings No. 1-4	1. Document procedure for: - preservation of samples - assessing the possible effect of dilution due to addition of preservatives - carrying out a blank test. 2. Train sampling personnel with regard to preserving samples and carrying out quality control tests.

3.3 Recommendations

'Each analyst should therefore verify, taking into account particularly the method of analysis which he intends to use, whether the suggestions in table 1 to 5 are suitable for the sample with which he is concerned.'

Findings	Non-Conformance	Corrective Action
1. No verification of suggested preservatives suggestion has taken place.	1. As per finding No. 1	1. Implement method to verify if the suggested preservations are suitable. 2. Document results.

4 Identification of samples

'Containers holding the samples should be marked in a clear and durable manner in order to permit identification without ambiguity in the laboratory.'

Findings	Non-Conformance	Corrective Action
1. All sample bottles are labelled, at the sampling location using a permanent marker. SOP No.'s 6, 8, 10 and 11 state the details to be included on each sampling bottle. 2. SOP No. 47 does not have any details regarding what is to be labelled on the sampling bottles.	1. As per finding No. 2.	1. Amend SOP No.47 stating what details are required to be marked on sampling bottles.

'Additionally, it is necessary to note, at the moment of sampling, numerous details which will permit a correct interpretation of the information obtained (date and hour of sampling, name of person sampling, nature and amount of preservative added).'

Findings	Non-Conformance	Corrective Action
1. Date and name of sampler is recorded in designated field sheets. SOP No.'s 6, 8, 10, 11 or 47 make no reference to recording these details on the field sheets. 2. The time of sampling is not recorded. 3. As no preservatives are currently added during sampling this is not recorded.	1. As per finding No. 2.	1. Amend SOP No.'s 6, 8, 10, 11 and 47 stating that field sheets are to be completed to include details with regard to the sample and sampler. 2. Amend field sheets to include details regarding time of sampling.

4 Identification of samples (ctd..)

'Special samples of anomalous material should be clearly marked and accompanied by a description of the observed anomaly. It is essential that samples containing hazardous or potentially hazardous materials, for example acids, are clearly identified as such.'

Findings	Non-Conformance	Corrective Action
1. No documented procedure for dealing with samples of anomalous material or for clearly identifying hazardous materials.	1. As per finding No. 1	1. Document procedure for: - dealing with samples of anomalous material - identifying hazardous materials. 2. Train sampling personnel with regard to dealing with samples of anomalous material.

5 Transport of samples

'Containers holding samples must be protected and sealed in such a way that they do not deteriorate and do not lose any part of their contents during transport. Packaging should protect the containers from possible external contamination and breakage, particularly near the opening, and should not itself be a source of contamination.'

Findings	Non-Conformance	Corrective Action
1. Plastic containers have plastic lids with seals. Glass containers are pyrex and have screw caps. 2. All samples are stored in cooler boxes during transport to the laboratory. Due to the nature of the sampling bottles i.e. plastic and pyrex additional packaging is not required.	None	None

5 Transport of samples (ctd..)

'During transportation, the samples should be kept as cool as practicable and protected from light, with each sample placed inside an individual waterproof container if possible.'

Findings	Non-Conformance	Corrective Action
1. All samples are transported to the laboratory in a cooler box. This is not documented in relevant SOP's. 2. Each sample is stored in watertight bottle.	1. As per finding No. 1	1. Amend relevant SOP's to include details regarding transportation of samples in a cooler box.

'If time of travel exceeds the maximum recommended preservation time before analysis then the samples should still be analysed and the time between sampling and analysis reported after consultation with the scientist interpreting the analytical results.'

Findings	Non-Conformance	Corrective Action
1. No documented procedures regarding the procedure to be taken when the time of travel exceeds the max recommended preservation time.	1. As per finding No. 1	1. Document the procedure for situations where the time of travel exceeds the max. recommended. preservation time. 2. Train sampling personnel to ensure correct measures are taken when the time of travel exceeds the max. recommended. preservation time.

6 Reception of samples in the laboratory

'On their arrival in the laboratory, the samples should, if their immediate analysis is impossible, be preserved under conditions such that any contamination of the outside of the containers is avoided and which prevent any change in their contents. The use, for this purpose, of refrigerated cabinets or cool and dark places is highly recommended.'

Findings	Non-Conformance	Corrective Action
1. All samples are stored in a refrigerator on arrival to the laboratory, if immediate analyses are not being carried out. 2. The above is not documented in SOP No.'s 6, 8, 10, 11 or 47.	1. As per finding No. 1	1. Amend SOP No.'s 6, 8, 10, 11 and 47 stating that samples are to be stored in a refrigerator on arrival to the laboratory, if immediate analyses are not being carried out..

6 Reception of samples in the laboratory (ctd..)

'It is recommended that the count of sample containers received be verified against the record of the number of sample bottles sent for each sample.'

Findings	Non-Conformance	Corrective Action
1. The above is not carried out.	1. As per finding No. 1	1. Develop, document and implement system for verifying the number of samples received v's those recorded. 2. Train sampling personnel.

DOCUMENT No. 6:

Summary of the Corrective Actions required in order to comply with: ***ISO 5667-3:1994 Water quality – Sampling- Part 3: Guidance on the preservation and handling of samples***

Note: *For the corrective actions to be implemented effectively staff training shall have to be paramount in all cases.*

1. Amend SOP No.'s 6, 8, 10, 11 and 47 to include field analyses, which are currently carried out *(ISO 5667-3:1994 (3.1)).*

2. Assess the need to preserve samples and implement appropriate method if necessary *(ISO 5667-3:1994 (3.1)).*

3. Amend SOP No.'s 6, 8, 10 and 11 to include details on the sample transportation from sampling site to laboratory in cooler boxes *(ISO 5667-3:1994 (3.1), (3.2.4), (5)).*

4. Amend SOP No. 43 to include details on the max. length of sample storage for the various analyses, making reference to guidelines in Standard Methods (20th Ed.) *(ISO 5667-3:1994 (3.1)).*

5. Amend SOP No.'s 10, 11 and 47 stating that the sample containers for physico-chemical parameters shall be filled completely and capped in such a way that there is no air above the sample.
   Amend SOP No. 6 stating that for microbiological examination, the sample container should not be filled to the brim *(ISO 5667-3:1994 (3.2.1)).*

6. Amend SOP No.'s 6, 8, 10, 11 and 47 stating that disposable HDPE sampling bottles are to be used for physico-chemical parameters *(ISO 5667-3:1994 (3.2.2)).*

7. Amend SOP No.'s 10 and 47 stating that sample containers, for physico-chemical monitoring, shall be rinsed prior to filling *(ISO 5667-3:1994 (3.2.2)).*

8. Prepare SOP detailing the exact type of sampling container that is to be used for each analyte of interest *(ISO 5667-3:1994 (3.2.2), (3.2.3.2), (3.2.3.3)).*

9. Implement system for the taking, preserving and analysing of blank samples, to act as a check on the suitability of the choice of container and cleaning procedure. Amend SOP No.'s 6, 8, 10, 11 and 47 accordingly *(ISO 5667-3:1994 (3.2.2)).*

10. Implement and document the method of cleaning the various types of sample containers, for the various analytes of interest *(ISO 5667-3:1994 (3.2.3.1) (3.2.3.2) (3.2.3.3)).*

11. Develop, document and implement a procedure for the freezing and thawing of samples *(ISO 5667-3:1994 (3.2.4)).*

12. Identify and document which samples are to be filtered or centrifuged. Develop, document and implement a procedure for the filtration/ centrifuging of samples at the time of taking the sample or immediately afterwards *(ISO 5667-3:1994 (3.2.5)).*

13. Implement a procedure for assessing whether the filter type used to filter samples is a cause of contamination *(ISO 5667-3:1994 (3.2.5))*.

14. Develop, document and implement a procedure for:
    - Preservation of samples, preferably using concentrated solutions.
    - Assessing the possible effect of dilution due to addition of preservatives
    - Carrying out a blank test

    (ISO 5667-3:1994 (3.2.6)).

15. Develop, document and implement a procedure to verify whether or not the preservation suggestions in Table 1 to 5 of ISO 5667-3:1994 are suitable for the sample with which it is concerned *(ISO 5667-3:1994 (3.3))*.

16. Amend SOP No.47 stating what details are required to be labelled on the sampling bottles *(ISO 5667-3:1994 (4))*.

17. Amend SOP No.'s 6, 8, 10, 11 and 47 stating that the appropriate field sheet is to be completed at the time of sampling *(ISO 5667-3:1994 (4))*.

18. Amend field sheets to include details regarding time of sampling *(ISO 5667-3:1994 (4))*.

19. Develop, document and implement a procedure for:
    - dealing with samples of anomalous material
    - identifying hazardous materials

    (ISO 5667-3:1994 (4)).

20. Develop, document and implement a procedure for situations where the time-of-travel exceeds the max recommend preservation time *(ISO 5667-3:1994 (5))*.

21. Amend SOP No.'s 6, 8, 10, 11 and 47 stating that all samples are to be stored in a refrigerator on arrival to the laboratory, if immediate analyses are not being carried out *(ISO 5667-3:1994 (6))*.

22. Develop, document and implement procedure for verifying that the number of samples received at the laboratory coincides with the number recorded on the field sheet *(ISO 5667-3:1994 (6))*.

DOCUMENT No. 7:

Gap Analysis results for: ***ISO 5667-5: 1991 Water quality – Sampling- Part 5:Guidance on sampling of drinking water and water used for food and beverage processing.***

1. Scope.

'It is important that the sampling purpose be defined as accurately as possible and that the measurements provide the required information in the most efficient and statistically representative manner.'

Findings	Non-Conformance	Corrective Action
1. Drinking water supplies are listed and mapped in the sampling programme folder. 2. The laboratory's Compliance Manual for the Drinking Water Regulations, 2000 contains – copy of Regulations, monitoring frequencies for various supplies, etc.. 3. Neither of the above define the sampling purpose.	1. As per finding No. 3	1. Define sampling purpose in the sampling programme and Compliance Manual

2. Normative References: Not applicable to gap analysis.

3. Sampling Equipment.

Makes reference to ISO 5667-2 and ISO 5667-3.

4 Sampling procedure

4.1 Sampling location

'Before collection it should be decided if some of the analysis are to be performed on site.'

Findings	Non-Conformance	Corrective Action
1. SOP No. 6 states that the chlorine test should be carried out on site. 2. pH, temperature and conductivity readings are also taken on site, although this is not documented in SOP No. 6.	1. As per findings No. 1 and 2	1. Amend SOP No. 6 to include all tests, which are carried out on site.

4.1 Sampling location (ctd..)

'On-site analysis is recommended particularly for such determinands as odour, taste, pH, chlorine, ozone, dissolved oxygen, acid (base) capacity, carbon dioxide, electrical conductivity and for the assessment of temperature.'

Findings	Non-Conformance	Corrective Action
1. Odour and taste are not monitored in-situ. The other parameters listed above are monitored in-situ. 2. Tasting is not performed because of the risk to human health from the consumption of water of unknown quality.	1. As per finding No. 1	1. Develop, document and implement method of on-site analysis of odour. 2. Train sampling personnel with regard to monitoring odour on-site.

'Before transporting the sample to the laboratory, the appropriate preservation technique has to be applied.'

Findings	Non-Conformance	Corrective Action
1. Samples are not preserved prior to transporting the sample to the laboratory.	1. As per finding No. 1	1. Identify and document which samples are to be preserved on-site. 2. Document method of preservation. 3. Implement system to record which samples were preserved on-site. 4. Train sampling personnel with regard to preserving and recording the preservation of samples.

4.1.1 Service reservoir

'Samples should be collected from the inlet and outlet pipe, as close as possible to the service reservoir. Generally 2 min or 3 min of free flow should be allowed to flush out any stale water within the sampling line before taking a sample.

If it is essential to take dip samples (i.e. no sampling valve on the outlet pipe), special care should be taken to ensure that the sampling operation does not introduce debris into the water and that equipment is sterilized before sampling.'

Findings	Non-Conformance	Corrective Action
1. No documented procedure in place with regard to sampling from service reservoirs.	1. As per finding No. 1	1. Develop, document and implement procedure for sampling from service reservoirs. 2. Train sampling personnel with regard to sampling from reservoirs.

4.1.2 Water treatment plant

'Samples should be collected from the inlet and outlet pipes, as close as possible to the treatment plant. For monitoring of the different stages of water treatment, sampling should take place before and after the respective stage being monitored.'

Findings	Non-Conformance	Corrective Action
1. No documented procedure in place with regard to sampling from water treatment plants.	1. As per finding No. 1	1. Develop, document and implement procedure for sampling from water treatment plants. 2. Train sampling personnel with regard to sampling from water treatment plants.

4.1.3 Disinfection plant

'Samples from the influent to the disinfection/oxidation plant should be taken as close as possible to the plant. Samples of the effluent should be collected after, allowing for appropriate contact period between water and disinfectant/oxidant.'

Findings	Non-Conformance	Corrective Action
1. No documented procedure in place with regard to assessing the efficiency of the disinfection plant.	1. As per finding No. 1	1. Develop, document and implement procedure for assessing the efficiency of the disinfection plant. 2. Train sampling personnel with regard to the above.

4.1.4 Distribution system

'Samples should be collected at different locations in the distribution system and in particular from the ends of the distribution systems, for example from predetermined sampling taps.'

Findings	Non-Conformance	Corrective Action
1. Sample locations are selected at random by the sampler, however under the EC (Drinking Water) Regulations 2000 predetermined sampling points are being mapped.	1. As per finding No. 1	1. Identify and map predetermined sampling points for the various water supplies.

'Sampling from hydrants should be avoided wherever possible; if this is unavoidable special disinfection precautions are required.'

Findings	Non-Conformance	Corrective Action
1. No documented procedure in place with regard to sampling from hydrants.	1. As per finding No. 1	1. Develop, document and implement procedure for sampling from hydrants. 2. Train sampling personnel with regard to sampling from hydrants.

'For microbiological purposes, sampling taps should be sterilized by flame or alternative methods of equivalent efficiency.'

Findings	Non-Conformance	Corrective Action
1. SOP No. 6 states 'soak mouth of tap in alcohol'	None	1. Determine if sterilisation by alcohol is as efficient as flame sterilisation.

'Samples should be taken in the turbulent zone of a pipe if possible.
A need may arise to sample water where there is a very low flow. When taking the sample care should be taken that disturbance of sedimentary material does not occur. If this cannot be avoided, a sufficient volume of water should be flushed or a sufficient time allowed for a steady state to occur.'

Findings	Non-Conformance	Corrective Action
1. The above has not been considered in SOP No. 6.	1. As per finding No. 1	1. Amend SOP No. 6 to include details with regard to sampling in the turbulent zone of a pipe and sampling in area where there is low flow. 2. Train sampling personnel with regard to the correct sampling procedure when sampling from a tap with very low flow.

'When collecting a sample from a distribution system the flushing time should be in accordance with the sampling purpose, 2min. to 3min. being generally sufficient. Sometimes it may be necessary to allow the water to flow freely for as long as 30 min. before collecting the sample.'

Findings	Non-Conformance	Corrective Action
1. SOP No. 6 states 'run tap for approx. 2 min'. No mention of exceptional circumstances i.e. when the system may have to be flushed for longer periods.	1. As per finding No. 1	1. Amend SOP No. 6 to include circumstances when a system may have to be flushed for extended periods. 2. Train sampling personnel with regard to when the system should be flushed for extended periods.

'If dissolution of materials from the pipework, or growth of micro-organisms within the pipework are being investigated, samples should be taken from the initial draw-off.'

Findings	Non-Conformance	Corrective Action
1. The above is not documented.	1. As per finding No. 1	1. Develop, document and implement procedure for investigating the dissolution of materials from the pipework, or growth of micro-organisms within the pipework 2. Train sampling personnel to ensure the initial draw-off is sampled when investigating the dissolution of materials from the pipework, or growth of micro-organisms within the pipework.

4.1.5 Consumer's tap

'The flushing time depends upon the sampling purpose; if the effects of materials on water quality are being investigated then the initial draw-off should be sampled

Findings	Non-Conformance	Corrective Action
1. The above is not documented.	1. As per finding No. 1	1. Document the flushing period required for the various sampling purposes. 2. Train sampling personnel to ensure system is flushed for the appropriate time-period.

'For most other purposes a flushing time of 2 min to 3 min is sufficient.'

Findings	Non-Conformance	Corrective Action
1. SOP No. 6 states 'run tap for approx. 2 min'.	1. None	1. None

'For microbiological sampling, metal taps should be flamed and plastic taps should be disinfected using an available chlorine solution.' All fittings should be removed from the taps prior to flushing and sampling.

Findings	Non-Conformance	Corrective Action
1. SOP No. 6 states 'soak mouth of tap in alcohol' 2. The requirement to remove all fittings from the taps prior to flushing and sampling is not documented in SOP No. 6.	1. As per finding No. 2.	1. Asses need to disinfect using chlorine solution as opposed to the use of alcohol. Amend SOP if necessary. 2. Amend SOP No.6 to include the requirement to remove all fittings from the taps prior to flushing and sampling.

4.1.6 Sampling of bottled drinking water and water in tanks and containers for bulk storage on trains, aircraft and ships.

Not applicable to gap analysis.

4.1.7 Sampling of water used in food and beverage processing.

Not applicable to gap analysis.

4.2 Frequency and timing of sampling.

'National and/or regional legislation, such as WHO or EEC recommendations, whichever has precedence, should be followed.'

Findings	Non-Conformance	Corrective Action
1. The laboratory's 'Sampling Programme and Compliance Manual' prepared in response to the EC (Drinking Water) Regulations 2000 details the monitoring frequency required for the various supplies in Co. Limerick.	None	None

5 Sampling technique

5.1 Sampling for physical, chemical and radiological analysis

'When sampling from taps the water should be allowed to flow slowly into the sampling container and to overflow. Samples that are to be preserved and microbiological samples should not be filled to overflowing. Then the completely filled container should be stoppered tightly and checked for the absence of air bubbles.
Reference should be made either to ISO5667-3 or the 'Sampling and preservation of samples' clause of the respective analytical International Standard for detailed instructions concerning the handling of samples after sampling.'

Findings	Non-Conformance	Corrective Action
1. SOP No. 6 does not include details on filling and sealing the sample container. 2. SOP No. 6 states 'put sterile bottle in cooler'.	1. As per finding No. 1	1. Amend SOP No. 6 to include details on filling and sealing the sample container. 2. State in SOP No. 6 that samples to be preserved and microbiological samples should not be filled to overflowing.

5.2 Sampling for biological analysis

Not applicable to gap analysis.

5.3 Sampling for microbiological analysis

'When collecting the sample form a sampling line or tap, it may be necessary to flush any part of the system that has been stagnant for 2h or more, except when investigating the microbiological quality of the water within the local pipework.'

Findings	Non-Conformance	Corrective Action
1. SOP No. 6 states 'run tap for approx. 2 min'. No mention of circumstances where samples may have to be taken from a system that has been stagnant.	1. As per finding No. 1	1. Amend SOP No. 6 to include circumstances where samples may have to be taken from a system that has been stagnant. 2. Train sampling personnel in order to ensure adequate flushing has been carried out prior to sampling stagnant system..

5.3 Sampling for microbiological analysis (ctd..)

'The water should be allowed to flow freely from the tap or the outlet. The sampling container should be filled directly.
After sampling the sampling container should be closed tightly. Contamination of the stopper should be avoided.'

Findings	Non-Conformance	Corrective Action
1. No documented procedure in place with regard to filling or sealing the sample container.	1. As per finding No. 1	1. Amend SOP No. 6 to include details regarding: - allowing the water to flow freely from the tap or the outlet - Filling the container directly. - Sealing the container after sampling.

'The sampling outlet should, if necessary, be sterilized by flame or other methods.'

Findings	Non-Conformance	Corrective Action
1. SOP No. 6 states 'soak mouth of tap in alcohol'	None	None

'Wide-mouth sample containers of at least 300ml capacity with ground glass stoppers or screw caps should be used. The sample containers should be sterilized for 20 min at 120^{O}C and 200 kPa above ambient pressure in a wet autoclave.
During sterilization and sample storage, the materials should not produce or release chemicals which inhibit or increase microbiological activity.'

Findings	Non-Conformance	Corrective Action
1. Various wide-mouth sample containers with screw caps are used – 500, 250 and 100ml. 2. The sample containers are sterilized at 121^{O}C for 15 min. 3. No documented procedure/SOP detailing how sample containers are to be sterilized. 4. No system in place to check if sample bottles used during sterilization or sample storage produce or release chemicals which inhibit or increase microbiological activity.	1. Sample containers less than 300ml capacity are used. 2. Sample containers are not sterilized for the required length of time. 3. As per finding No. 3 and 4.	1. Amend SOP No. 6 to ensure only bottles of at least 300ml capacity are used. 2. Develop, document and implement procedure/SOP detailing how bottles are to be sterilized and method to assess if materials produce or release chemicals.

5.4 Sampling for virological analysis

Not applicable to gap analysis.

6 Safety precautions

'It is essential that personnel responsible for the design of sampling programmes and for carrying out sampling operations ensure that the requirements of relevant national safety Regulations are taken into account and complied with and that the sampling personnel are informed of the necessary precautions to be taken in sampling operations.

Findings	Non-Conformance	Corrective Action
1. The Council Safety Officer deals with safety. 2. There is a safety statement available for the Environment Section, within which there is a Section on the Environmental Laboratory. 3. Laboratory personnel sign the front of safety statement to indicate that they have read the contents. 4. There is no reference to safety in laboratory procedures/SOPs	1. As per finding No. 4	1. Amend drinking water SOPs to include reference to safety and the relevant section of the safety statement.

7 Volume of sample, handling of samples

7.1 Volume of sample

'Reference should be made to the relevant International Standard for the analytical methods for the volumes needed for each determination.'

Findings	Non-Conformance	Corrective Action
1. SOP No. 6 makes no reference to the volume of sample that is to be collected.	1. As per finding No. 1	1. Amend SOP No. 6 making reference to the volume of sample that is to be collected. 2. Train sampling personnel to ensure the correct volume of sample is collected.

7.2 Handling of samples

'As different analytical methods may require different methods of preservation, distribution of the sample into several containers may be required. To minimize changes in the sample during collection, storage and transport, these operations should be carried out in as short a time period and as soon after sampling as possible.'

Findings	Non-Conformance	Corrective Action
1. Preservation of samples is not carried out on-site. 2. There is no documented SOP detailing the type of sampling containers to be used.	1. As per finding No. 1	1. Develop, document and implement method to ensure samples are preserved and stored in the correct containers as soon as possible after sampling. 2. Train sampling personnel with regard to the correct preservation and storage of samples.

'If contact of the sample with air has to be avoided the sample container should be filled completely and then immediately stoppered.
If samples require vigorous mixing before taking portions for analyses, the sample container should not be filled completely or, if air has to be avoided a few pieces of clean, sterile, inert solids should be placed in the sampling container, for example solid beads or a magnetic strirrer.'

Findings	Non-Conformance	Corrective Action
1. Samples with which contact with the air has to be avoided or those that require vigorous mixing before taking portions for analyses are not identified and documented.	1. As per finding No. 1	1. Identify and document the samples with which contact with the air must be avoided and those that require vigorous mixing before taking portions for analyses. 2. Document procedure for dealing with these samples. 3. Train sampling personnel.

'If filtration is necessary the sample should be filtered during or immediately after collection to minimize any changes that may occur in the sample.'

Findings	Non-Conformance	Corrective Action
1. Filtration of samples is not carried out during or immediately after collection.	1. As per finding No. 1	1. Develop, document and implement procedure for filtering the required samples during or immediately after collection. 2. Train sampling personnel with regard to filtering the samples.

'Contamination of the outside of the sample containers, particularly necks and stoppers should be avoided.
The sampling containers should be secured for transport.
Unnecessary agitation or exposure to light during transport should be avoided.'

Findings	Non-Conformance	Corrective Action
1. All sample bottles are capped. Plastic bottles are sealed with a plastic cap and glass bottles are sealed with screw caps prior to transport. 2. All samples are transported in a sealed cooler box. 3. The above is not documented in SOP No. 6.	1. As per finding No. 3	1. Amend SOP No. 6 to include details regarding: - Sealing the sample containers. - Transportation of samples to the laboratory.

'The samples should be stored in a clean room, which can be kept dark and cool and in which no chemical reagents are used, separated from the laboratory.'

Findings	Non-Conformance	Corrective Action
1. All samples are stored in designated fridge for drinking water samples. 2. The above is not documented in SOP No. 6.	1. As per finding No. 2	1. Amend SOP No. 6 to include details regarding storage of samples.

8 Sample identification and records

'Immediately after collection of a sample, the container should be labelled so that the sample is easily identifiable.'

Findings	Non-Conformance	Corrective Action
1. SOP No. 6 states 'label sample bottles with name of supply, date, chlorine level (total and free) and temperature prior to taking the sample.'	None	None

'Describe each sampling location. If the same location is used permanently, it is not necessary to repeat all details every time. In this case only a statement of the on-site measurements and variables such as weather conditions and unusual observations need be recorded
When sampling for specific reasons (e.g. customer complaint) detailed information should be given including the reasons for sampling.'

Findings	Non-Conformance	Corrective Action
1. On the field report sheet the sampling date, sampler, sample location, LE (Laboratory Equipment) number of the equipment used and on-site measurements are recorded. 2. Weather conditions and unusual observations are not recorded. 3. When sampling for specific reasons (e.g. customer complaint) detailed information including the reasons for sampling are not recorded. 4. SOP No. 6 does not state that the above must be recorded.	1. As per findings No. 2-4.	1. Amend field sheet to include details on: - weather conditions - unusual observations - information on samples taken for a specific reason. 2. Amend SOP No. 6 to include requirement to complete field sheet.

9 Quality assurance of sampling and training of sampling personnel

' A quality assurance programme should be established as a routine procedure accompanying every series of sampling.
A system of blanks should be used to check bottles, filters and storage and transport using distilled water in place of samples on a regular basis.'

Findings	Non-Conformance	Corrective Action
1. There is no quality assurance programme in place. 2. No blanks are used to check bottles, filters and storage and transport.	1. As per findings No. 1 and 2.	1. Develop, document and implement quality assurance programme including system of blanks. 2. Train sampling personnel with regard to taking samples for quality assurance purposes.

'Personnel performing the sampling should be instructed to avoid contamination of samples and containers. Particular importance should be given to the correct measurement of those determinands that are carried out on site, and to their correct recording.'

Findings	Non-Conformance	Corrective Action
1. On commencement of employment all sampling personnel are trained with regard to correct sampling and on-site measurement techniques. 2. There is no documented procedure for training sampling personnel with regard to the avoidance of contamination of samples and containers. 3. There is no documented procedure for training sampling personnel with regard to on-site measurement techniques.	1. As per findings No. 2 and 3.	1. Document the procedure for training sampling personnel with regard to correct sampling and on-site measurement techniques.

DOCUMENT No. 8:

Summary of the Corrective Actions required in order to comply with: ***ISO 5667-5: 1991 Water quality – Sampling- Part 5:Guidance on sampling of drinking water and water used for food and beverage processing.***

Note: *For the corrective actions to be implemented effectively staff training shall have to be paramount in all cases.*

1. Define sampling purpose in the sampling programmes *(ISO5667-5:1999 (1)).*

2. Amend SOP No. 6 to include a list of all the parameters, which are measured on site *(ISO5667-5:1999 (4.1)).*

3. Develop, document and implement method of on-site analysis for odour *(ISO5667-5:1999 (4.1)).*

4. Identify and document which samples are to be preserved on-site. Document method of preservation and implement system to record which samples were preserved *(ISO5667-5:1999 (4.1), (7.2)).*

5. Develop, document and implement procedure for sampling from service reservoirs *(ISO5667-5:1999 (4.1.1)).*

6. Develop, document and implement procedure for sampling from water treatment plants *(ISO5667-5:1999 (4.1.2)).*

7. Develop, document and implement procedure for assessing the efficiency of the disinfection plant at water treatment plants *(ISO5667-5:1999 (4.1.3)).*

8. Identify and map predetermined sampling points for the various water supplies *(ISO5667-5:1999 (4.1.4)).*

9. Develop, document and implement procedure for sampling from hydrants *(ISO5667-5:1999 (4.1.4)).*

10. Amend SOP No. 6 stating that water samples should be taken in the turbulent zone of a pipe, if possible. When taking the sample where there is a very low flow, care should be taken that disturbance of sedimentary material does not occur. If this cannot be avoided, a sufficient volume of water should be flushed or a sufficient time allowed for a steady state to occur *(ISO5667-5:1999 (4.1.4)).*

11. Document the flushing period required for the various sampling purposes *(ISO5667-5:1999 (4.1.5)).*

12. Amend SOP No. 6 to include circumstances where a system may have to be flushed for extended periods *(ISO5667-5:1999 (4.1.4), (4.1.5))).*

13. Develop, document and implement procedure for investigating the dissolution of materials from pipework, or growth of microorganisms within pipework *(ISO5667-5:1999 (4.1.4), (4.1.5))*.

14. Assess the need to disinfect using a chlorine solution versus alcohol. Amend SOP if necessary *(ISO5667-5:1999 (4.1.5))*.

15. Amend SOP No.6 to include the requirement to remove all fittings from taps prior to flushing and sampling *(ISO5667-5:1999 (4.1.5))*.

16. Amend SOP No. 6 to include details on filling and sealing the sample container *(ISO5667-5:1999 (5.1), (5.3))*.

17. Amend SOP No. 6 to include circumstances where samples may have to be taken from a system that has been stagnant *(ISO5667-5:1999 (5.3))*.

18. Amend SOP No. 6 to ensure that only bottles of at least 300ml capacity are used *(ISO5667-5:1999 (5.3))*.

19. Develop, document and implement SOP detailing how bottles are to be sterilized and a method to assess if materials used produce or release chemicals *(ISO5667-5:1999 (5.3))*.

20. Amend drinking water SOP No. 6 to include reference to safety precautions required, when sampling drinking waters *(ISO5667-5:1999 (6))*.

21. Amend SOP No. 6 making reference to the volume of sample that is to be collected, for the various parameters *(ISO5667-5:1999 (7.1))*.

22. Develop, document and implement method to ensure samples are stored in the correct containers as soon as possible after sampling *(ISO5667-5:1999 (7.2))*.

23. Identify and document the samples with which contact with the air must be avoided and those that require vigorous mixing before taking portions for analyses. Document procedure for dealing with both types of samples *(ISO5667-5:1999 (7.2))*.

24. Identify the samples which are required to be filtered immediately after collection. Develop, document and implement procedure for filtering samples and train sampling personnel *(ISO5667-5:1999 (7.2))*.

25. Amend SOP No. 6 to include details regarding the sealing of sample containers and transportation of samples to the laboratory *(ISO5667-5:1999 (7.2))*.

26. Amend SOP No. 6 to include details on storage of samples in the laboratory *(ISO5667-5:1999 (7.2))*.

3. Amend field sheet to include details on:
   - weather conditions.
   - unusual observations.
   - information on samples taken for a specific reason.

   (ISO5667-5:1999 (8)).

4. Amend SOP No. 6 to include requirement to complete field sheet *(ISO5667-5:1999 (8))*.

5. Develop, document and implement quality assurance programme including system of blanks *(ISO5667-5:1999 (9))*.

6. Document the procedure used for training sampling personnel with regard to correct sampling techniques and on-site measurement techniques *(ISO5667-5:1999 (9))*.

DOCUMENT No. 9:

Gap Analysis results for *ISO 5667-6: 1990 Water quality – Sampling- Part 6: Guidance on sampling of rivers and streams.*

1. Scope:

'A definition of the purpose of sampling is an essential prerequisite to identifying the principles to be applied to a particular sampling problem.'

Findings	Non-Conformance	Corrective Action
1. A definition of the purpose of sampling is not stated in the sampling programme.	1. As per finding No. 1	1. Amend sampling programme to include definition of the purpose of sampling. (Refer to standard for examples)

2. Normative References

Not applicable to gap analysis.

3. Definitions

Not applicable to gap analysis.

4. Sampling Equipment

4.1 Materials

'Glass containers should be used when organic constituents are to be determined.'

Findings	Non-Conformance	Corrective Action
1. All river samples are collected in plastic sampling bottles (HDPE).	1. Glass containers are not used when organic constituents are being determined.	1. Identify and document which samples are to be taken in glass containers. 2. Amend appropriate methods and train sampling personnel in order to ensure the correct sample container is used.

'Polyethylene containers are preferable for sampling those determinands that are major constituents of glass (e.g. sodium, potassium, boron and silicon) and for sampling of trace metallic impurities.

4.1 Materials (ctd..)

However polyethylene containers may not be suitable for collecting samples to be subjected to some trace metallic analyses (e.g. mercury) and these containers should only be used if preliminary tests indicate acceptable levels of contamination.'

Findings	Non-Conformance	Corrective Action
1. All river samples are collected in plastic sampling bottles (HDPE). 2. No preliminary tests are carried out to assess the suitability of polyethylene containers for collecting samples for trace metallic analyses.	1. As per finding No. 2	1. Identify and document which samples are to be taken in plastic containers. 2. Identify, document & implement test to assess the suitability of polyethylene containers for collecting samples for trace metallic analyses.

'If glass bottles are used for storing weakly buffered water, borosilicate rather than soda-glass containers should be chosen.'

Findings	Non-Conformance	Corrective Action
1. All river samples are collected in plastic sampling bottles (HDPE).	1. Some samples may need to be taken in glass bottles.	1. Identify and document which samples are to be taken in glass containers. 2. Ensure weakly buffered samples are taken in borosilicate glass bottles. 3. Amend appropriate methods and train sampling personnel in order to ensure the correct sample container is used.

4.1 Materials (ctd..)

'Refer to relevant standard analytical procedures for detailed guidance on the type of sample container to be used.'

Findings	Non-Conformance	Corrective Action
1. The type of sample container to be used is not documented.	1. As per finding No. 1	1. Identify & document the type of sample container to be used for various analytical procedures. 2. Train sampling personnel in order to ensure that the correct sample container is used.

4.2 Types of apparatus

4.2.1 Surface samplers

'For many applications concerned with the chemical sampling of rivers and streams, it is often sufficient to immerse an open-mouthed vessel (e.g. a bucket or can) just below the surface in order to collect the sample.'

Findings	Non-Conformance	Corrective Action
1. River samples are taken using a bucket. 2. SOP No.'s 8 and 47 do not state what type of sampling device is be used.	1. As per finding No. 2	1. Amend SOP No. 8 to include details on sampling device.

Microbiological sampling bottles: 'usually have a capacity of at least 250ml are fitted with a large screw caps, ground glass or other sterilizable stopper, covered with aluminium foil. If screw caps are used silicone rubber liners capable of withstanding autoclaving at 121^{O}C should be used inside the cap.

Findings	Non-Conformance	Corrective Action
1. 250ml screw cap bottles with sterilizable stopper, covered with aluminium foil are used. 2. The above is not documented in SOP No 47.	1. As per finding No. 2	1. Amend SOP No.47 to include details on type and preparation of microbiological sampling bottles.

4.2.1 Surface samplers (ctd..)

'If bacteriological contamination from the hand is a potential problem, a clamp or pole should be attached to the bottle.'

Findings	Non-Conformance	Corrective Action
1. SOP No. 47 states 'bacteriological samples will be taken aseptically.' Details on how this should be done are not given.	1. As per finding No. 1	1. Amend SOP No. 47 to include details on how bacteriological samples are to be taken. 2. Train sampling personnel in order to ensure bacteriological samples are taken correctly.

4.2.2 Sealed immersion devices

Not applicable to gap analysis.

4.2.3 Open tube or cylinder devices

Not applicable to gap analysis.

4.2.4 Pumping devices

Not applicable to gap analysis.

4.2.5 Automatic sampling machines

'It is essential to ensure that sample instability does not lead to errors as a result of the longer storage time of samples.'

Findings	Non-Conformance	Corrective Action
1. Automatic sampling devices are currently not used for sampling rivers.	None	None

5 Sampling procedure

5.1 Sampling point selection

5.1.1 Choice of sampling site

'In choosing the exact point from which samples are required, two aspects are generally involved:

a) The selection of the sampling site

b) The identification of the precise point at the sampling site.

The purpose of the sampling often precisely defines sampling sites.'

Findings	Non-Conformance	Corrective Action
1. The 'sampling programme' identifies and maps the river sampling points. 2. The 'sampling programme' lists the sampling points for the purpose of compliance with the EC (Quality of Surface Water Intended for the Abstraction of Drinking Water) Regulations, 1989 but does not map them.	1. As per finding No. 2.	1. Amend 'sampling programme' to include map of the sampling points used for the purpose of compliance with the EC (Quality of Surface Water Intended for the Abstraction of Drinking Water) Regulations, 1989

5.1.1.1 Importance of mixing

'When the effects of a tributary, or an effluent, on the quality in a particular reach of the main stream are of interest, at least two sites are necessary one just upstream of the confluence and the other sufficiently far downstream to ensure that mixing is complete.

The physical characteristics of the channels of watercourses largely control distances required for the complete mixing of effluents with stream flow.

The distance over which effluent's mix in the three dimensions needs to be considered in selecting the sampling sites.

To obtain representative samples a stream should be sampled at two or more points across its width at sites downstream from effluent or tributary discharge.'

5.1.1.1 Importance of mixing (ctd.)

Findings	Non-Conformance	Corrective Action
1. The above is applicable in wastewater and pollution investigation sampling. 2. SOP No. 8 (for STP's) states 'where time allows or where the effluent looks poor take both upstream and downstream samples.' 3. SOP No. 11 (re industrial waste water sampling) has no statement re upstream and downstream samples. 4. Therefore details on identifying where samples should be taken are not given.	1. As per finding No.'s 2 – 4.	1. Identify, document and implement method for assessing the effects of a tributary/effluent on a main stream. 2. Train sampling personnel in order to ensure samples are taken correctly.

5.1.1.2 Consideration of time of travel

Time-of- travel: residence time within the system under investigation.

' In determining the time-of- travel one of the three principal methods should be used, namely the use of surface floats, use of tracers or measurement of flow with a knowledge of cross-sectional areas.'

Findings	Non-Conformance	Corrective Action
1. The time-of-travel of pollutants has not been ascertained.	1. As per finding No. 1.	1. Assess the need to ascertain the time-of-travel of pollutants. 2. Identify, document and implement method for assessing the time-of-travel data. 3. Train sampling personnel with regard to determining the time-of-travel of pollutants.

5.1.2 Choice of sampling point

'Problems arise in selecting suitable sampling sites whenever the determinands are not homogeneously distributed throughout the water body of interest. In general, such sampling sites are best avoided. If there is any possibility of a non-homogeneous distribution of the determinands of interest at the chosen site, experimental tests on the nature and magnitude of any heterogeneity in all three dimensions should be made.'

Findings	Non-Conformance	Corrective Action
1. The possibility of the non-homogeneous distribution of the determinands of interest at the chosen site has not been ascertained.	1. As per finding No. 1	1. Assess the possibility of the non-homogeneous distribution of the determinands of interest at the various sampling sites. 2. Identify, document and implement method for assessing the magnitude of any heterogeneity. 3. Train sampling personnel with regard to assessing the magnitude of any heterogeneity.

5.2 Frequency of sampling

'If the objectives do not include a definition of the magnitude of the tolerable error, a statistically-based sampling programme is impossible.''

Findings	Non-Conformance	Corrective Action
1. The sampling objectives are not stated nor is the magnitude of the tolerable error.	1. As per finding No. 1	1. Define the sampling objectives and the magnitude of tolerable error in the sampling objectives.

5.2 Frequency of sampling (ctd..)

'When using systematic sampling it is essential to ensure that the frequency of sampling does not coincide with any natural cycle or some other time based effect.
It will usually be adequate to choose the sampling times in a systematic manner with samples evenly distributed throughout the period of interest.'

Findings	Non-Conformance	Corrective Action
1. A sampling calendar is prepared at the beginning of each year and sampling times are distributed, depending on sampling frequency required. 2. The sampling programme does not define how sampling times are selected.	1. As per finding No. 2	1. Define in sampling programme how sampling times are selected, ensuring it is done in a systematic manner.

5.3 Choice of sampling method

5.3.1 Physical chemical sampling

'Sampling of surface films should be avoided, unless these are particularly required for analysis.'

Findings	Non-Conformance	Corrective Action
1. The above is not considered in SOP No.'s 8 or 47.	1. As per finding No. 1	1. Amend SOP No.'s 8 and 47 to include details on when sampling of surface films is required and when it should be avoided. 2. Train sampling personnel with regard to sampling of surface films.

'Sampling systems for rivers should be carefully selected and installed.....'
- Not applicable to gap analysis.

5.3.2 Microbiological sampling

'When sampling for microbiological purposes, the use of a clean, sterilized sample bottle is necessary. This should be protected until the moment it is required for filling and the stopper should be covered with a piece of metallic foil. Immediately prior to sampling the foil and stopper should be removed from the bottle and retained in one hand. Note that care is essential to avoid contamination of the stopper or neck of the bottle by the hand.

5.3.2 Microbiological sampling (ctd..)

Findings	Non-Conformance	Corrective Action
1. SOP No. 47 states 'all bacteriological samples will be taken aseptically'	1. Adequate detail on the aseptic technique required is not given.	1. Amend SOP No. 47 to include details on the aseptic technique required. 2. Train sampling personnel to ensure samples are taken correctly.

'The bottle is then filled without rinsing and the stopper is replaced immediately Samples should be taken by holding the bottle by the base and plunging it neck downwards to a depth of about 0.3m below the surface. The bottle should then be tilted so that the neck points slightly upwards, the mouth being directed into the direction of flow.'

Findings	Non-Conformance	Corrective Action
1. SOP No. 47 does not include details on how the microbiological samples are to be taken.	1. As per finding No. 1	1. Amend SOP No. 47 to include details on how exactly microbiological sample are to be taken. 2. Train sampling personnel to ensure samples are taken correctly.

5.4 Transport stabilization and storage of samples.

'For some applications, sampling will be concerned with an assessment of soluble species (e.g. trace metals in river water). If this is the case then it is necessary to separate the 'dissolved' from the 'undissolved' material as soon as practicable after sampling (preferably at the sampling site before transportation to the laboratory).

Whatever medium is used for filtration, it is recommended that subsequent results be reported as 'filterable' species (quoting the appropriate pore size of the filter) rather than 'dissolved' species.'

Findings	Non-Conformance	Corrective Action
1. When sampling for soluble species the 'dissolved' is not separated from the 'undissolved' material as soon as practicable after sampling. 2. Subsequent results are not reported as 'filterable' species nor is the pore size of the filter recorded.	1. As per findings No.'s 1 and 2.	1. Develop, document & implement method for sampling of soluble species. 2. Implement system for the reporting of samples which are filtered together with the pore size of the filter used. 3. Train sampling personnel with regard to sampling for soluble species.

'In all cases sample containers should be delivered to the laboratory tightly sealed and protected from light and excessive heat.'

Findings	Non-Conformance	Corrective Action
1. SOP No. 47 states 'all samples will be transported in cooler boxes containing ice packs'. 2. SOP No. 47 does not state that sample containers should be delivered to the laboratory tightly sealed. 3. SOP No. 8 has no details on sample transportation or sealing of container.	1. As per findings No. 1-3.	1. Amend SOP No. 47 to include details on the sealing of sampling containers. 2. Amend SOP No. 8 to include details on sample transportation and the sealing of sampling containers.

5.4 Transport stabilization and storage of samples (ctd..)

'The samples which cannot be analysed within a day should be stabilized or preserved in accordance with the standard analytical method.'

Findings	Non-Conformance	Corrective Action
1. Samples that are not analysed within a day are not stabilized or preserved.	1. As per finding No. 1.	1. Develop, document & implement method for the preservation of samples that cannot be analysed within a day. 2. Train sampling personnel with regard to the preservation of samples.

'In cases where preservatives are used, the sample container cannot be pre-rinsed with the material to be collected. In all other sampling circumstances pre-rinsing of sample containers may be carried out, unless there are specific circumstances rendering this undesirable.'

Findings	Non-Conformance	Corrective Action
1. SOP No. 47 does not give details regarding the pre-rinsing of sample containers.	1. As per finding No. 1.	1. Amend SOP No.'s 8 and 47 to include details on when sample containers can/cannot be pre-rinsed. 2. Train sampling personnel with regard to rinsing sample containers.

5.4 Transport stabilization and storage of samples (ctd..)

'All preservation steps should be recorded in the report and the temperature measured and recorded on site, if appropriate. Ideally other physical and chemical parameters should be determined on site or as soon as possible afterwards.'

Findings	Non-Conformance	Corrective Action
1. Preservation steps are not recorded. 2. Where appropriate temperature, pH, conductivity and dissolved oxygen are determined on site. 3. SOP No.'s 8 and 47 do not state that these parameters are to be measured and recorded on site.	1. As per findings No. 1 & 3.	1. Amend SOP No. 8 & 47 to include - the parameters which are to be measured and recorded on site. - that preservation steps are to be recorded. 2. Amend appropriate field sheets to include the above details.

5.5 Quality control procedures

'All sampling methods should be periodically tested using field-based quality control and audit procedures, particularly those aspects relating to the transportation, stabilization and storage of samples prior to analyses. This may be carried out using field blanks, samples with added determinands and duplicate samples taken specifically to test the effectiveness of the particular part of the sampling process under investigation.'

Findings	Non-Conformance	Corrective Action
1. Sampling methods are not periodically tested using field-based quality control and audit procedures.	1. As per finding No. 1.	1. Develop, document & implement quality control method(s) for periodically testing the sampling methods used. 2. Train sampling personnel with regard to implementing the quality control methods.

6 Safety precautions

'Reasonable access to routine sampling sites in all weathers is particularly important. When samples are to be taken by wading into a river or stream, account should be taken of the possible presence of soft mud, deep holes and swift currents. A wading rod or similar probing instrument is essential to ensure safe wading.
If circumstances dictate that sampling must take place at remote sites and in the vicinity of deep water, by a person working alone, then it is recommended that a life jacket be worn and an appropriate system of regular reporting to a central control point be employed.
It should be recognised that there may be bacteriological, virological and zoological hazards in many river or stream sampling situations.'

Findings	Non-Conformance	Corrective Action
1. SOP No. 8 & 47 make no reference to the safety precautions necessary when sampling. 2. The laboratory's ancillary Safety Statement for the Environment Section details the hazards and controls related to field work, infectious diseases and Weil's disease.	1. As per finding No. 1	1. Amend SOP No.'s 8 and 47 to include reference to the safety precautions necessary when sampling.

7 Sample identification and records.

'Sample containers should be clearly and unambiguously marked..... ....it will usually be more convenient to identify the containers by code number and to record all relevant details on a sample form.'

Findings	Non-Conformance	Corrective Action
1. Sample containers are identified by codes or general description, with all relevant details on a field report form. 2. SOP No. 8 & 47 do not give details on this procedure.	1. As per finding No. 2.	1. Amend SOP No. 8 & 47 to include procedure for labelling sample containers and completing field report forms.

'The detailed form of the sampling report will depend on the objectives of sampling. Matters, which could be considered for inclusion, are:

a) name of river or stream
b) sampling site (description should be complete enough to allow another person to find the exact location without further guidance)
c) sampling point
d) date and time of collection
e) name of sample collector
f) weather conditions at the time of sampling and/or immediately prior to sampling

7 Sample identification and records (ctd..)

g) the appearance, condition and temperature of the water body
h) the flow condition of the water body
i) the appearance of the sample
j) the type of sampling device used
k) information on any sample preservation technique used
l) information on any sample filtration technique used
m) information on any sample storage requirements.

Findings	Non-Conformance	Corrective Action
1. There is no specific field report sheet for sampling surface water intended to be used as a source of drinking water. 2. The river field report sheet does not include the following: - time of collection - the flow condition of the water body - the appearance of the sample - the type of sampling device used - information on any sample preservation technique used - information on any sample storage requirements	1. As per findings No. 1 & 2.	1. Develop appropriate field report sheet for sampling surface water intended to be used as a source of drinking water. 2. Amend river field report sheet to include all required details.

DOCUMENT No. 10:

Summary of the Corrective Actions required in order to comply with: ***ISO 5667: 1990 Water quality – Sampling- Part 6: Guidance on sampling of rivers and streams.***

Note: *For the corrective actions to be implemented effectively staff training shall have to be paramount in all cases.*

1. Amend sampling programme to include:
   - the objectives of sampling (Refer to standard for examples)
   - Definition of the magnitude of the tolerable error.
   - Description on how the sampling times were selected, ensuring it is done in a systematic manner.

   (ISO 5667-6:1990 (1), (5.2))

2. Identify and document which samples are to be taken in glass containers (borosilicate glass if used for storing weakly buffered water) and which are to be taken in plastic containers. Amend appropriate methods/SOPs *(ISO 5667-6:1990 (4.1))*.

3. Identify, document SOP No.'s implement test to assess the suitability of polyethylene containers for collecting samples for trace metallic analyses *(ISO 5667-6:1990 (4.1))*.

4. Amend SOP No. 8 to include details on the sampling equipment to be used when sampling surface water *(ISO 5667-6:1990 (4.2))*.

5. Amend SOP No.47 to include details/reference on the type and preparation of microbiological sampling bottles and on how the microbiological samples are to be taken *(ISO 5667-6:1990 (4.2), (5.3.2))*.

6. Amend 'sampling programme' to include map of the sampling points used for the purpose of compliance with the EC (Quality of Surface Water Intended for the Abstraction of Drinking Water) Regulations, 1989 *(ISO 5667-6:1990 (5.1.1))*.

7. Identify, document and implement method for assessing the effects of a tributary/effluent on a main stream *(ISO 5667-6:1990 (5.1.1.1))*.

8. Assess the need to ascertain the time-of-travel of pollutants. If required, identify, document and implement method for assessing the time-of-travel of pollutants *(ISO 5667-6:1990 (5.1.1.2))*.

9. Determine the possibility of a non-homogeneous distribution of the determinands of interest at the various sampling sites. If required identify, document and implement method for assessing the magnitude of any heterogeneity *(ISO 5667-6:1990 (5.1.2))*.

10. Amend SOP No.'s 8 and 47 to include details on when the sampling of surface films is required and when it should be avoided *(ISO 5667-6:1990 (5.3.1))*.

11. Develop, document and implement method for the sampling of soluble species. Implement system of reporting on samples that are filtered and the pore size of the filter used *(ISO 5667-6:1990 (5.4))*.

12. Amend SOP No. 47 to include details on the sealing of sampling containers *(ISO 5667-6:1990 (5.4))*.

13. Amend SOP No. 8 to include details on sample transportation and the sealing of sampling containers *(ISO 5667-6:1990 (5.4))*.

14. Develop, document and implement method for the preservation of samples and develop method of recording when samples are preserved *(ISO 5667-6:1990 (5.4))*.

15. Amend SOP No.'s 8 and 47 to include details on when sample containers can/cannot be pre-rinsed *(ISO 5667-6:1990 (5.4))*.

16. Amend SOP No.'s 8 and 47 to include parameters which are to be measured and recorded on site *(ISO 5667-6:1990 (5.4))*.

17. Develop, document and implement method(s) for periodically testing the sampling methods used i.e. field blanks, samples with added determinands and/or duplicate samples *(ISO 5667-6:1990 (5.5))*.

18. Amend SOP No.'s 8 and 47 to include reference to the safety precautions necessary when sampling from river *(ISO 5667-6:1990 (6))*.

19. Amend SOP No.'s 8 and 47 to include procedure for labelling sample containers and completing field report forms *(ISO 5667-6:1990 (7))*.

20. Develop appropriate field report sheet for sampling surface water for abstraction, as per *(ISO 5667-6:1990 (7))*.

21. Amend river field report sheet to include all required details as per *ISO 5667-6:1990 (7)*.

DOCUMENT No. 11:

Gap Analysis results for *ISO 5667-10: 1992 Water quality – Sampling- Part 10:Guidance on sampling of waste waters.*

1. Scope

'This part of ISO 5667 contains details on the sampling of domestic and industrial wastewater. It covers wastewaters in all its forms i.e. industrial waste water and crude and treated domestic waste water.'

1.1 Objectives

'When designing a waste-water sampling programme, it is essential for the objective of the study to be kept in mind.'

Findings	Non-Conformance	Corrective Action
1. SOPs No. 10 and 11 detail the procedure for sampling wastewaters. 2. The sampling programme identifies the sampling locations but does not define the objectives.	1. As per finding No.2	1. Amend sampling programme to define the objectives of the waste-water sampling programme.

1.1.1 Quality characterisation
Not applicable to gap analysis.

1.1.2 Quality control
Not applicable to gap analysis.

2. Normative References:

Not applicable to gap analysis.

3. Definitions.

Not applicable to gap analysis.

4. Sampling equipment

4.1 Sample containers

'The sample container needs to prevent losses due to adsorption, volatilization and contamination by foreign substances.
Desirable factors to be considered when selecting sample containers are:

- *high resistance to breakage*
- *good sealing efficiency*
- *ease of re-opening*
- *good resistance to temperature extremes*
- *practicable cost, shape and mass*
- *good potential for cleaning and re-use*
- *availability and cost.'*

4.1 Sample containers (ctd..)

Findings	Non-Conformance	Corrective Action
1. There is no documented procedure for the selection of the sample containers.	1. As per finding No.1	1. Develop, document and implement procedure for the selection of the sample containers for wastewaters.

'For wastewater sampling, plastic containers are recommended for most determinands. Some exceptions exist when for example the following analyses are to be made:
- *oil and grease*
- *hydrocarbons*
- *detergents*
- *pesticides.'*

Findings	Non-Conformance	Corrective Action
1. SOP No.'s 10 and 11 do not state what type of sample containers are to be used.	1. As per finding No.1	1. Amend SOP No.'s 10 and 11 to include the type of sample containers to be used for the various analyses. 2. Train sampling personnel in order to ensure the correct sample container is used.

4.2 Type of apparatus

4.2.1 Manual sampling equipment
'The simplest equipment used for taking effluent samples consists of a bucket, ladle or wide mouthed bottle. The volume should not be less than 100ml.'

Findings	Non-Conformance	Corrective Action
1. Samples are taken by attaching the sample container to a long armed sampler. This procedure is not documented in SOP No.'s 10 or 11. 2. One litre sample containers are used. This procedure is not documented in SOP No.'s 10 or 11.	1. As per findings No.1 and 2.	1. Amend SOP No.'s 10 and 11 stating how samples are taken and the sample volume required.

4.2.1 Manual sampling equipment (ctd..)

'When manual samples are to be used for preparation of composite samples the volume of the bucket, ladle or bottle should be well defined and known to a precision of within +/-5%.'

Findings	Non-Conformance	Corrective Action
1. Not applicable to the current sampling programme in the laboratory as only automatic composite samplers are used.	None	None

'Manual sampling equipment should be made of an inert material that does not influence the analyses that will be carried out on the samples later.
Before starting sampling, the equipment should be cleaned with detergent and water.
The sampling equipment cannot be washed in the waste stream when this will influence the analysis carried out later (e.g. analysis for oil and grease and microbiological analysis)'

Findings	Non-Conformance	Corrective Action
1. Samples are collected directly into a sampling bottle. 2. SOP No.'s 10 and 11 do not give details regarding the washing of the sampling equipment in the waste stream.	1. As per finding No. 2.	1. Amend SOP No 10 and 11 to include details of washing of sampling equipment in the waste stream. 2. Train sampling personnel with regard to the preparation of sampling equipment.

4.2.2 Automatic sampling equipment

'When selecting sampling equipment, the following features should be taken into consideration and the user should determine the relative importance of each feature when establishing the requirements for a specific sampling application.
(Refer to P3 ISO 5667-10: 1992 (E))

Additionally, the user should also aim for the following attributes when choosing sampling equipment, unless the circumstances dictate that certain of them may not be necessary.
(Refer to P3-4 ISO 5667-10: 1992 (E))'

4.2.2 Automatic sampling equipment (ctd.)

Findings	Non-Conformance	Corrective Action
1. The automatic sampling equipment was purchased in order to meet the requirements of the Environmental Protection Agency Act, 1992 (Urban Waste Water Treatment) Regulations, 1994 i.e. take time-based 24-hour samples. 2. The automatic sampling equipment selection criteria is not documented.	1. As per finding No. 2.	1. Identify and document criteria for the selection of automatic sampling equipment, taking into account the above features and attributes.

5. Sampling procedure

5.1 Sampling location

'SAFETY PRECAUTIONS – In all cases when selecting sampling locations, safety and health aspects should be observed.

Findings	Non-Conformance	Corrective Action
1. The sampling programme does not detail how the sampling sites were selected.	1. As per finding No. 1	1. Amend sampling programme detailing how the sampling sites were selected, ensuring that safety and health aspects are considered.

5.1.1 General description

'In all cases, it is essential that a location is selected which is representative of the waste stream to be examined.'

Findings	Non-Conformance	Corrective Action
1. The sampling programme lists the STP sampling locations, the industrial sampling locations are specified in the various Local Authority discharge licences. 2. There is no detail given in the above as to how the sites are selected	1. As per finding No. 2	1. Amend sampling programme to include details on how the sampling sites are selected

5.1.1 General description (ctd..)

'Subsequently, a site inspection, including the use of chemical tracer studies, as necessary, should be conducted in order to ensure that the locations of the sewers and the path of the waste stream correspond to the drawings and to make sure the selected location is representative for the sampling purpose.'

Findings	Non-Conformance	Corrective Action
1. The above is not applicable to STP sampling locations or industrial discharges to water. 2. No site inspection has been carried out or was required to be carried out to assess the suitability of the selected industrial discharge points to sewer.	1. As per finding No. 2.	1. Identify the situations where site inspection should be carried out. 2. Develop system of carrying out the site inspections. 3. Document results.

5.1.2 Sampling from sewers, channels and manholes

'Before sampling, the chosen sampling location should be cleaned in order to remove scale, sludge, bacterial film, etc. from the walls.'

Findings	Non-Conformance	Corrective Action
1. No procedure in place for cleaning the chosen sampling location prior to sampling.	1. As per finding No. 1.	1. Ascertain the need to clean the various sampling locations prior to sampling. 2. Identify and document the sampling locations, which require to be cleaned and the appropriate cleaning procedure. 3. Train sampling personnel with regard to the correct cleaning procedure for the sample location.

'A location should be chosen where the effluent has a high turbulent flow, to ensure good mixing.'
'In the absence of a location with turbulent flow conditions, such conditions should be induced by restricting the flow e.g. with a baffle or a weir.'
'The sampling intake point should always be located downstream from the restriction and, as a general rule, it should be located at least three times the pipe diameter downstream of the restriction. The inlet of the sampling probe should preferably face the direction of the flow but may face downstream if too many blockages result.'

5.1.2 Sampling from sewers, channels and manholes (ctd..)

Findings	Non-Conformance	Corrective Action
1. The sampling programme does not give details on the selection of the sampling location, the sampling point or the introduction of turbulent flow conditions.	1. As per finding No. 1.	1. Amend sampling programme giving details on the: - sampling location chosen - sampling point chosen - the introduction of turbulent flow conditions, where necessary.

'Before proceeding with the sampling of industrial discharges, the conditions inside the plant (e.g. processes and production rates) should be noted and recorded along with potential hazards.

Findings	Non-Conformance	Corrective Action
1. The conditions inside the plant are not noted or recorded.	1. As per finding No. 1.	1. Develop, document and implement procedure for noting and recording the conditions inside the industrial plant prior to sampling the discharge.

'As a general rule the sampling point should be one-third of the effluent water depth below the surface of the water.'

Findings	Non-Conformance	Corrective Action
1. SOPs No. 10 and 11 do not state at what depth the samples should be taken.	1. As per finding No. 1.	1. Amend SOPs No. 10 and 11 stating the depth at which the samples should be taken.

5.1.3 Wastewater treatment plants

'When choosing sampling locations for wastewater treatment plants, it is again important to refer to objective of the data collection programme.'

'When sampling at the inlets of plants, the objective of the sampling programme should be carefully considered. In some situations, there may be a need to sample crude sewage in the mixture with recirculated processing liquid. In other cases, it may be necessary to exclude the effect of these liquids.'

Findings	Non-Conformance	Corrective Action
1. The sampling programme identifies the location of the wastewater treatment plants. 2. SOP No. 10 states the sampling locations i.e. influent and effluent. 3. The sampling objectives are not stated. 4. The exact sampling point for the influent is not stated.	1. As per findings No. 3 and 4.	1. Identify and document sampling objectives. 2. Identify and document the exact sampling point for the influent and effluent samples for all wastewater plants.

'Frequent reviews of a plant's sampling locations need to be made, to ensure that any relevant changes in the operation of unit processes are taken into account when sampling.'

Findings	Non-Conformance	Corrective Action
1. Discharge licences are reviewed on a non-regular basis, as required by the company or as a result of a Local Authority investigation. As part of this process the plant's sampling locations are reviewed in order to ensure they are representative. 2. STP sampling locations do not generally change unless the plant layout is changed i.e. plant upgraded.	1. The licensed plant's sampling locations are not frequently reviewed.	1. Develop, document and implement system for frequently reviewing the licensed plant's sampling locations.

5.1.3 Wastewater treatment plants (ctd..)

'Whenever sampling wastewaters, great care should be exercised to overcome or minimize the substantial heterogeneity caused by suspended solids that are often present. Similarly, thermal stratification of separate industrial effluent streams may be found when sampling effluents or discharges from industrial process and measures have to be taken to promote the mixing of such streams before sampling.'

Findings	Non-Conformance	Corrective Action
1. There are no measures in place to minimize the heterogeneity caused by suspended solids. 2. The possibility of thermal stratification of industrial effluent streams has not been considered.	1. As per findings No. 1 and 2.	1. Ascertain the possibility of thermal stratification for all LA licensed industrial effluent discharges 2. Where applicable identify, document and implement measures to minimize: - The heterogeneity caused by suspended solids. - The thermal stratification of industrial effluent

5.1.4 Qualitative sampling

'It may be necessary to sample the surface by skimming in order that qualitative information about emulsified and floating material can be obtained. Wide mouth jars are suitable containers.'

Findings	Non-Conformance	Corrective Action
1. SOPs No. 10 and 11 do not identify when these parameters are to be sampled or how it is to be done.	1. As per finding No. 1.	1. Identify and document when and how emulsified and floating material is to be sampled. 2. Train sampling personnel to ensure the correct sampling procedure is carried out.

5.2 Frequency and timing of sampling

5.2.1 General aspects

Not applicable to gap analysis.

5.2.2 Number of samples

'Water analyses should be based on samples taken at regular intervals during a certain period. The samples should be composite samples, unless the determinations to be carried out prohibit the use of a composite sample. The necessary number of samples taken during each composite sample should be decided on statistical techniques.'

Findings	Non-Conformance	Corrective Action
1. Samples are taken at regular intervals, the weeks on which the samples are taken are documented on wall planner and the locations to be sampled are documented in the sampling programme. 2. The STP samples taken are primarily grab samples as it is not feasible to taken composite at all sites. Composite samples are taken in plants with a P.E. > 2000 as required under the UWWT Regulations 1994. 3. Many of the companies with LA licensed discharges are required to take monthly composite samples. 4. The number of samples taken during each composite sample is not based on statistical techniques.	1. Not all STP samples taken are composite. 2. As per finding No. 4.	1. Ascertain the cost and work required in order to take composite samples at each STP sampling location. 2. Determine statistically the number of samples to be taken during each composite sample.

5.2.3 Sampling time

'Generally, when sampling sewages and effluents, it is normal to make allowance for the following sources of variation in quality:
(a) diurnal variation
(b) variations between days of the week
(c) variations between weeks
(d) variations between months and seasons
(e) trends.

'If there is little or no diurnal variation, or day-to-day variations, then the particular time of day or day of the week for sampling is relatively unimportant. The solution then is to sample evenly throughout the year, but at any time of day and on any day of the week (these being chosen at convenience).

If the identification of the nature and magnitude of peak load are important, sampling should be restricted to those periods of the day, week, or month when peak loads are known to occur.'

5.2.3 Sampling time (ctd..)

Findings	Non-Conformance	Corrective Action
1. Influents to STP are likely to experience variations in quality throughout the day, these variations would be similar each day. 2. The STP's are sampled at regular intervals throughout the year. 3. Industrial discharges may vary in quality throughout the day and between days of the week/seasons. 4. The time of sampling of industrial discharges is recorded.	1. The sampling of industrial discharges does not take into account variations in quality.	1. Ascertain the need to take into account variations in industrial wastewater quality when sampling. 2. If required, identify the industrial variations in industrial wastewater quality and implement appropriate sampling programme.

'Relating the times of sampling to the particular process being monitored may be very important when considering industrial effluent discharges that are either seasonal or operated on a batch basis. In either case, the discharge will not be continuous and the sampling programme will need to take this fact into account.'

Findings	Non-Conformance	Corrective Action
1. The time of sampling of industrial discharges is recorded. 2. The requirement to record the time of sampling is not stated in SOP No. 11	1. As per finding No.2	1. Amend SOP No. 11 to include requirement to record time of sampling.

Samples should normally be taken at fixed intervals during the whole control period. The control period may be one year, a number of months or weeks, or even shorter periods of time.

If the control period covers one year, the days of sampling may be determined from the formulae on P.6 ISO 5667-10:1992.

Ensure that the sampling does not lead to any risk of systematic error for example by always taking samples on one particular day or week number.'

5.2.3 Sampling time (ctd..)

Findings	Non-Conformance	Corrective Action
1. The number of sampling times per control period (i.e. month/year) is stated in the UWWT Reg 1994, discharge licence or determined by the EPA. 2. Sampling times are distributed at regular intervals at the beginning of each year. This is documented on a wall planner. 3. The possibility of systematic errors has not been considered. 4. Formulae are not used to determine the sampling times. 5. The sampling programme does not detail how the specific sampling times were selected.	1. As per findings No. 3-5.	1. Identify and document the sampling times required using the formulae given on p.6 ISO 5667-10:1992. 2. Ascertain if there is systematic error in the sampling times selected. 3. Document in the sampling programme how specific sampling times were selected.

5.2.4 Duration of each sampling period

'This subclause deals with the selection of the period over which a composite sample has to be taken.'

'When selecting the period, two factors should be considered:

a) objective of the sampling programme

b) the stability of the sample

The stability of the sample may often limit the duration of the sampling period.'

Findings	Non-Conformance	Corrective Action
1. Composite samples are taken over a 24 hour period as required under the Environmental Protection Agency Act, 1992 (Urban Waste Water Treatment) Regulations, 1994. 2. The period of time over which a composite sample has to be taken is not documented.	1. As per finding No. 2.	1. Develop, document and implement a method for the selection of the period over which a composite sample has to be taken, taking the above factors into account.

5.3 Choice of sampling method

5.3.1 Types of samples

5.3.1.1 Spot samples

'Spot samples are essential where the objective of a sampling programme is to estimate the compliance with standards not related to average quality. In cases where quality compliance is judged on the basis of average effluent quality, composite samples should always be used.'

Findings	Non-Conformance	Corrective Action
1. The objectives of the sampling programme are not identified. 2. SOPs No. 10 and 11 do not identify when spot or composite samples should be taken.	1. As per findings No. 1 and 2.	1. Identify and document the objectives of the sampling programme. 2. Identify and document when spot or composite samples should be taken.

'For certain determinations, only spot samples can be used. For example this is the case with oil and grease, dissolved oxygen,, chlorine and sulfide.'

Findings	Non-Conformance	Corrective Action
1. The parameters that can only be determined in spot samples have not been identified or documented.	1. As per finding No. 1	1. Identify and document the parameters that can only be determined in spot samples.

5.3.1.2 Composite samples

'Time-weighted composite samples are appropriate where the average sewage or effluent quality is of interest.'

'Flow-weighted composite samples should be used when the determination of loadings of pollutants is the objective of the sampling.'

Findings	Non-Conformance	Corrective Action
1. The sampling programme does not identify when or what type of composite samples are to be taken.	1. As per finding No. 1	1. Identify and document when and what type of composite samples are to be taken.

5.3.1.2 Composite samples (ctd.)

'In both flow-weighted and time-weighted composite sampling, each of the spot samples should be greater than 50ml in volume, often advisable that spot samples are 200-300ml in volume.'

Findings	Non-Conformance	Corrective Action
1. The spot samples taken are generally 200ml volume. 2. No documented procedure with regard to composite sampling.	1. As per finding No. 1	1. Develop and document procedure for the taking of composite samples, including details on the volumes to be taken. 2. Train sampling personnel to ensure composite samples are taken correctly.

5.3.2 Continuous measurements

Not applicable to gap analysis.

5.4 Sample preservation, transportation and storage.

'The most common way of preserving wastewater samples is to cool to temperature between $0^{O}C$ and $4^{O}C$. When cooled to this temperature and stored in dark, most samples are stable for up to 24h.'

Findings	Non-Conformance	Corrective Action
1. Wastewater samples are stored in cooler boxes during transportation and either analysed immediately or refrigerated in the laboratory. 2. SOPs No.'s 10 and 11 do not document this procedure.	1. As per finding No. 2.	1. Amend SOP No. 10 and 11 to include details on sample preservation and storage.

'When collecting composite samples during extended periods, preservation should be an integral part of the sampling operation.'

Findings	Non-Conformance	Corrective Action
1. Preservation is not an integral part of the sampling operation during composite sampling.	1. As per finding No. 1.	1. Ascertain the need to preserve samples when collecting composite samples. 2. If necessary implement system of sample preservation.

6. Safety aspects of sampling.

'When working in sewers, cesspools, pumping stations and waste-water treatment plants there should be an awareness of the following:

- *danger of explosion*
- *risk of poisoning caused by toxic gases*
- *risk of suffocation caused by lack of oxygen*
- *risk of diseases*
- *risk of physical injury*
- *risk of drowning*
- *risk of impact from falling objects.'*

Findings	Non-Conformance	Corrective Action
1. The above risks are identified and the appropriate control measures documented in the Laboratory Safety Statement. 2. Laboratory personnel sign Laboratory Safety Statement once they read it.	None	None

'Before entering a confined space, the following procedures should be observed.....'
6.2 p.8 ISO 5667-10:1992(E)

Findings	Non-Conformance	Corrective Action
1. Confined space entry is dealt with in the safety statement. 2. Laboratory staff are not trained to enter confined spaces and therefore don't do so.	None	None

'In many countries there are legal requirements on the vaccination of people working in contact with wastewater. Such requirements should be fulfilled for personnel involved in sampling wastewater.'

Findings	Non-Conformance	Corrective Action
1. Weil's disease and infectious diseases are dealt with in the Laboratory Safety Statement. 2. It is stated in the Laboratory Safety Statement that "vaccination against tetanus and hepatitis to be available to all workers at risk."	None	None

6. Safety aspects of sampling (ctd..)

'If it is necessary to interfere with traffic it is essential that the appropriate warning signs and lights are used.'

Findings	Non-Conformance	Corrective Action
1. Work on/at roads is dealt with in the Laboratory Safety Statement. The control measures are clearly documented. 2. This may be relevant in industrial wastewater sampling locations. The discharge licence states that the sampling location should be safe and accessible. However SOP No. 11 makes no reference to ensuring the sampling location is safe.	1. As per finding No. 2.	1. Amend SOP No. 11 to include details on ensuring the sampling location is safe to access. 2. Train sampling personnel with regard to safety precautions necessary.

7. Sample identification and records

'A printed form for the sampling report should include the following information where appropriate:

- *sampling point*
- *abbreviated sampling point designation*
- *date, start and stop of sampling*
- *time, start and stop of sampling*
- *duration of the sampling period*
- *purpose of the sampling*
- *details of the sampling method*
- *details of field tests.*

The sampling report should apply to both permanent and occasional sampling points.

In appropriate cases, the sampling report should be accompanied by a sketch identifying the site.

Under 'comments' details should be given on items such as:

- *Preservation and storage conditions prior to delivery to the laboratory.*
- *Changes subsequently observed*
- *Control samples taken by other investigators*
- *Presence of witnesses*
- *Nature, origin and volume of suspected harmful substances and injured parties (in the case of pollution incidents or emergencies)'*

Annex A gives an example of a sampling report.

7. Sample identification and records (ctd..)

Findings	Non-Conformance	Corrective Action
1. There are no designated sampling report forms for either STP or industrial wastewater.	1. As per finding No. 1.	1. Develop, document and implement sampling report form for STP and industrial wastewater sampling as per requirement 7 of ISO 5667-10:1992 (E).

DOCUMENT No. 12:

Summary of the Corrective Actions required in order to comply with: ***ISO 5667-10: 1992 Water quality – Sampling- Part 10:Guidance on sampling of waste waters.***

Note: *For the corrective actions to be implemented effectively staff training shall have to be paramount in all cases.*

1. Amend sampling programme to define the objectives of the wastewater sampling programme *(ISO 5667-10:1992 (1), (5.1.3), (5.3.1.1)).*

2. Develop, document and implement procedure for the selection of sample containers *(ISO 5667-10:1992 (4.1)).*

3. Amend SOPs No 10 and 11 stating the type of sample containers that are to be used for various analyses *(ISO 5667-10:1992 (4.1)).*

4. Amend SOPs No 10 and 11 to include details on:
   - The preparation of the sampling equipment,
   - How the samples are to be taken,
   - The sample volume required for the various analyses.

   (ISO 5667-10:1992 (4.2.1))

5. Identify and document criteria for the selection of automatic sampling equipment, taking into account the features and attributes stated in *ISO 5667-10:1992 (4.2.1).*

6. Amend sampling programme to include details on how sampling sites were selected, ensuring that safety and health aspects are considered *(ISO 5667-10:1992 (5.1), (5.1.1)).*

7. Identify the situations where site inspection should be conducted in order to ensure that the locations of the sewers and the path of the waste stream correspond to the drawings and to ensure the selected location is representative for the sampling purpose. Develop system of carrying out the site inspections using chemical tracer studies or other approved method. Document results *(ISO 5667-10:1992 (5.1.1)).*

8. Ascertain the need to clean the various sampling locations prior to sampling. This being done in order to remove scale, sludge, bacterial film, etc. from the walls. Identify and document the sampling locations that require to be cleaned *(ISO 5667-10:1992 (5.1.2)).*

9. Amend sampling programme to give details on the:
   - sampling location chosen
   - sampling point chosen
   - the introduction of turbulent flow conditions, where necessary.

   (ISO 5667-10:1992 (5.1.2))

10. Develop, document and implement procedure for noting and recording the conditions inside a licensed industrial plant prior to sampling the discharge *(ISO 5667-10:1992 (5.1.2)).*

11. Amend SOPs No. 10 and 11 stating the depth at which the samples should be taken i.e. one-third of the effluent water depth below the surface of the water *(ISO 5667-10:1992 (5.1.2)).*

12. Identify and document the exact sampling point for the influent and effluent for all wastewater plants, in the sampling programme *(ISO 5667-10:1992 (5.1.3))*.

13. Develop, document and implement system for frequently reviewing the plant's sampling locations *(ISO 5667-10:1992 (5.1.3))*.

14. Ascertain the possibility of thermal stratification for all licensed industrial effluent discharges. Identify, document and implement measures to promote the mixing of these streams prior to sampling *(ISO 5667-10:1992 (5.1.3))*.

15. Identify, document and implement measures to overcome or minimize the substantial heterogeneity caused by suspended solids in wastewater treatment plants *(ISO 5667-10:1992 (5.1.3))*.

16. Identify and document when and how emulsified and floating material are to be sampled *(ISO 5667-10:1992 (5.1.4))*.

17. Determine statistically the number of samples to be taken during each composite sample *(ISO 5667-10:1992 (5.2.2))*.

18. Ascertain the need to take into account variations in industrial wastewater quality when sampling. If required, identify the industrial variations in industrial wastewater quality and implement appropriate sampling programme *(ISO 5667-10:1992 (5.2.3))*.

19. Amend SOP No. 11 to include requirement to record time of sampling *(ISO 5667-10:1992 (5.2.3))*.

20. Identify and document the sampling days required during the control period. Ascertain if there is systematic error in the sampling times selected. Document in the sampling programme how the specific sampling times were selected *(ISO 5667-10:1992 (5.2.3))*.

21. Develop, document and implement a method for selecting the period over which a composite sample has to be taken, taking the following factors into account:
    c) objective of the sampling programme
    d) the stability of the sample
    (ISO 5667-10:1992 (5.2.4))

22. Identify and document when spot or composite samples should be taken *(ISO 5667-10:1992 (5.3.1.1))*.

23. Identify and document the parameters that can only be determined by taking spot samples *(ISO 5667-10:1992 (5.3.1.1))*.

24. Identify and document what type of composite samples are to be taken and when this should occur *(ISO 5667-10:1992 (5.3.1.2))*.

25. Develop and document procedure for the taking of composite samples, including details on the volumes to be taken *(ISO 5667-10:1992 (5.3.1.2))*.

26. Amend SOPs No. 10 and 11 to include details on sample preservation and storage *(ISO 5667-10:1992 (5.4))*.

27. Ascertain the need to preserve samples during the collection of composite samples. If necessary, implement system of sample preservation *(ISO 5667-10:1992 (5.4))*.

28. Amend SOP No. 11 to include details on ensuring the sampling location is safe to access *(ISO 5667-10:1992 (6))*.

29. Develop, document and implement sampling report form for STP and industrial wastewater sampling as per requirement 7 of ISO 5667-10:1992 (E).

DOCUMENT No. 13:

Gap Analysis results for *ISO 5667-14:1998 Water quality – Sampling- Part 14:Guidance on quality assurance of environmental water sampling and handling*

1. Scope
Not applicable to gap analysis.

2. Normative References:
Not applicable to gap analysis.

3. Definitions.
Not applicable to gap analysis.

4. Sources of sampling error.
Not applicable to gap analysis.

5. Sampling control techniques
5.1 General
'The quality control - this would include a review of the whole approach to sampling with respect to its fitness for the intended purpose. Within this the choice of sampling techniques, sampling locations, numbers and types of samples taken, training of sampling staff, sample transport, preservation and storage should be considered. The chosen approach should be adequately documented and a system of record keeping established. A suitable quality control programme could contain any or all of the techniques listed below.'

Findings	Non-Conformance	Corrective Action
1. The current sampling system has the following quality control measures: - Sampling programme, which identifies sampling locations and the number of samples to be taken. - New members of sampling staff are trained and training record is completed. - The training record is a generic for all sampling procedures i.e. it does not specify which procedures the sampler is trained for - Samples are transported from sampling location to laboratory in cooler boxes. - Field meters are calibrated and/or checked with a known standard, prior to use. Results are recorded in designated record book.	1. Most of the sampling SOPs do not include details on the transportation of samples. 2. The training procedure is not documented. 3. The training records are not very detailed. 4. The sampling SOPs do not include details on the calibration and checking of field meters prior to use.	1. Amend sampling SOPs including details on the transportation of samples and calibration and checking of field meters. 2. Document the sampling training procedure. 3. Develop and document detailed training records. 4. Develop, document and implement analytical quality control programme for sampling, as per ISO 5667-14:1998(E).

The following quality control techniques are described in ISO 5667-14:1998(E):

5.2 Replicate quality control samples

5.3 Field blank samples

5.4 Rinsing of equipment (sampling containers)

5.5 Filtration recovery

5.6 Spiked samples.

Findings	Non-Conformance	Corrective Action
1. None of the above analytical quality control techniques are carried out.	1. As per finding No. 1.	1. Develop document and implement system for carrying out the above analytical quality control techniques. 2. Train sampling personnel in order to ensure the quality control techniques are effectively implemented.

6. Transport, stabilization and storage of samples.

'Care is essential to ensure that any preservatives are accurately prepared and dispensed.'

Findings	Non-Conformance	Corrective Action
1. Preservatives are not used on a regular basis. 2. There is no documented procedure for the preparation and use of preservatives.	1. As per findings No. 1 and 2.	1. Identify and document when and what preservatives are to be used. 2. Document procedure for the preparation and use of preservatives. 3. Train sampling personnel with regard to preserving samples.

6. Transport, stabilization and storage of samples (ctd...)

'Measure and record the temperature of the sample on-site. Physical parameters (e.g. pH, dissolved gases, suspended solids) should be determined on site or as soon as possible afterwards.'

Findings	Non-Conformance	Corrective Action
1. Temperature, pH, conductivity and DO are measured and recorded at the sampling site. 2. The requirement to measure and record these parameters are not clearly documented in the relevant sampling SOPs.	1. As per finding No. 2.	1. Amend relevant sampling SOPs detailing what parameters are to be measured and recorded on site.

'It is recommended that sample containers are tightly sealed and protected from the effects of light and excessive heat, because the characteristics of the sample may rapidly deteriorate due to gas exchange, chemical reactions and the metabolism of organisms which may be present. Ensure that samples, which cannot be analysed quickly, are stabilized. Cooling to $4^{O}C$ may be applied; for longer periods, freezing to $-20^{O}C$ as recommended in ISO5667-3.'

Findings	Non-Conformance	Corrective Action
1. Samples are tightly sealed and transported from sampling location to laboratory in cooler boxes and refrigerated immediately if analyses are not being carried out. 2. SOP No.'s 6, 8, 10, 11 and 47 do not state that sample containers are to be tightly sealed. 3. SOP No.'s 6, 8, 10 and 11 do not give details on the transportation or storage of samples.	1. As per findings No. 2 and 3.	1. Amend SOP No.'s 6, 8, 10, 11 and 47 stating that sample containers are to be tightly sealed. 2. Amend SOP No.'s 6, 8, 10 and 11 to give details on the transportation or storage of samples.

6. Transport, stabilization and storage of samples (ctd...)

'Samples may be preserved by the addition of chemicals of suitable quality. Ensure that the chosen method of preservation does not interfere with the subsequent examination or influence results. Record all preservation steps in the test report.'

Findings	Non-Conformance	Corrective Action
1. There is no documented procedure for the preservation of samples. 2. There is no procedure in place to ensure that the chosen method of preservation does not interfere with the subsequent examination or influence results. 3. Preservation steps are not recorded in the test report.	1. As per findings No. 1, 2 and 3.	1. Document and implement procedure for the preservation of samples. 2. Document and implement method for ensuring that the preservation used does not interfere with the subsequent examination or influence results. 3. Implement system of recording all preservation steps. 4. Train sampling personnel with regard to the preservation of samples.

7. Analysis and interpretation of quality control data.

Not applicable to gap analysis.

8. Sample identification and records

'Describe each sampling point. In the case of long-term programme, conditions which are agreed and remain unchanged need not be restated. In this case only a statement of the in situ measurements and variables such as weather conditions and unusual observations need to be recorded.'

Findings	Non-Conformance	Corrective Action
1. The sampling programme describes each sampling point. 2. River sites are allocated a reference number, which is used to label sample bottles and in the recording of all results.	None	None

8. Sample identification and records (ctd...)

'When sampling for special reasons, detailed information should be given, including the reasons for sampling and any preservation steps taken.'

Findings	Non-Conformance	Corrective Action
1. The information, which should be recorded when sampling for special reasons is not documented or standardised.	1. As per finding No.1.	1. Identify and document what exact information should be recorded when sampling for special reasons.

DOCUMENT No. 14:

Summary of the Corrective Actions required in order to comply with: ***ISO 5667-14:1998 Water quality – Sampling- Part 14:Guidance on quality assurance of environmental water sampling and handling***

Note: *For the corrective actions to be implemented effectively staff training shall have to be paramount in all cases.*

1. Amend SOP No.'s 6, 8, 10, 11 and 47 to include details on the calibration and checking of field meters prior to sampling and details on the transportation of samples from the sampling site to the laboratory *(ISO 5667-14:1998 (5.1)).*

2. Document the sampling training procedure and develop detailed training records *(ISO 5667-14:1998 (5.1)).*

3. Develop, document and implement analytical quality control programme for sampling, as per ISO 5667-14:1998(E).

4. Identify and document when and what preservatives are to be used, for the various analyses. Document procedure for the preparation and use of these preservatives. Implement system of recording all preservation steps *(ISO 5667-14:1998 (6)).*

5. Document and implement method for ensuring that the preservation used does not interfere with the subsequent examination or influence results *(ISO 5667-14:1998 (6)).*

6. Amend SOP No.'s 6, 8, 10, 11 and 47 detailing what parameters are to be measured and recorded on site *(ISO 5667-14:1998 (6)).*

7. Amend SOP No.'s 6, 8, 10 11 and 47 to give details on the sealing, transportation and storage of samples prior to analyses *(ISO 5667-14:1998 (6)).*

8. Identify and document what exact information should be recorded when sampling for special reasons *(ISO 5667-14:1998 (8)).*

DOCUMENT No. 15:

Sampling Programme Corrective Actions

Note: *For the corrective actions to be implemented effectively staff training shall have to be paramount in all cases.*

1. Amend sampling programme to include details of:
   (a) how sampling sites (location and point) were selected, ensuring that safety and health aspects are considered *(ISO 5667-1:1980 Section 1 (3))*.
   (b) how the frequency of analysis is calculated, ensuring it is done in a systematic manner *(ISO 5667-1:1980 Section 3 (16.1)), (ISO 5667-6:1990 (1), (5.2))*.
   (c) when spot and composite samples are to be taken *(ISO 5667-2:1991 (4.2), (5))*.

2. State the objectives of the various sampling programmes *(ISO 5667-1:1980 Section 1 (3)* e.g. drinking water monitoring *(ISO5667-5:1999 (1))*, wastewater sampling programme. *(ISO 5667-10:1992 (1), (5.1.3), (5.3.1.1))*.

3. Identify and document the degree of detail and precision that will be adequate for analytical field results. Outline the manner in which the results are to be expressed and presented, as part of the sampling programme. Amend sampling programme to include definition of the magnitude of tolerable error in analytical field results *(ISO 5667-1:1980 Section 1 (3))*, *(ISO 5667-6:1990 (1), (5.2))*.

4. Review the sampling locations ensuring samples are taken from turbulent, well-mixed liquids *(ISO 5667-1:1980 Section 2 (8.3))*.

5. Amend sampling programme to give details on the introduction of turbulent flow conditions, where necessary *(ISO 5667-10:1992 (5.1.2))*.

6. Ascertain the need to statistically determine the number of samples required for a given confidence interval. If required, carry out statistical analysis, document results and amend sampling programme as required *(ISO 5667-1:1980 Section 3 (16.4))*.

7. Identify and document the wastewater sampling times required. These can be ascertained using the formulae given in *ISO 5667-10:1992 (5.2.3)*, which calculates the sampling times over a specified control period e.g. one year, a number of months or weeks.

8. a) Identify whether the water bodies sampled have random or systematic variations in quality.
   b) Determine statistically the number of samples required, to determine whether random or systematic variation occurs.
   c) If systematic variations in quality exist determine the times of sampling (these should be spaced approximately equally over trend periods in which variations occur).
   d) Document results and amend sampling programme as required
   (ISO 5667-1:1980 Section 3 (16.5))

9. Compile a list of the parameters of interest for each sample type e.g wastewater, river, etc. with reference to the relevant analytical procedure used in the laboratory *(ISO 5667-1:1980 Section 1 (3)).*

10. Amend 'sampling programme' to include map of surface waters used for the abstraction of drinking water. Outline the various sampling points in these water bodies *(ISO 5667-6:1990 (5.1.1)).*

DOCUMENT No. 16:

Quality Control Corrective Actions

Note: *For the corrective actions to be implemented effectively staff training shall have to be paramount in all cases.*

1. Implement a procedure for assessing whether the filter type used to filter samples is a cause of contamination *(ISO 5667-3:1994 (3.2.5))*.

2. Develop, document and implement a procedure for situations where the time-of -travel exceeds the max recommend preservation time *(ISO 5667-3:1994 (5))*.

3. Develop, document and implement procedure for verifying that the number of samples received at the laboratory coincides with the number recorded on the field sheet *(ISO 5667-3:1994 (6))*.

4. Develop, document and implement method to ensure samples are preserved and stored in the correct containers as soon as possible after sampling *(ISO5667-5:1999 (7.2))*.

5. Develop, document and implement analytical quality control (QC) programme for periodically testing the sampling methods used. This should include the use of field blanks, samples with added determinands and/or duplicate samples *(ISO 5667-6:1990 (5.5))*, *(ISO 5667-14:1998(E))*.

6. Develop, document and implement procedure for training sampling personnel with regard to correct sampling and on-site measurement techniques *(ISO5667-5:1999 (9)*. Document the sampling training procedure and develop detailed training records *(ISO 5667-14:1998 (5.1))*, *(ISO 5667-3:1994 (3.2.1))*.

7. Identify, document and implement a procedure to assess the suitability of polyethylene containers for the collection of samples for trace metal analyses *(ISO 5667-6:1990 (4.1))*.

DOCUMENT No. 17:

Preservation Corrective Actions

Note: *For the corrective actions to be implemented effectively staff training shall have to be paramount in all cases.*

1. Identify and document the preservation method(s) required for the various samples. Implement preservation methods, where required and develop method of recording when samples are preserved *(ISO 5667-1:1980 Section 1 (3), (5.3)), (ISO 5667-3:1994 (3.1)), (ISO 5667-14:1998 (6)).*

2. Ascertain the need to preserve samples during the collection of composite samples. If necessary, implement system of sample preservation *(ISO 5667-2:1991 (4.6)), (ISO 5667-10:1992 (5.4)).*

3. Document and implement method for ensuring that the preservative used does not result in dilution of the analyte or interfere with the subsequent analysis thereby influencing the final result *(ISO 5667-3:1994 (3.2.6)), (ISO 5667-14:1998 (6)).*

4. The efficiency of the preservation process depends on the constituents which have to be analysed, their levels and on the nature of the sample. Therefore develop, document and implement a procedure to verify whether or not the preservation suggestions in Table 1 to 5 of ISO 5667-3:1994 are suitable for the sample with which it is concerned *(ISO 5667-3:1994 (3.3)).*

DOCUMENT No. 18:

Drinking Water Corrective Actions

Note: *For the corrective actions to be implemented effectively staff training shall have to be paramount in all cases.*

1. (a) Map drinking water locations *(ISO 5667-1:1980 Section 1 (3), Section 2 (8.2))* and predetermined sampling points for the various water supplies *(ISO5667-5:1999 (4.1.4))*.
   (b) Amend sampling programme to include details on how the various drinking water sampling points are selected *(ISO 5667-1:1980 Section 2 (9.8.1))*.

2. Amend SOP No. 6 to include details regarding:
   (a) the selection of drinking water sampling taps, stating that "anti-splash or similar devices should be removed before sampling and that mixer taps are not recommended for sampling" (*ISO 5667-1:1980 Section 2(9.8.1), (9.8.3)), (ISO5667-5:1999(4.1.5))*.
   (b) sampling in areas of low flow and avoiding disturbance of sedimentary material *(ISO5667-5:1999 (4.1.4))*.
   (c) flushing for extended periods prior to sampling from stagnant systems *(ISO5667-5:1999 (5.3))*.
   (d) the exact type of sampling container that is to be used for each parameter *(ISO 5667-2:1991 (6.1.1)), (ISO5667-3:1994 (3.2.2), (3.2.3.2), (3.2.3.3))*.
   (e) the cleaning and preparation of the sampling containers used for each parameter *(ISO 5667-3:1994 (3.2.3.1), (3.2.3.2) (3.2.3.3))*.
   (f) the calibration and checking of field meters prior to sampling *(ISO 5667-14:1998 (5.1))*.
   (g) the volume of sample that is to be collected, for the various parameters *(ISO 5667-2:1991 (6.3.1)), (ISO5667-5:1999 (7.1))*.
   (h) sampling large volumes e.g. for *Cryptosporidium* analysis *(ISO 5667-2:1991(4.7))*.
   (i) minimum sample bottle capacity of 300ml *(ISO5667-5:1999 (5.3))*.
   (j) the filling and sealing of sample container *(ISO 5667-3:1994 (3.2.1), (3.2.2)), (ISO5667-5:1999 (5.1), (5.3), (7.2))*.
   (k) the parameters, which are measured on-site *(ISO 5667-2:1991 (4.1)), (ISO5667-3:1994 (3.1)), (ISO 5667-14:1998 (6)) (ISO5667-5:1999(4.1))*.
   (l) the taking, preservation and analyses of blank samples *(ISO 5667-3:1994 (3.2.2)), (ISO5667-5:1999 (9))*.
   (m) the requirement to complete the field sheet *(ISO 5667-2:1991 (7.1)), (ISO5667-3:1994 (4),(ISO5667-5:1999(8))*.
   (n) sealing samples and transportation of samples to the laboratory *(ISO 5667-2:1991 (6.2.4)), (ISO5667-3:1994 (3.1), (3.2.4), (5)), (ISO 5667-14:1998 (5.1),(6)), (ISO5667-5:1999 (7.2))*.
   (o) immediate storage of samples in a refrigerator in cases where immediate analyses is not being carried out *(ISO 5667-3:1994 (6))*.
   (p) the safety precautions required with reference to the Safety Statement for the Environment Section *(ISO 5667-1:1980 Section 2 (7.1)), (ISO5667-5:1999 (6))*.

3. Assess the need to use a flexible inert tube, to deliver liquid to the bottom of the sampling bottle, when sampling from a tap or pump outlet *(ISO 5667-2:1991 (6.7))*.

4. Asses need to disinfect using a chlorine solution versus alcohol (which is currently being used). Amend SOP if necessary *(ISO5667-5:1999 (4.1.5))*.

5. Develop, document and implement method of on-site analysis of odour and taste *(ISO5667-5:1999 (4.1))*.

6. Develop, document and implement procedure for:
   a) sampling from water treatment plants *(ISO5667-5:1999 (4.1.2))*; reservoirs *(ISO 5667-1:1980 Section 2 (9.5), (9.8.2)), (ISO5667-5:1999 (4.1.1))* and hydrants. *(ISO5667-5:1999 (4.1.4))*.
   b) assessing efficiency of disinfection plant *(ISO5667-5:1999 (4.1.3))*.
   c) sampling for investigating dissolution of materials from pipework or growth of microorganisms within pipework *(ISO5667-5:1999 (4.1.4), (4.1.5))*.
   d) sampling during abnormal conditions e.g. drinking water contamination and the subsequent reporting of these results (ISO 5667-1:1980 Section 3 (17)), (ISO 5667-14:1998 (8)).
   e) selection and purchase of sampling containers (for microbiological, physical and chemical analysis). Include details on cap types to be used for the various parameters *(ISO 5667-2:1991 (6.1.1), (6.2.1), (6.2.3), (6.2.4), (6.5))*.

7. Develop, document and implement SOP detailing how bottles are to be sterilized and a method to assess if the sampling container materials used produce or release chemicals *(ISO5667-5:1999 (5.3))*.

8. Identify and document samples with which contact with the air must be avoided and that require vigorous mixing before taking portions for analyses. Document procedure for dealing with both types of samples *(ISO5667-5:1999 (7.2))*.

9. Identify samples that require to be filtered/ centrifuged at the time of taking the sample or immediately afterwards. Implement procedure for filtration/ centrifuging of samples *(ISO 5667-3:1994 (3.2.5)), (ISO5667-5:1999 (7.2))*.

10. Amend SOP No. 43 to include details on the max. length of sample storage for the various analyses, making reference to guidelines in Standard Methods (A.P.H.A. 20th Ed.) *(ISO 5667-3:1994 (3.1))*.

11. Amend field sheet to include details on weather conditions, unusual observations and information on samples taken for a specific reason *(ISO 5667-1:1980 Section 2 (8.13)), (ISO 5667-2:1991 (7.2), ISO 5667-3:1994 (4)), (ISO5667-5:1999 (8))*.

DOCUMENT No. 19:

River Corrective Actions

Note: *For the corrective actions to be implemented effectively staff training shall have to be paramount in all cases.*

1. Reassess river sampling locations in order to:
   a) take flow stations into account *(ISO 5667-1:1980 Section 2 (8.1))*.
   b) ensure they provide representative samples by taking into account locations where marked quality changes are likely to occur or locations where there are important river uses *(ISO 5667-1:1980 Section 2 (9.3.2))*.

   Amend sampling programmes to take the above factors into account.

2. Identify appropriate method to assess each river sampling location for stratification. Take appropriate measures following the results of the assessment *(ISO 5667-1:1980 Section 2 (9.3.1))*.

3. Identify and document an appropriate method to assess the effects of a discharge on a river by selecting representative upstream and downstream locations (Note: the discharge may be a wastewater discharge or an adjoining tributary) *(ISO 5667-1:1980 Section 2 (9.3.2)), (ISO 5667-6:1990 (5.1.1.1))*.

4. Amend SOPs No. 8 and 47 to include details of the:
   a) safety precautions necessary when sampling from rivers, with reference to 'Safety Statement for the Environment Section' *(ISO 5667-1:1980 Section 2 (7.1))*, *(ISO 5667-6:1990 (6))*.
   b) measures required to ensure the sampling location is safe prior to commencing sampling (ISO 5667-1:1980 Section 2 (7.4)).
   c) calibration/ checking of field meters prior to sampling *(ISO 5667-14:1998 (5.1))*.
   d) sampling equipment to be used *(ISO 5667-6:1990 (4.2))*.
   e) type of sampling container that is to be used for each parameter *(ISO 5667-2:1991 (6.1.1))*, *(ISO 5667-3:1994 (3.2.2), (3.2.3.2), (3.2.3.3), (ISO 5667-6:1990 (4.1))*.
   f) cleaning and preparation of the sampling containers used for each parameter *(ISO 5667-3:1994 (3.2.3.1) (3.2.3.2) (3.2.3.3))*.
   g) when the sampling of surface films is required and when it should be avoided *(ISO 5667-6:1990 (5.3.1))*.
   h) when sample containers can/cannot be pre-rinsed *(ISO 5667-6:1990 (5.4))*.
   i) volume of sample to be collected for various parameters *(ISO 5667-2:1991 (6.3.1))*.
   j) filling and sealing of sample container(s) *(ISO 5667-3:1994 (3.2.1), (3.2.2))*.
   k) parameters which are to be measured and recorded on-site *(ISO 5667-2:1991 (4.1), ISO 5667-3:1994 (3.1), ISO 5667-6:1990 (5.4), ISO 5667-14:1998 (6))*.
   l) taking, preservation and analyses of blank samples *(ISO 5667-3:1994 (3.2.2)*.
   m) labelling of sampling bottles and completion of the field sheet *(ISO 5667-2:1991 (7.1))*, *(ISO 5667-3:1994 (4))*, *(ISO 5667-6:1990 (7))*.
   n) sample transportation and the sealing of sampling containers *(ISO 5667-2:1991 (6.2.4))*, *(ISO 5667-3:1994 (3.1), (3.2.4), (5))*, *(ISO 5667-6:1990 (5.4))*, (*ISO 5667-14:1998 (5.1),(6))*.
   o) storage of samples in a refrigerator on arrival to the laboratory, where immediate analyses is not being carried out *(ISO 5667-3:1994 (6))*.

5. Amend SOP No. 47 to include details on:
   a) the type of sampling containers to be used for microbiological samples
   b) the preparation of microbiological sampling bottles
   c) how microbiological samples are to be taken *(ISO 5667-6:1990 (4.2), (5.3.2)).*

6. Develop appropriate field report sheet for sampling rivers and surface water for abstraction *ISO 5667-1:1980 Section 2 (8.13)), (ISO 5667-2:1991 (7.2)), (ISO 5667-3:1994 (4)), (ISO 5667-6:1990 (7)).*

7. Identify the samples which require to be filtered/centrifuged at the time of taking the sample or immediately afterwards. Implement a procedure for the filtration/ centrifuging of these samples *(ISO 5667-3:1994 (3.2.5)), (ISO5667-6:1990 (5.4)).*

8. Document and implement procedures for the selection of effective samplers *(ISO 5667-2:1991 (6.3.1))* and containers. Include details on the cap types to be used for the various parameters *(ISO 5667-2:1991 (6.1.1), (6.2.1), (6.2.3), (6.2.4), (6.5)).*

9. Identify abnormal sampling situations (e.g. flood conditions in a river or times of an algal bloom). Prepare SOP detailing the procedure for sampling during these conditions and the subsequent reporting of these results *(ISO 5667-1:1980 Section 3 (17), ISO 5667-14:1998 (8)).*

10. Assess whether an accurate determination of dissolved oxygen (D.O.) is required i.e. a measurement of D.O. taken directly in the water-body as opposed to the current practice of measuring D.O. in the sampling bucket *(ISO 5667-2:1991 (6.7)).*

11. Assess the need to ascertain the time-of-travel of pollutants in rivers. If required, identify, document and implement method for assessing the time-of-travel of pollutants in rivers (*ISO 5667-6:1990 (5.1.1.2)).*

12. Determine the possibility of a non-homogeneous distribution of determinands of interest at the various sampling sites. Identify, document and implement method for assessing same *ISO 5667-6:1990 (5.1.2).*

13. Amend SOP No. 43 to include details on the max. length of sample storage for the various analyses *(ISO 5667-3:1994 (3.1)).*

DOCUMENT No. 20:

Wastewater Corrective Actions

Note: *For the corrective actions to be implemented effectively staff training shall have to be paramount in all cases.*

1. a) Review wastewater sampling locations to ensure sufficient turbulence is present at all sites *(ISO 5667-1:1980 Section 2 (8.9)), (ISO 5667-10:1992 (5.1.2)).*
   b) Identify sampling points where incomplete mixing of wastewaters exists, due to low flow rates or mixing of wastewaters from different sources *(ISO 5667-1:1980 Section 2 (12.1.1)).*

2. Identify, document and implement measures to overcome or minimize heterogeneity caused by suspended solids and/or thermal stratification in wastewater streams *(ISO 5667-10:1992 (5.1.3)).*

3. Identify and document when and how emulsified and floating material are to be sampled *(ISO 5667-10:1992 (5.1.4), ISO 5667-1:1980 Section 2 (12.1.1)).*

4. Identify and document exact sampling point;
   a) for influent and effluent at all wastewater plants routinely sampled *(ISO 5667-10:1992 (5.1.3)), (ISO 5667-1:1980 Section 2 (12.1.1)).*
   b) to extract samples from aeration tanks in a wastewater treatment plant. *(ISO 5667-1:1980 Section 3 (19.2))*

5. Develop, document and implement system for frequently reviewing the plant's sampling locations *(ISO 5667-10:1992 (5.1.3)).*

6. Prepare SOP for sampling of storm sewage and surface run-off taking into account the guidelines provided in ISO 5667-1:1980 Section 2 (13).

7. Amend SOP No.'s 10 & 11 to include details on:
   a) Calibration/checking of field meters prior to sampling *(ISO 5667-14:1998 (5.1)).*
   b) Cleaning/preparation of the sampling containers and equipment *(ISO 5667-3:1994 (3.2.3.1) (3.2.3.2) (3.2.3.3), ISO 5667-10:1992 (4.2.1)).*
   c) sample container type to be used for various analyses *(ISO 5667-2:1991 (6.1.1)), (ISO 5667-3:1994 (3.2.2), (3.2.3.2), (3.2.3.3)), (ISO 5667-10:1992 (4.1)).*
   d) taking of samples and filling of sampling containers *(ISO 5667-3:1994 (3.2.1), (3.2.2), (ISO 5667-10:1992 (4.2.1)).*
   e) sample volume required for the various analyses *(ISO 5667-2:1991 (6.3.1)) (ISO 5667-10:1992 (4.2.1)).*
   f) the depth at which the samples should be taken i.e. one-third of the effluent water depth below the surface of the water *(ISO 5667-10:1992 (5.1.2)).*
   g) handling corrosive or abrasive liquids *(ISO 5667-1:1980 Section 2 (8.7)).*
   h) parameters, which are measured on site *(ISO 5667-2:1991 (4.1)), (ISO 5667-3; 1994 (3.1)), (ISO 5667-14:1998 (6)).*
   i) preservation and storage of samples *(ISO 5667-10:1992 (5.4)).*
   j) taking, preservation and analyses of blank samples *(ISO 5667-3:1994 (3.2.2).*
   k) the requirement to complete field sheet *(ISO 5667-2:1991 (7.1)), (ISO 5667-3:1994 (4).*

l) the sealing and transportation of samples to the laboratory *(ISO 5667-2:1991 (6.2.4), ISO 5667-3:1994 (3.1), (3.2.4), (5), ISO 5667-14:1998 (5.1),(6).*

m) storage of samples in a refrigerator on arrival to the laboratory, where immediate analyses is not being carried out *(ISO 5667-3:1994 (6)).*

n) Safety precautions necessary, (include details from the Laboratory Safety Statement) *(ISO 5667-1:1980 Section 2 (7.1)).*

8. Develop, document and implement sampling report form for STP and industrial wastewater sampling as per ISO 5667. *(ISO 5667-1:1980 Section 2 (8.13), ISO 5667-2:1991 (7.2), ISO 5667-3:1994 (4)), (ISO 5667-10:1992 (7))*

9. Identify and document whether sampling locations require to be cleaned (to remove scale, sludge, bacterial film, etc. from the walls) prior to sampling and detail how cleaning is to be carried out *(ISO 5667-10:1992 (5.1.2)).*

10. Assess the need to use a flexible inert tube, to deliver liquid to the bottom of the sampling bottle, when sampling from a tap or pump outlet *(ISO 5667-2:1991 (6.7)).*

11. Identify the samples which require to be filtered/centrifuged at the time of taking the sample or immediately afterwards. Implement a procedure for the filtration/ centrifuging of these samples *(ISO 5667-3:1994 (3.2.5).*

12. Develop, document and implement a procedure for the freezing and thawing of samples *(ISO 5667-3:1994 (3.2.4)).*

13. Amend SOP No. 43 to include details on the max. length of sample storage for the various analyses, making reference to guidelines in Standard Methods (A.P.H.A. 20th Ed.) *(ISO 5667-3:1994 (3.1)).*

14. Document and implement procedures for the selection of effective samplers *(ISO 5667-2:1991 (6.3.1))* and the selection and purchase of sampling containers, including details on the cap types to be used for the various parameters *(ISO 5667-2:1991 (6.1.1), (6.2.1), (6.2.3), (6.2.4), (6.5)), (ISO 5667-10:1992 (4.1)).*

15. Document criteria for the selection of automatic sampling equipment, taking into account the features and attributes stated in *ISO 5667-10:1992 (4.2.2).*

16. Develop, document and implement a method for selecting the period over which a composite sample is to be taken, taking the objective of the sampling programme and the stability of the sample into account *(ISO 5667-10:1992 (5.2.4)).*

17. Statistically determine the number of samples to be taken during each composite sample *(ISO 5667-10:1992 (5.2.2)).*

18. Identify and document the parameters that can only be determined on spot or composite samples *(ISO 5667-10:1992 (5.3.1.1)).*

19. Develop and document procedure for the taking of composite samples, including the type of composite sample & details on the volumes to be taken *(ISO 5667-10:1992 (5.3.1.2)).*

20. Implement a procedure for:
    - dealing with samples of anomalous material
    - identifying hazardous materials

    (ISO 5667-3:1994 (4))

21. a) Identify areas where a site inspection may be necessary in order to ensure the locations of the sewers and path of the waste stream correspond to the site map drawings and the selected location is representative for sampling purpose.
    b) Develop a system of carrying out site inspections using chemical tracer studies or other approved method. Develop an appropriate method to document results of same *(ISO 5667-10:1992 (5.1.1))*.

22. Develop, document and implement procedure for noting and recording conditions inside a licensed industrial plant prior to sampling (ISO 5667-10:1992 (5.1.2))