A GWS guide to the drinking water parameters

What's in your water?

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Group Water Schemes

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A GWS guide to the parameters in the European Communities (Drinking Water) (No.2) Regulations 2007 (S. I. No. 278 of 2007)

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Acknowledgements

The crucial role of the Rural Water Programme (RWP) in addressing quality deficiencies in the GWS sector has to be recognised as a major success of the period referred to as the Celtic Tiger years. With substantial financial investment from the Irish exchequer through the Department of the Environment, Heritage & Local Government (now the Department of the Environment, Community & Local Government [DECLG]), group water schemes have been transformed, while retaining their core community structures and voluntary ethos.

Apart from the construction of water treatment facilities and other essential infrastructure, the principal focus of the RWP has been to improve the capacity of GWS committees/boards of management and staff to meet their obligations under the Drinking Water Directive by delivering a service that is second to none.

While the infrastructural investment programme is largely completed, the challenge now is to protect that investment. Capacity building, through relevant training programmes and the provision of information and advisory resources will, therefore, continue to be a priority for the National Federation of Group Water Schemes (NFGWS). The rural water sector has been fortunate in recent years to have had the support of the Department and the Water Services Training Group (WSTG) and FÁS in developing educational and training resources. As a result of this support appropriate training programmes are now available for rural water personnel.

Quality Assurance implementation is key to the future of this sector. This short guide is designed to provide rural water activists with a resource that will assist them in planning the safety of their supply from source to tap. It is not intended to be interpreted as an original work of scientific research. Rather, it has been compiled from existing publications and credible sources of information and is presented in a format that will assist individual group schemes to establish the relevance of particular drinking water parameters to their own circumstances. To this end, the guide borrows shamelessly from the excellent documents provided by the World Health Organisation (WHO) and from many international and national guidelines (in particular those for Australia) that are grounded in the WHO analysis and recommendations.

Here in Ireland, monitoring of drinking water quality is a key function of the Environmental Protection Agency (EPA). Their reports (collated from monitoring results provided through local authorities) detail compliance and non-compliance with each drinking water parameter, providing an annual reminder that we cannot be complacent. In addition, the EPA's publication *Parameters of Water Quality Interpretation and Standards* (2001) provides anyone interested in drinking water quality with essential background reading, as does the acknowledged bible of the water services industry, *Twort's Water Supply* (6th Edition).

As part of the National Source Protection Pilot Project, funded by the Department, valuable educational and information material was developed. All of this has fed into this short guide. I am especially grateful to Dr Suzanne Linnane, Director of the Centre for Freshwater Studies at Dundalk Institute of Technology and to Bernie O'Flaherty of Monaghan County Council, both of whom have been generous in sharing their considerable expertise on water quality issues.

The vibrant Irish hydrogeological community has proved more than willing to enlighten the rural water sector about particular issues that arise in relation to groundwater supplies. Dónal Daly of the EPA and Monica Lee, Taly Hunter-Williams and Caoimhe Hickey of the Geological Survey of Ireland are just a few of those within this sector to whom I owe thanks.

Similarly, the EPA's drinking water quality team is always available to provide practical support and advice where issues arise about water quality in the GWS sector. In particular, thanks are due to Darragh Page, Matthew Craig and Nigel Hayes for their comments in relation to this booklet.

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I am indebted to my colleague, Colm Brady, who closely read and corrected earlier drafts of this booklet and to the Board of the NFGWS who demonstrated considerable foresight in the development of a Quality Assurance approach to water management. They have readily supported all initiatives that assist GWS activists in delivering a professional and environmentally-sustainable service to their members.

To all of the above, míle buíochas!

Brian MacDonald
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'The most undesirable constituents of drinking-water are undoubtedly those that are capable of having a direct impact on public health and for which guideline values have been developed. The management of these substances is in the hands of organisations responsible for the provision of the supply, and it is up to these organisations to instil in their consumers the confidence that this task is being undertaken with responsibility and efficiency.'

World Health Organisation

Introduction

From time to time, group water schemes receive the results of water quality analysis carried out by their local authority (i.e. Water Services Authority (WSA)) or by an agent working on their behalf, such as the Health Services Executive (HSE). These results contain a lot of information about what is and isn't in drinking water, but for most of us (who were never great at science in school anyway), it's all gobbledegook. We sit up and take notice when we hear familiar terms such as arsenic and cyanide, but as for enterococci, benzo(a)pyrene, epichlorohydrin, tetrachloroethene and trichloroethane ... these induce a state of bewilderment. What are they? Will they flavour a cup of tea? Will they kill me?

This booklet aims to unravel the mystery and to explain, in as simple terms as possible, what analysis of the 48 parameters that come under the Drinking Water Regulations is telling you about the state of your water supply.

The first thing to note is that, under compliance monitoring, many group water schemes normally won't have to concern themselves about the bulk of these parameters. If a scheme is supplying less than 100 cubic metres a day, then the local authority is only obliged to carry out check sampling, involving *up to* 13 parameters. Depending on the raw water source and on the type of treatment used, it might be even less. [See note, page x]

This begs the question, why is a small supply excused from more rigourous testing and shouldn't it be as concerned about benzo(a)pyrene, for example, as the rest of us? Well, it appears that where water supplies are concerned, size really does matter. The more water being supplied, the greater the potential risk – another argument for reducing unaccounted for water and wastage in the network! And it's not that small schemes shouldn't be concerned about the chemical and physical properties of their water: from time to time, all schemes should have a broad spectrum analysis carried out to get a better understanding of their raw and treated water supplies.

Check sampling is also carried out on larger schemes, but in their case the monitoring is more frequent and they are also subject to at least one audit sampling per year involving most, if not all, of the 48 parameters. Again, the nature of the source and of the treatment used will decide if it is sensible to test for particular parameters or not.

That's the thing about the Drinking Water Regulations; they are not one-size-fits-all. Common sense must be applied and if a supply is clearly not at risk from particular contaminants then why waste time and money in testing for them? Resources need to be focussed on actual risks. Similar logic is applied to microbiological testing. After all, there are loads of bacteria, protozoa and viruses that might be checked for individually and we know that there are enteric pathogens (tummy bugs to you and me) that are, as yet, unrecognised. Instead of incurring the major expense involved in testing for each and every microbe that might cause a problem, a small number of parameters are checked because their presence or absence will indicate if your disinfection system is doing its job. In other words, if it's capable of dealing with *Escherichia coli* (*E.coli*) and coliform bacteria, then you can be reasonably certain that most other microbiological contaminants are being dealt with also.

The microbiological parameters are the main focus for drinking water supplies precisely because they represent the most significant threat. Sampling carried out in recent years has shown that for most chemical and physical parameters, compliance by water providers across Ireland is 100% or very close to it. Which isn't to say that we should ignore these parameters. After all, some of them have a direct bearing on treatment processes and others can have longer term and very serious impacts on health. You may have seen the film *Erin Brokovitch*, with Julia Roberts exposing the dreadful impact that contamination of a groundwater source by hexavalent chromium had on the health of a community. Their problem began with industrial pollution, but chemical pollutants can enter a supply through natural processes also, or through diffuse sources such as the spreading of pesticides, or from point sources such as an oil spill, a sheep dip or a malfunctioning septic tank!

Even if the maximum value for chemical parameters hasn't been reached, you should be looking at upward trends that suggest a growing problem. For example, while the maximum allowable concentration for nitrates is 50 mg/litre, the alarm bells should sound much earlier, especially if the graph line is climbing and you are already getting readings in the high 20s! A timely response to identifying the cause of such an increase and taking early actions to protect the source is a far better option than waiting for the maximum to be reached, by which point it is likely that you will have to invest in additional and expensive treatment to remove the contaminant.

Another thing to note about chemical and physical parameters is that many of them are elementary substances, meaning that they are part of the natural environment. So we shouldn't get overly excited when they turn up in our water in tiny amounts. If nothing else, what we consume through water is likely to be only a small fraction of our intake of these substances from other sources, such as eating. To put the scale of the risk into perspective, compared to the limited number of chemicals that might be in a drinking water supply in relatively small amounts, there are more than 4,000 chemicals in tobacco smoke, of which at least 250 are known to be harmful and more than 50 are known to cause cancer!

With some chemicals (such as those that are elementary), it's a case of damned if you do and damned if you don't: not enough of them can be harmful and too much can also be harmful. It's all about getting the balance right and the World Health Organisation and the European Community have provided guidelines on what is the recommended intake for a range of substances in our water supplies, taking into account that we are also getting these substances from other sources.

Apart from the microbiological and chemical/physical parameters, there are two parameters that may seem trivial, but they are arguably very important in terms of maintaining consumer confidence in a water supply. These are what are called the organoleptic or sensory parameters: taste and odour. The main reason for their inclusion is explained in the updated guidelines published by the World Health Organisation in 2011. This states: 'Water that is aesthetically unacceptable can lead to the use of water from sources that are aesthetically more acceptable, but potentially less safe.' Probably the biggest issue for GWS consumers in this regard is the smell arising from excessive chlorine in water, which has the potential to drive people to rely on spring water supplies that may be problematic.

The lowest level of detection for most parameters isn't zero, but is fractionally higher than that (the degree of accuracy depends on the sophistication of the laboratory analysis). For example, the lowest level at which most laboratories can detect aluminium is 5 μg/litre, while ammonium is detectable at 0.009 mg/litre. If you see this lowest figure, then you know that a tiny trace of the substance has been found. However, if the symbol < (meaning less than) appears before the figure, you can rest assured that no trace of the parameter was found in your supply.

This guide deals with the parameters as they are listed in three tables under the Drinking Water Regulations from 1 to 48. Table A lists two microbiological parameters, while 26 chemical parameters are listed in Table B. Finally, Table C includes an assortment of 20 chemical, microbiological, physical and aesthetic parameters, in addition to two radiological parameters. These are described as indicator parameters.

Of course, the results of any monitoring will only be as reliable as the location and method in which samples were taken, how they were preserved and the competence of the laboratory in which they are analysed. These issues are addressed in the *Handbook on the Implementation of the Regulations for Water Services Authorities for Private Water Supplies*, published by the EPA in 2010. Also useful is the HSE guidance for sampling published in 2008, titled *Drinking Water and Health: A Review and Guide for Population Health*. Each GWS can and should play its part in ensuring the reliability of sampling by identifying households in their supply zone where water is fed to the cold tap in the kitchen directly from the mains supply and without any intermediary treatment system or softener. If houses can be identified that don't have mixer taps then all the better. This information should be supplied to the relevant WSA when the annual monitoring programme is being drawn up.

As part of check and audit monitoring practice, samplers will usually test residual chlorine and (possibly) total chlorine also, because the results of these might help explain a microbiological non-compliance. Chlorine readings are unlikely to be included with the wider parametric results, so group water schemes should, if possible, get such information at the time of sampling and note it as part of their own records. Where possible, and by agreement, a representative of the GWS should be present during sampling, as a measure to increase confidence in the sampling process.

Format

In this booklet, each of the 48 parameters is dealt with on its own individual page, in the order that it appears in the Drinking Water Regulations. Whether it is part of the list of check or audit monitoring parameters, or both, is also shown.

The maximum allowable value for most parameters is measured either in milligrams per litre (mg/litre) [1 milligram = one thousandth (1/1,000) of a gram], or in micrograms per litre (μg/litre) [1 microgram = one millionth (1/1,000,000) of a gram]. To change from one to the other, simply move the decimal point three spaces (e.g. 0.2 mg/litre is 200 μg/litre, while 50 μg/litre is 0.05 mg/litre).

The health risks outlined for parameters in this guide are generally as described in the World Health Organisation *Guidelines for Drinking Water Quality*, 4th Edition, and a further WHO publication *Chemical safety of drinking-water: Assessing priorities for risk management* (2007).

Additional information on potential health risks was secured from the EPA's *Parameters of Water Quality Interpretation and Standards* (2001) and from fact sheets provided as part of the Australian Drinking Water Guidelines. On occasion, other sources (such as the US Environmental Protection Agency) analysis have been used.

Where group schemes wish to verify particular risks, they should contact either their Water Services Authority or the Health Services Executive.

Note: The 'Handbook on the implementation of the Drinking Water Regulations', produced by the EPA, contains a section of specific interest to small group water schemes, supplying between $10m^3$ and $100m^3$ per day. It states as follows:

'Sampling and analysis, even once per year, for a whole range of parameters that are unlikely to be present in small private water supplies is not an effective use of resources. Therefore, the EPA recommends that for each of these small supplies the WSA, in consultation with the private water supplier, carries out a risk assessment, taking into account the nature of the catchment, the activities in the catchment and any treatment provided to decide whether any of the parameters are likely to be present in the supply.

'For audit monitoring of private water supplies between $10m^3$ and $100m^3$ per day, the WSA should monitor any parameters identified in the risk assessment that are not included in the check monitoring at a frequency of 2 per year (in other words add them to the list of check monitoring parameters).'

What this means, in effect, is that where there is a history of nitrates exceedances in a supply (for example) then that supply is likely to be sampled for nitrates as one of the check monitoring parameters, even though for larger schemes it is an audit monitoring parameter only.

Table A Microbiological Parameters

1. Escherichia coli (*E.coli*) Max. allowed: 0/100 ml Check & Audit

What are *E.coli*? These are bacteria found in large numbers in the faeces of humans and other warm-blooded animals. Following consumption, they make themselves at home in the intestine. While not all faecal bacteria will be harmful, their detection may indicate the presence of additional bacteria, viruses and parasites that can cause serious illness.

Are they in the source? *E.coli* are likely to be in any surface source where animals (including wildlife) stand in water along the catchment, where there are poor land-spreading or farmyard management practices, or where wastewater treatment facilities are inadequate (e.g. poorly operating septic tanks/municipal wastewater treatment systems). They may also be present in groundwater supplies where the natural filtration processes are inadequate (e.g. where thin soil cover, fractured rock or karst features, or poor protection around a well provide a pathway for faecal material to enter the water body).

Is it a major issue for Irish water suppliers? Yes. Non-compliance with the *E.coli* parameter has been unacceptable for many years past, especially on privately-sourced group water schemes. On the positive side, the level of non-compliance has fallen consistently in recent years – from 31.4% (184 schemes) in 2007 to 17% (84 schemes) in 2009. On publicly-sourced group water schemes 1.8% (14 schemes) had *E. coli* failures in 2007, but just .8% (1 scheme) failed in 2009.

What does an *E.coli* non-compliance tell us? It suggests faecal pollution of a source, an inadequate or malfunctioning disinfection system, or the contamination of water in the pipe network (e.g. through backflow from a contaminated source).

What risk do they pose? The scale of the risk will vary, depending on the concentration of bacteria, viruses and parasites in the faeces that has entered a water supply. Various strains of *E.coli* pose a range of health risks, including gastroenteritis, dysentery, diarrhoea and a cholera-like syndrome. Enterohaemorrhagic *E. coli* – including the O157 strain found in Irish water supplies in recent years – can cause illnesses ranging from mild diarrhoea to haemorrhagic colitis. Infants and the immuno-compromised are at a particular risk from *E.coli* contamination.

What to check? Source protection measures must be in place to prevent the entry of faecal matter into your raw water supply and the intake area/well head must be monitored consistently. Check that your disinfection system is working properly. Use meter readings to check that all connecting pipes are accounted for.

Response: Devise and implement a source protection plan and, where necessary, improve intake/well head protection also. Positive consideration should be given to installing an early warning system (e.g. turbidity alarm) and installing automatic shutdown of the intake. Apart from appropriate filtration, duty and stand-by disinfection with automatic switch-over should be installed as standard. Where *E.coli* contamination of a source is a problem, there will almost certainly be a risk of Cryptosporidium also. In such cases a further treatment barrier should be installed, such as UV.
Scouring of the distribution network will certainly be required following detection of *E.coli*. Where the contamination entered the network after the treatment plant, the source of contamination must be located. Install non-return valves at all connections and identify and eliminate any unauthorised connections.

Table A Microbiological Parameters

2. Enterococci **Max. allowed: 0/100 ml** **Audit**

What are enterococci? They are defined as 'chain forming gram-positive cocci', an antibiotic-resistant bacteria found in the faeces of people and many warm-blooded animals. Like other enteric organisms, they breed in the stomach.

Are they in the source? Enterococci are likely to be in any surface source where animals (including wildlife) stand in water along the catchment, where there are poor land-spreading or farmyard management practices, or where wastewater treatment facilities are inadequate (e.g. poorly operating septic tanks/municipal wastewater treatment systems). They may also be present in groundwater supplies where the natural filtration processes are inadequate (e.g. where thin soil cover, fractured rock or karst features provide a pathway for faecal material to enter the water body).

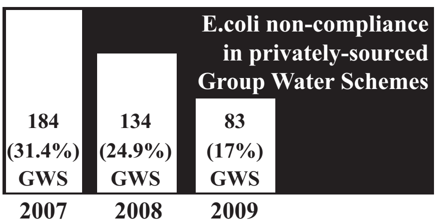
Is it a major issue for Irish water suppliers? Yes, even though the rate of non-compliance in the GWS sector has improved greatly in recent years. In 2007, non-compliance was detected on 46 schemes and this reduced to 18 non-compliant schemes in 2009.

What does their presence tell us? Because they are more resistant to stress and to chlorination than *E. coli* and other coliform bacteria, enterococci serve as a useful indicator of treatment efficiency. Their presence suggests that source protection is inadequate and that the disinfection system may not be working as it should be. An unauthorised connection might also result in faecal contamination of the supply in the distribution network through backflow.

What risk do they pose? Like other bad stomach bugs, they may cause gastroenteritis, diarrhoea etc.

What to check? Check that your disinfection system is working properly. Use meter readings to check that all connecting pipes are accounted for.

Response: Ensure that a source protection plan is put in place to limit (and prevent, if possible) the entry of faecal matter into your raw water supply. To protect against periodic incidents, due to weather conditions or a single pollution incident, positive consideration should be given to the installation of an early warning system, such as a turbidity alarm and/or automatic shutdown of the intake. Apart from filtration, duty and stand-by disinfection with automatic switch-over should be standard in all water treatment facilities. Where the risk of faecal contamination of the source is deemed moderate to high, a further treatment barrier should be installed, such as UV treatment.



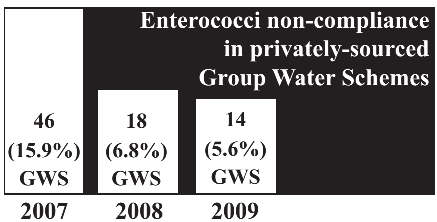


Table B Chemical and Physical Parameters

3. Acrylamide **Max. allowed: 0.10 μg/litre** **Audit**

What is acrylamide? This is a chemical compound [C_3H_5NO]. When its molecules bind together it forms a chain known as polyacrylamide, a synthetic substance that is used in water-based applications including water treatment, sludge treatment, grouting, the manufacture of contact lenses and even the absorbant lining in disposable nappies! Acrylamides form naturally in a variety of foods when cooked at high temperatures.

Is it in the source? Not unless it has infiltrated through seepage from grouting in a well or because sludge from the treatment process has been discharged to a raw water source (where polyacrylamides are used in the sludging agent).

Is it a major issue for Irish water suppliers? No. Because effective testing for acrylamides at a level where they are potentially harmful must be carried out in highly-specialised laboratories, the EPA advises Water Services Authorities not to sample for it unless and until 'a routinely practical method becomes available'. Indeed, acrylamide is one of three parameters (the others being along epichlorohydrin and vinyl chloride) not currently being monitored under the Drinking Water Regulations. The EPA assumes that the standards for these parameters have been met provided that the products (mainly coagulants) that contain them have been approved by the Drinking Water Inspectorate in England and Wales or any equivalent European approval system. Therefore, where care is taken in purchasing treatment chemicals, acrylamide is unlikely to be an issue.

What does an exceedance tell us? Acrylamide in drinking water is most likely telling us that polyacrylamide is being used in the treatment process. Alternatively (although far less likely), it might arise from the use of grouting agents in a water storage tank or well where these contain polyacrylamides. Assuming that no such grouting agent has been used, where acrylamide levels exceed the parametric value, it would suggest that there has been excessive carry over of polyacrylamide from the treatment process and that the chain of the synthetic formation has broken down, so we are left with acrylamide.

What risk does it pose? Acrylamide has been identified as a neurotoxin. Confusion, disorientation, memory disturbances and hallucination have been found in humans, while the International Agency for Research on Cancer has concluded that acrylamide is probably carcinogenic to humans. Having said that, the maximum parametric value under the Drinking Water Regulations [0.10 μg/litre] is well below any level of risk, especially as acrylamide consumed through water consumption is likely to constitute only a tiny proportion of total intake of the chemical from all sources, including the food we eat!

What to check? Check that the products used in water treatment meet the required standard of the Drinking Water Inspectorate in England and Wales, or an equivalent European approval system. Check also that dosing levels are appropriate and that sludge is properly dealt with.

Response: According to the Australian guidelines, acrylamide can be removed from drinking water by adsorption onto granular activated carbon. The World Health Organisation advises that it is best controlled by product and dose specification and this is the approach adopted by our own EPA.

Table B Chemical and Physical Parameters

4. Antimony [Sb] Max. allowed: 5.0 μg/litre Audit

What is antimony? A natural substance, resembling a metal in its appearance and physical properties, its most common form is a hard, extremely brittle, lustrous, silver-white, crystalline material. It is used as a compound in a wide variety of alloys, especially with lead in battery plates and in the manufacture of flame-proofing compounds, paint, semiconductor devices and ceramic products. Antimony-tin solder is reportedly replacing lead solder in plumbing.

Is it in the source? It may be, as it can occur naturally from weathering of rocks, but typically in very low concentrations. The risk would be highest in areas where there has been copper or lead mining and smelting operations.

Is it a major issue for Irish water suppliers? No. In the period 2007-2009, there was 100% compliance with this parameter in 781 samples taken from privately-sourced group water schemes. There was 100% compliance on publicly-sourced group schemes also, but there were a small number of failures on public supplies.

What does an exceedance tell us? Antimony exceedances in drinking water tell us either that the source has naturally high concentrations, or that it is being picked up in the distribution system (perhaps through corrosion of brass fittings and solders). There are two messages from the World Health Organisation on this issue: it states that 'there is no evidence of any significant contribution to drinking-water concentrations from this source [ie. soldering]', while 'the most common source of antimony in drinking water appears to be dissolution from metal plumbing and fittings'. It advises that 'control of antimony from such sources would be by product control'.

What risk dose it pose? Direct evidence of health issues arising from antimony in drinking water is hard to come by. According to the Australian guidelines, the biggest issue arises from antimony dust. Workers exposed to this over many years reported a range of medical conditions, including respiratory and eye problems, as well as staining of the front tooth surface. A dermatitis condition was observed in more than half of the exposed workers. Other studies on the impact of high levels of exposure to antimony showed heart irregularities, lung cancer and spontaneous abortions amongst female workers.
The International Agency for Research on Cancer has concluded that antimony trioxide is probably carcinogenic to humans, but only if inhaled.

What to check? Assuming that your source doesn't exhibit high levels of antimony, check plumbing at the location the exceedance was detected to see if there is any evidence of dissolution of metal plumbing and fittings.

Response: Consult your Water Services Authority to determine the level of risk and the steps that should be taken to deal with the non-compliance.

Table B Chemical and Physical Parameters

5. Arsenic [As] Max. allowed: 10 μg/litre Audit

What is arsenic? This is a naturally-occurring element, widely distributed in the Earth's crust. It can be introduced into water as the minerals and ores in rocks dissolve, or from industrial effluent, atmospheric deposition (through the burning of fossil fuels and waste incineration), drainage from old gold mines, or the use of some types of sheep dip. Natural sources can make a significant contribution to the arsenic concentration in drinking water. Arsenic has many industrial uses and can also be in the food we eat!

Is it in the source? Because of the weathering of rocks, groundwater sources are more likely to show traces of naturally-occurring arsenic than are surface supplies. The concentration will be as low as 0.5 μg/litre. Some countries report very high concentrations, particularly in regions with active volcanoes. The concentration of arsenic in groundwater is often highly dependent on the depth to which a borewell is sunk.

Is it a major issue for Irish water suppliers? No. From 805 samples taken on privately-sourced schemes in the period 2007-2009, two schemes had exceedances in both 2007 and 2008, while there was 100% compliance in 2009. There were no parametric failures on any publicly-sourced GWS in this period, while public supplies had well over 99% compliance.

What does an exceedance tell us? Arsenic exceedances in drinking water tell us either that the source has naturally high concentrations, or that chemical pollution is occurring.

What risk does it pose? Arsenic is recognised by the World Health Organisation as one of the two most serious inorganic contaminants in drinking water on a worldwide basis. Consumption of elevated levels of arsenic through drinking-water is related to the development of cancer of the skin, bladder and lung. In several parts of the world (including south Asia), arsenic-induced disease, including cancer, is a significant public health problem.
The International Agency for Research on Cancer has concluded that arsenic is carcinogenic to humans.

What to check? Schemes with relatively high levels of arsenic (i.e. greater than 1 μg/litre) should establish whether it is as a result of natural processes or may be attributed to some activity in the vicinity of the water source.

Response: Coagulation as part of the treatment process will deal effectively with arsenic. Where there is concern at a consistent rise in the values being recorded, your Water Services Authority will be keen to identify any polluting activity that may be responsible.

6. Benzene **Max. allowed: 1.0 μg/litre** **Audit**

What is benzene? This is a colourless, flammable, liquid aromatic hydrocarbon [C_6H_6], derived from petrol and used to manufacture a wide variety of chemical products, including DDT, detergents, insecticides and motor fuels. The major sources of benzene in water are atmospheric deposition, chemical plant effluent and underground petrol storage tank leakage.
Benzene is made commercially for use by the chemical industry in the production of styrene, phenol and cyclohexane, but its use as a solvent has diminished in recent years.

Is it in the source? You'd hope not! The principal source of benzene is from vehicle emissions that find their way into water. Concentrations of up to 18.0 μg/litre have been detected in chemical plant effluent. Remote and/or well protected sources should be fine, but other sources close to busy roadways etc. may be more exposed.

Is it a major issue for Irish water suppliers? No. Between 2007-2009, no exceedances were recorded on any drinking water supply. Indeed, values in Irish drinking water supplies are typically below the limit of detection (i.e. 0.2 μg/litre).

What does an exceedance tell us? A benzene exceedance in drinking water tells us that the source or the distribution network is susceptible to contamination from a petroleum-based product/chemical effluent.

What risk does it pose? Benzene is highly toxic. It is rapidly absorbed and widely distributed throughout the body and is metabolised predominantly into phenol by the liver, and also by bone marrow. Exposure to high concentrations in air can cause death. Lower concentrations can induce toxic effects, with white blood cells being most sensitive. There is considerable evidence that occupational exposure to low benzene concentrations for periods as short as 12 months may result in leukaemia.
The International Agency for Research on Cancer has concluded that benzene is carcinogenic to humans.

What to check? Schemes should check that water source abstraction points are secure, so that infiltration by petrol or petroleum-based products is prevented. As a simple measure, drainage from roadways should be directed away from any abstraction point and there should be close monitoring of petrol/diesel facilities in the vicinity of any drinking water source.

Response: Benzene concentrations are not reduced significantly by conventional water treatment processes, but according to the Australian guidelines can be efficiently removed from drinking water by the use of granular activated carbon.
Having said that, the best response is to eliminate the source of the contamination with the advice/support of your Water Services Authority.

Table B Chemical and Physical Parameters

7. Benzo(a)pyrene Max. allowed: 0.01 *µg*/litre Audit

What is benzo(a)pyrene? This is a naturally-occurring chemical compound [$C_{20}H_{12}$], found in oil, coal and tar. Based on benzene, it is one of several polycyclic aromatic hydrocarbons [PAHs] and is, perhaps, the nastiest of the lot. This is why it has been designated a parametric value in its own right.

Is it in the source? It certainly shouldn't be, but a source might be at risk where there was activity such as road-tarring or burning of oil-based fuels in the vicinity.

Is it a major issue for Irish water suppliers? No. All privately-sourced and publicly-sourced schemes sampled for this parameter in 2007, tested clear. However, there was one exceedance detected in a privately-sourced GWS in 2008 and a single exceedance on a publicly-sourced GWS and on a public scheme in 2009. Values in Irish drinking water supplies are typically below the level of detection (i.e. 0.003 *µg*/litre).

What does an exceedance tell us? A benzo(a)pyrene exceedance in drinking water tells us either that a contaminated product has been used in the treatment process or, more likely, that the source/distribution network has been polluted.

What risk does it pose? Benzo(a)pyrene is extremely toxic and is carcinogenic to humans. In fact, it was the first chemical carcinogen to be discovered (and is one of many carcinogens found in cigarette smoke)! It was responsible for sooty warts (cancer of the scrotum) suffered by chimney sweeps in bygone days and it has been shown to result in malignant skin tumours. It is also considered an important contributor to emphysemia in smokers as it induces vitamin A deficiency, which is linked to the disease.

What to check? Schemes should check that water source abstraction points as well as the distribution network are secure, so that infiltration by carbon-based fossil fuels and tar is prevented. Schemes should also check that any products used in water treatment processes meet the required standard.

Response: Where treatment products and processes are not the issue, the best response is to identify and eliminate the source of the contamination with the advice/support of your Water Services Authority. Particular attention should be paid to drainage from roads, so that petro/chemical contaminants don't have an easy pathway to a source abstraction point.

Table B Chemical and Physical Parameters

8. Boron [B] Max. allowed: 1.0 mg/litre Audit

What is boron? It is a naturally-occurring element, described as a metalloid (i.e. somewhere between metals and non-metals), some forms of which are more metallic than others. Metallic boron is extremely hard and has a very high melting point. Boron compounds are usually found in sediments and sedimentary rock formations and have a wide range of uses from glass-making and ceramics to cosmetic products, antiseptics, food preservatives, agricultural fertilisers, algicides, herbicides, insecticides and even for tank armour and bullet-proof vests! Boron is naturally present in foods such as fruits, leafy vegetables and nuts.

Is it in the source? It could be, depending on whether or not it is mineralised in local rock formations. There are parts of Ireland where natural boron levels are higher than elsewhere. Boron levels are quite high in seawater and this has implications for schemes using desalinated water or that have a fresh water supply that is influenced by sea water.

Is it a major issue for Irish water supplies? No. There were no exceedances in the boron parameter in any sample taken from Irish drinking water supplies in the three years from 2007-2009. Values here are typically below the limit of detection, although some areas (e.g. parts of Wicklow) recorded up to 0.2 mg/litre, still well below the maximum allowed.

What does an exceedance tell us? Boron exceedances in drinking water tell us either that natural leaching of boron-containing minerals has occurred, or that there has been a contamination incident. The main threat of boron contamination comes from industrial discharges or from detergents in sewage effluent.

What risk does it pose? Gastrointestinal disturbances, skin eruptions and central nervous system stimulation and depression have been reported following the ingestion of high doses of boron. At the same time, low concentrations are thought to have a positive role in the prevention of chronic diseases such as osteoporosis, arthritis and heart disease!

What to check? Find out if there are naturally-occurring high levels in the bedrock that might account for the non-compliance. If not, check that your source is protected from contamination by industrial or wastewater effluent.

Response: Conventional water treatment (coagulation, sedimentation, filtration) does not significantly remove boron. According to the Australian guidelines, boron levels can be reduced by the use of granular activated carbon or by lime softening. Ion exchange and reverse osmosis processes may enable substantial reduction but are likely to be prohibitively expensive. Blending with low-boron supplies may be the only economical method to reduce boron concentrations in waters where concentrations are high.

Table B Chemical and Physical Parameters

9. Bromate Max. allowed: 10 μg/litre Audit

What is bromate? This is a water disinfection byproduct [BrO_3^-] and is not found in nature. In particular, when ozone is used to disinfect drinking water, it reacts with (oxidises) naturally-occurring bromide ions to form bromate. This is the main drawback of using ozonation as a water treatment method. The amount of bromate produced is influenced by the amount of (naturally-occurring) bromide in the water. Bromate linked to sodium or potassium is used in hair-care products (to give you that unnatural wave!) and in some food processing (although it is not considered appropriate for this).

Is it in the source? This is extremely unlikely, but there are documented instances where sources have been contaminated by bromate pollution from an industrial source.

Is it a major issue for Irish water supplies? No. However, it is a parameter that needs to be closely monitored by schemes using ozone treatment. Compliance is generally very high. Three exceedances were found in privately-sourced group water schemes in 2007, none in 2008 and three in 2009. There was 100% compliance on publicly-sourced group schemes in all three years. Five public schemes failed to meet the parametric value in 2009, whereas they had no failures in 2008 and just one in 2007.

What does an exceedance tell us? Bromate exceedances in drinking water suggest that ozone is being used as part of the treatment process and that controls on its use may be inadequate. The World Health Organisation states that bromate may also be formed in concentrated hypochlorite solutions that have been produced by electrolysis of seawater and brines.

What risk does it pose? The International Agency for Research on Cancer has concluded that bromate is possibly carcinogenic to humans.

What to check? If you have an ozone treatment system, check bromide levels in the raw water.

Response: According to the World Heath Organisation, bromate is difficult to remove once formed. However, by appropriate control of disinfection conditions, it is possible to achieve bromate concentrations below 10 μg/litre. Switching to sodium hypochlorite with ultra low bromide content has been successful in reducing bromate exceedances in drinking water.

Note: The EPA advises that disinfection should not be compromised when addressing bromate exceedances.

Table B Chemical and Physical Parameters

10. Cadmium [Cd] Max. allowed: 5.0 μg/litre Audit

What is cadmium? A soft, bluish-white metallic element occurring primarily in zinc, copper and lead ores, cadmium is easily cut with a knife and is used in low-friction, fatigue-resistant alloys, solders, dental amalgams, nickel-cadmium storage batteries, nuclear reactor shields and in rustproof electroplating. Compounds of cadmium are used in pigments, television and computer monitor screens, as pesticides, in photographic applications and analytical chemistry.
Cadmium is released to the environment in wastewater from the above industrial processes.

Is it in the source? As an elementary substance, cadmium is found in certain rocks and soils and in water bodies that flow through these. Cadmium concentrations in non-polluted natural waters are usually lower than 1.0 μg/litre.

Is it a major issue for Irish water supplies? No. There was 100% compliance with this parameter in Irish drinking water supplies sampled between 2007 and 2009.

What does its presence tell us? The presence of cadmium exceedances in drinking water tells us either that source levels are high or that there is a pollutant entering the supply.

What risk does it pose? Long-term exposure to cadmium can cause kidney dysfunction leading to the excretion of protein in the urine. About 10% of the population is estimated to be sensitive to cadmium in this respect. Other effects can include osteomalacia (softening of the bones). Cases of Itai-Itai disease have been reported in Japan among elderly women exposed to highly contaminated food and water. Symptoms are similar to osteomalacia, accompanied by kidney dysfunction characteristic of cadmium poisoning. The International Agency for Research on Cancer has concluded that cadmium is probably carcinogenic to humans

What to check? Find out if there are naturally-occurring high levels in the bedrock that might account for the non-compliance. If not, check that your source is protected from contamination by industrial or wastewater effluent.

Response: Consult with your Water Services Authority in trying to identify and eliminate the source of the contamination. Cadmium can be treated through lime softening or coagulation using ferric.

Table B Chemical and Physical Parameters

11. Chromium [Cr] Max. allowed: 50 μg/litre Audit

What is chromium? A lustrous, hard, metallic element, resistant to tarnish and corrosion, chromium is used in the hardening of steel alloys and the production of stainless steel, in corrosion-resistant decorative platings and as a pigment in paints, dyes and in glass. There are two types of chromium, trivalent and hexavalent. Whereas trivalent chromium is an essential nutrient, with food being the principal source of intake, hexavalent chromium occurs infrequently in nature and has potentially serious health implications. The drinking water parameter measures for total chromium and if the maximum value is exceeded, a separate test is carried out to determine if hexavalent chromium is present.

Is it in the source? Although chromium occurs in nature — as chrome iron ore — it is rarely found in natural waters at levels above 2 μg/litre. Its presence in water is generally the result of industrial and domestic chromium waste discharges or from contaminated land. When released to land, chromium compounds bind to soil and are not likely to migrate to groundwater. If they do get into a water supply, however, they are very persistent as sediments and are likely to build up in aquatic life.

Is it a major issue for Irish water supplies? No. There was 100% compliance with this parameter on all drinking water supplies sampled between 2007-2009.

What does its presence tell us? The presence of chromium exceedances in drinking water suggests that there has been pollution of the source.

What risk does it pose? As already stated, trivalent chromium is essential for human health. The health risks appear to be confined to hexavalent chromium. Short term problems include skin irritation and ulcers. Long-term exposure can damage the liver and kidney. The International Agency for Research on Cancer has concluded that hexavalent chromium is carcinogenic to humans.

What to check? Identify commercial activities in your source catchment that use chromium as part of an industrial process and check that there is safe disposal of effluent from these. As trivalent chromium can be oxidised to hexavalent chromium (the more dangerous form) through disinfection with chlorine, chlorine dioxide and ozone, the extent of naturally-occurring chromium in the raw water should also be checked in the event of a non-compliance.

Response: Where chromium level are high, appropriate treatment will have to be introduced. Chromium can be removed by coagulation/filtration, ion exchange, reverse osmosis and lime softening.

Table B Chemical and Physical Parameters

12. Copper [Cu] Max. allowed: 2.0 mg/litre Audit

What is copper? It is a reddish metal that occurs naturally in rocks, soils, water, sediment, air, plants and animals and is an essential element for all living things. Because it can be easily moulded and shaped, it is widely used in household plumbing materials, the electroplating and chemical industries, electric wiring and in many household goods. Copper sulphate has been used extensively to control the growth of algae in water storage.

Is it in the source? Copper is likely to be present in uncontaminated surface waters at very low concentrations, usually less than 0.01 mg/litre and is generally found at similar levels in groundwaters. Some years ago, it was regularly used in lakes as an algicide and it may have remained in the sediment of lakes treated in this way. Copper mining, smelting operations and municipal incineration would pose a threat to sources.

Is it a major issue for Irish water supplies? No. Of nearly 1,000 samples taken over the 3-year period 2007-2009, there was one failure on a privately-sourced group water scheme in 2007 and again in 2008, and four failures in 2009. Compliance levels on public schemes were also close to 100% in this period.

What does its presence tell us? Corrosion of plumbing material in the distribution network is by far the greatest risk. All water is corrosive toward copper to some degree, but very acidic water (low Ph) or high-carbonate waters with an alkaline pH are particularly corrosive. The threat is greatest where water is standing in the distribution system, thereby increasing its exposure to copper fittings etc. In these circumstances, the concentration of copper can rise substantially, reaching 5.0 mg/litre or higher.

What risk does it pose? Exposure to high levels of copper can cause gastrointestinal disturbance, including nausea and vomiting. Over a long period, water high in copper could cause liver or kidney damage. It is thought that people with Wilson's disease may be more sensitive than others to the effect of copper contamination and should consult their health care provider. Apart from health considerations, concentrations above 1 mg/litre may cause blue or green stains on sanitary ware. Such stains may also be due to slowly leaking taps, where copper corrosion occurs over a long time.

What to check? The copper level in most supplies will be about 0.05 mg/litre. Where an exceedance is detected, check that there hasn't been pollution of the source. Check pH levels on the day the exceedance was detected. Also check plumbing at the house where the exceedance was detected and take samples in neighbouring premises to determine if the problem was particular to one premises or may be more widespread.

Response: Copper is not removed by conventional treatment processes. However, where the problem is caused by corrosion in the pipe network, it can be addressed by adjusting the pH level and then using coagulation followed by filtration. Aggressive water should be stabilised with respect to pH and hardness as part of the treatment process.

Table B Chemical and Physical Parameters

13. Cyanide Max. allowed: 50 μg/litre Audit

What is cyanide? This is a carbon-nitrogen chemical unit [CN] that combines with many organic and inorganic compounds. The most commonly-used form, hydrogen cyanide, is mainly used to make the compounds needed to make nylon and other synthetic fibres and resins. Other cyanides are used as herbicides, or in gold mining. The major cyanide releases to water are discharges from metal finishing industries, iron and steel mills, and organic chemical industries.
Some foods can contain naturally high levels of cyanide.

Is it in the source? Cyanide can be present in source water through the natural decomposition of some plants that synthesise cyanoglycosides or through contamination. It is found at very low concentrations, typically less than 10 μg/litre, in uncontaminated sources. The behaviour of cyanide in water will be controlled by various parameters including pH, trace metal levels, dissolved oxygen and temperature.

Is it a major issue for Irish water supplies? No. There was 100% compliance in the 716 samples taken from privately-sourced group water schemes in the three years 2007-2009. There was also 100% compliance on all public water supplies.

What does its presence tell us? A cyanide exceedance would suggest an industrial spill, or that levels of cyanogen chloride have been generated during the production of chloramines *in situ* for use as a residual disinfectant.

What risk does it pose? There is little or no risk from cyanide at the low levels normally detected in water supplies. However, high levels of cyanide would be very toxic and have been linked to effects on the thyroid gland and the nervous system. The brain is the organ most sensitive to cyanide toxicity. Cyanide may deplete vitamin B12 and result in a deficiency that can cause goitre and cretinism. People most at risk are those with a nutritionally inadequate diet. Death from cyanide poisoning is believed to result from central nervous system depression.
The major source of cyanide exposure for the general population is cigarette smoke.

What to check? As industrial effluents are the main source of cyanide contamination, identify commercial/industrial activities within your source catchment that may be causing pollution. Where chloramination is practised as part of the treatment process, it is important that treatment be optimised to minimise the formation of cyanogen chloride, while maintaining adequate chloramine residuals.

Response: Although low concentrations of cyanide in water sources can occur, this is easily removed through treatment, such as chlorination. Where a contamination incident is suspected, get advice/help from your Water Services Authority.

Table B Chemical and Physical Parameters

14. 1,2-dichloroethane Max. allowed: 3.0 μg/litre Audit

What is 1,2-dichloroethane? This is a clear, chemically-manufactured liquid [$C_2H_4C_{12}$]. It evaporates quickly at room temperature and has a pleasant smell and a sweet taste. The most common use is in the production of vinyl chloride, which is employed in the manufacture of a variety of plastic and vinyl products. These include important construction materials such as polyvinyl chloride (PVC) pipes, but also packaging materials, furniture, car parts, wall coverings and houseware.
1,2-dichloroethane is present in some industrial effluent and has occasionally been found in drinking water supplies elsewhere.

Is it in the source? Contamination of Irish drinking water sources by 1,2-dichloroethane is highly unlikely, except as the result of industrial effluent seeping into a surface water, or seepage from waste sites into a groundwater supply.

Is it a major issue for Irish water supplies? No. All 790 samples taken from privately-sourced group water schemes between 2007-2009 were in compliance with the parametric value, as were all samples taken on public supplies.

What does its presence tell us? The presence of 1,2-dichloroethane exceedances in drinking water suggests that a pollution incident has occurred.

What risk does it pose? Cases of poisoning have occurred in other countries following consumption of high doses of 1,2-dichloroethane. While not all cases have been fatal, death is attributed to circulatory and respiratory failure. According to the EPA, other ill-effects include eye damage, dermatitis and narcotic effects.
The International Agency for Research on Cancer has concluded that 1,2-dichloroethane is possibly carcinogenic to humans.

What to check? Check that piping used in the distribution network meets the required standard and that effluent from any industrial process/waste facility in the vicinity of your raw water source is properly disposed of.

Response: The concentration of 1,2-dichloroethane in drinking water can be reduced by the use of granular activated carbon in combination with packed tower aeration (a treatment process whereby water is mixed with air to remove volatile organic chemicals and dissolved gases).

Table B Chemical and Physical Parameters

15. Epichlorohydrin Max. allowed: 0.10 μg/litre Audit

What is epichlorohydrin? This is a colourless, flammable liquid [C_3H_5ClO], with a pungent, garlic-like smell. It is insoluble in water. Epichlorohydrin is used as a building block in the manufacture of plastics, epoxy resins, phenoxy resins and other polymers, some of which are used in water treatment as a flocculating agent or in the lining of pipes and other water retaining structures. According to the United States EPA, the maximum residual epichlorohydrin content in flocculating agent should not exceed 0.01%.

Is it in the source? No, unless through industrial pollution.

Is it a major issue for Irish water supplies? No. Epichlorohydrin is one of three parameters (the others being along acrylamide and vinyl chloride) not currently being monitored under the Drinking Water Regulations. The EPA assumes that the standards for these parameters have been met provided that the products (mainly coagulants) that contain them have been approved by the Drinking Water Inspectorate in England and Wales or any equivalent European approval system. Therefore, where care is taken in purchasing treatment chemicals, epichlorohydrin is unlikely to be an issue.

What does its presence tell us? The presence of epichlorohydrin exceedances in drinking water suggests that the flocculant used in the treatment process is not fit for purpose.

What risk does it pose? Epichlorohydrin is toxic. Skin contact can cause initial redness, itching, or a burning sensation. The initial effects of inhalation are similar and can be followed by vomiting and severe headache. Long-term exposure can cause kidney and liver damage.
The International Agency for Research on Cancer has concluded that epichlorohydrin is probably carcinogenic to humans.

What to check? Check that coagulants used in the treatment process meet the required standard of the Drinking Water Inspectorate in England and Wales or any equivalent European approval system. Check also that dosing levels are appropriate. Competent technical advice should be considered in relation to both issues.

Response: Conventional treatment processes do not remove epichlorohydrin. Epichlorohydrin concentrations in drinking water are controlled by limiting either the content of the substance in polyamine flocculants or the dose used, or both. Where you have concerns about these issues, ask your Water Services Authority for advice/support.

Table B Chemical and Physical Parameters

16. Fluoride Max. allowed: 0.8 mg/litre* Audit

What is flouride? Fluoride compounds are salts that form naturally when the element, fluorine [F] combines with minerals in soil or rocks. They are also formed as a by-product of industrial processes. Public water supplies in Ireland and in many other countries add fluoride, through the dosing of Hexafluorophosphoric acid (F_6HP), to drinking water to reduce cavities in teeth. It is also used in toothpaste, as an insecticide and as a disinfectant.

Is it in the source? It may be, although the amount will depend on the extent to which it is mineralised in local soils and rocks. Generally, concentrations in surface water are relatively low (<0.1-0.5 mg/litre), while water from deeper wells may have quite high concentrations (1-10 mg/litre) if the rock formations are fluoride-rich. Fluoride can also enter drinking water sources as a by-product of the spreading of phosphate fertilisers (which contain 4% flourine), or as effluent from industry.

Is it a major issue for Irish water supplies? No. It is not a major issue for privately-sourced group water schemes, as these aren't fluoridated. There was almost 100% compliance in the 928 samples taken from privately-sourced schemes in the three-year period 2007-2009: five schemes had exceedances in 2007, four in 2008. Two exceedances were returned for 2009, but this was an error as both schemes (in Westmeath) were, in fact, publicly-sourced. By contrast, compliance on publicly-sourced group schemes ranged from 80% in 2007 to 95.9% in 2008 and 93.6% in 2009, reflecting the rates of compliance in public schemes.

What does its presence tell us? Flouride exceedances in privately-sourced schemes drinking water tells us that the source has naturally-occurring high levels. In publicly-sourced group water schemes, an exceedance suggests that the dosing regime in the parent scheme needs to be improved.

What risk does it pose? There is general agreement that while some fluoride is helpful to dental health, fluoride consumption may give rise to mild dental fluorosis [mottling of teeth] at drinking-water concentrations between 0.9 and 1.2 mg/litre, depending on intake. This is why the standard (where fluoridation is being used) has been reduced from 1.5 mg/litre to 0.8 mg/litre. Elevated fluoride intake can also have more serious effects on bone tissue.

What to check? Check that raw water fluoride levels are within the parametric value allowed (1.5 mg/litre).

Response: Where fluoride occurs naturally in a borewell source, levels will be substantially reduced through dilution with a surface water supply. Where this is not an option, distillation and reverse osmosis are methods of reducing fluoride to less than 4 mg/litre (the US standard), but this is still well above the standard required in Europe. The Australian guidelines state that fluoride levels may be reduced using activated alumina or bone char. For publicly-sourced schemes, in particular, contact should be made with your Water Services Authority to ascertain the cause of the non-compliance and the proposed solution.

*The maximum allowed for naturally-occurring fluoride is 1.5 mg/litre.

Table B Chemical and Physical Parameters

17. Lead [Pb] Max. allowed: 25 μg/litre* Audit

What is lead? An elementary substance, lead is the most common of the heavy metals and is mined widely throughout the world. It is used in the production of lead acid batteries, solder, alloys, cable sheathing, paint pigments, rust inhibitors, ammunition, glazes and plastic stabilisers. Lead compounds are used extensively as lubricating compounds in petrol.
Drinking water concentrations of lead are usually less than 2 μg/litre, but where lead pipes are used in conjunction with soft, acidic water, concentrations of 100 μg/litre have been detected. Approximately 80% of the daily intake of lead is from the ingestion of food, dirt and dust.

Is it in the source? Yes, as an element found in rocks and soil worldwide, there will be trace elements of lead in most sources, particularly groundwaters.

Is it a major issue for Irish water supplies? No. Privately-sourced GWS supplies recorded 100% compliance in the years 2007-2008, although a single non-compliance was recorded in 2009. On publicly-sourced schemes, a single non-compliance was recorded in both 2007 and in 2008, while there were no exceedances in 2009. The problem is more significant on public supplies due to older plumbing systems.

What does its presence tell us? Lead is rarely present in tap water as a result of its dissolution from natural sources; rather, its presence is primarily from household plumbing systems containing lead in pipes, solder, fittings, or the service connections to homes. The amount of lead dissolved from the plumbing system depends on several factors, including pH, temperature, water hardness and standing time of the water. Soft, acidic water is the most plumbosolvent.

What risk does it pose? Lead is a cumulative poison that can severely affect the central nervous system. Infants, fetuses and pregnant women are most susceptible. Exposure to lead can adversely affect intelligence. Other adverse effects associated with exposure to high amounts of lead include kidney damage, interference with the production of red blood cells and interference with the metabolism of calcium needed for bone formation.
The International Agency for Research on Cancer has concluded that lead is possibly carcinogenic to humans.

What to check? Group schemes should check if any lead pipes were used during construction of their scheme and if they might have been householders should be encouraged to replace lead service pipes.

Response: Lead concentrations can be reduced using coagulation and through lime softening. The best response, however, is to replace lead pipes and fittings.

* The maximum allowed from 25 December 2013 is 10 μg/litre.

Table B Chemical and Physical Parameters

18. Mercury [Hg] Max. allowed: 1.0 μg/litre Audit

What is mercury? A silvery-white poisonous metallic element, liquid at room temperature, mercury (also called quicksilver) is occasionally found free in nature (organic) but usually occurs as a red sulfide ore (inorganic).
A good conductor of electricity, mercury has many applications including its use in thermometers, barometers, fluorescent light bulbs and batteries and in the preparation of medicines and pesticides. It is also used in the electrolytic production of chlorine.
The major sources of mercury in drinking water are erosion of natural deposits, discharge from refineries and factories, run-off from landfills and run-off from croplands. Food is the main route of exposure, with highest concentrations found in fish and fish products.

Is it in the source? Yes. Mercury is present in its organic form in surface water and groundwater, generally at concentrations below 0.5 μg/litre, although local mineral deposits may produce higher levels in groundwater.

Is it a major issue for Irish water supplies? No. There has been 100% compliance on both privately-sourced and publicly-sourced group water schemes in the years 2007-2009.

What does its presence tell us? The guideline value applies to inorganic mercury. The presence of inorganic mercury in drinking water indicates pollution of the source.

What risk does it pose? Mercury is a dangerous pollutant. associated with kidney damage and with haemorrhagic gastritis and colitis.

What to check? Ensure that the source is protected from potential sources of contamination.

Response: According to the World Heath Organisation, it should be possible to achieve a concentration below 1 μg/litre by treatment of raw waters that are not grossly contaminated with mercury using methods that include coagulation/sedimentation/filtration, PAC and ion exchange.

Table B   Chemical and Physical Parameters

19. Nickel [Ni]   Max. allowed: 20 μg/litre   Audit

What is nickel? This is a silvery-white metallic chemical element that takes on a high polish. It has been used in coins, for plating iron, brass, etc., in certain alloys and in the production of stainless steel. It is present in foods, especially cocoa, soy beans and some cereals.

Is it in the source? Yes. There will be a trace element of nickel in most supplies, depending on the concentration of nickel in local rock formations etc. Naturally-occurring nickel in water supplies is usually less than 10 μg/litre. However, raw water can be contaminated by diffuse nickel emissions from power plants, waste incinerators and metal industries, while discharge to surface waters from various industries can also be problematic.

Is it a major issue for Irish water supplies? No. Although there were five nickel exceedances on public water supplies in 2007, there was 100% compliance with this parameter in the GWS sector, both privately-sourced and publicly-sourced.

What does its presence tell us? The World Health Organisation advises that '*where there is heavy pollution, where there are areas in which nickel that naturally occurs in groundwater is mobilised, or where there is use of certain types of kettles, of non-resistant material in wells or of water that has come into contact with nickel- or chromium-plated taps, the nickel contribution from water may be significant*'. Nickel exceedances in drinking water most likely point to a supply that has been in prolonged contact with nickel-plated plumbing fittings, rather than to a problem at source. According to the Australian guidelines, levels as high as 500 μg/litre have been detected where water reacts to plumbing fittings.

What risk does it pose? Long-term exposure may result in toxic effects to the kidney. Nickel is known to be a common skin allergen and can cause dermatitis, particularly in younger women. Several studies have demonstrated that inhalation of nickel can cause lung, sinus and nasal cancer. There is no evidence that other organs are affected, nor that nickel is carcinogenic when ingested. Having said that, metallic nickel is possibly carcinogenic and is listed as such by the International Agency for Research on Cancer.

What to check? Ascertain (from previous sampling returns, if possible) that nickel levels in your raw water supply are ok. Assuming this is so, you can be reasonably certain that any exceedance is as a result of a problem with internal plumbing at the sampling point.

Response: Where the problem lies in the plumbing system, flushing the taps before use will help. Advice should be given to replace problematic fittings. Conventional coagulation will reduce nickel, as will the use of iron and manganese oxides. For naturally-occurring nickel in groundwater, removal is by ion exchange or adsorption.

Table B   Chemical and Physical Parameters

20. Nitrate   Max. allowed: 50 mg/litre   Audit

What is nitrate? This is a chemical unit [NO_3], combining nitrogen [N] with oxygen [O]. Nitrate, in turn, combines with various organic and inorganic compounds. Naturally-occurring soil nitrates are essential for plant growth. Nitrates will also occur naturally in compost and in wastewater treatment systems. Natural levels of nitrates in soil are increased by the use of nitrogen-based inorganic fertilisers, a portion of which aren't taken up by plants and may instead leach into groundwater supplies over time. Apart from their use in fertilisers, nitrates are used in explosives.
Food, particularly vegetables and cured meat, is the major source of nitrate intake for humans. Once it enters the human body, nitrate is converted to nitrite.

Is it in the source? Yes, but naturally-occurring nitrates don't normally cause a problem as levels are typically well under 2 mg/litre. Groundwater sources (particularly shallow wells) are particularly vulnerable to contamination from nitrates in fertilisers and sewage. They are found especially in free-draining tillage lands. While there are relatively few exceedances of the parametric value in drinking water, many schemes have relatively high (i.e. in excess of 30 mg/litre) nitrates levels in their raw waters. Given that nitrate contamination in groundwater can occur long after the pollution activity, the full scale of the nitrate problem may not emerge for some time to come.

Is it a major issue for Irish water supplies? Yes. In some areas it is a problem, particularly for those schemes relying on shallow wells in areas of intensive farming, or where there is vulnerability to effluent from septic tanks or public wastewater facilities.

What does its presence tell us? The presence of nitrates (especially where a consistent rise in amounts is detected) tells us that the source is being polluted.

What risk does it pose? Nitrate is only a risk because it changes to nitrite in the human body. Infants below six months who drink water containing nitrate/nitrite could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue baby syndrome.

What to check? Take raw water samples and check that levels of nitrate are stable, or are reducing. Where levels are rising, action should be taken. Where an exceedance is recorded, appropriate treatment will have to be introduced, in addition to taking source protection measures. Check that effluent from individual wastewater treatment systems and public wastewater supplies is being effectively dealt with.

Response: Where an exceedance in the parametric value for nitrate is detected, consumers must be informed immediately, in particular those caring for infants under 3 months. These must be advised to use an alternative source of water for bottle feeds. Nitrate treatment is costly. Ion exchange, reverse osmosis and electrodialysis are shown to reduce nitrate levels to below 10 mg/litre. A long-term source protection strategy should be devised and implemented.

Table B Chemical and Physical Parameters

21. Nitrite Max. allowed: 0.50 mg/litre Check or Audit*

What is nitrite? Like nitrate, nitrite [NO_2] is part of what is called the nitrogen cycle and is described by the EPA as 'an intermediate in the oxidation of ammonia to nitrate'. Anaerobic conditions (i.e. where there is little or no oxygen) may result in the formation and persistence of nitrite. Chloramination may give rise to the formation of nitrite within the distribution system if the formation of chloramine is not sufficiently controlled. The formation of nitrite is as a consequence of microbial activity and may be intermittent. Nitrification in distribution systems can increase nitrite levels, usually by 0.2–1.5 mg/litre.

Is it in the source? Possibly, where anaerobic conditions exist and there has been pollution by ammonia or nitrates.

Is it a major issue for Irish water supplies? No. This parameter is checked at the water treatment plant and at the taps of consumers. The allowable level at the treatment plant is 0.1 mg/litre. Between 2007 and 2009, samples were taken at ten water treatment plants supplying privately-sourced group schemes and there was 100% compliance. Extensive testing at consumers' taps showed only one exceedance in the years 2007 and 2009, with two in 2008. Compliance on publicly-sourced group schemes was similarly very high, at almost 100%.

What does its presence tell us? The presence of nitrite tells us that the supply has been polluted.

What risk does it pose? Nitrite is 10 times more potent than nitrate, with respect to blue baby syndrome. Long-term exposure to nitrite induced morphological changes in the adrenals, heart and lungs in laboratory animal studies.

What to check? All water systems that practice chloramination should closely and regularly monitor their systems to verify disinfection efficiency, microbiological quality and nitrite levels. Nitrite is rapidly oxidised to nitrate and is seldom present in well oxygenated or chlorinated supplies.

Response: If nitrification is detected (e.g. reduced disinfectant residuals and increased nitrite levels), steps should be taken to modify the treatment or water chemistry in order to maintain a safe water quality. At the very least, the water needs to be oxygenated. Nitrite levels of 0.1 mg/litre should be achievable using chlorination (to form nitrate).

* This parameter needs to be measured as part of check monitoring only where chloramination is used as a disinfectant. Otherwise, it must be included as part of audit monitoring.

Table B Chemical and Physical Parameters

22. Pesticides Max. allowed: 0.10 μg/litre Audit

What are pesticides? This term includes a wide range of chemicals used for the control of pests. According to the Drinking Water Regulations, this will include organic insecticides, herbicides, fungicides, nematocides, acaricides, algicides, rodenticides, slimicides, heptachlore and heptachlore epoxide and related products and their relevant metabolites, degradation and reaction products. As the toxic nature of some pesticides and insecticides became clear in the 1970s, they were withdrawn from use, but they have proved very resilient in the environment. The parametric value above is given for an individual pesticide, but depending on how toxic they are, the levels might be even lower in some cases [see below].

Are they in the source? Hopefully not, but there may have been some run-off from weed control on hard surfaces, gardening, agriculture or forestry.

Are they a major issue for Irish water supplies? No. Privately-sourced and publicly-sourced group water schemes were 100% compliant in the years 2007-2009. However, there *is* evidence of herbicides in drinking water supplies in some counties. Particular care is needed when controlling weeds in and around water services infrastructure, including sources, water treatment plants, reservoirs, meter boxes and valves.

What does their presence tell us? The presence of an individual pesticide at levels exceeding the maximum value tells us that there may have been careless or excessive use of a product in the source catchment or in the vicinity of (treated) water retaining infrastructure.

What risk do they pose? This will depend on what chemical is in question. The EPA states that where a pesticide is detected above the maximum allowed an analysis will have to be carried out to detemine the chemicals involved and the extent to which they are toxic. In the case of aldrin, dieldrin, heptachlor epoxide, the parameteric value is 0.030 μg/litre. Aldrin and dieldrin were widely used in agriculture in the 1970s, but their use has stopped. Similarly, heptachlor – from which heptachlor epoxide comes – was a broad spectrum insecticide but was withdrawn from use because it proved acutely neurotoxic at high doses and was judged to be carcinogenic by the International Agency for Research on Cancer. The highest incidences of pesticide exceedances encountered in Ireland's drinking water is MCPA (2-methyl-4-chlorophenoxyacetic acid), a commonly-used herbicide present in many products used to control thistle, dock and rush.

What to check? Check that a robust source protection plan is implemented and that information to the public (and to GWS operational staff) emphasises the potential dangers of pesticides to a drinking water supply.

Response: If detected, remedial action should be taken to stop contamination. Contact your Water Services Authority for advice. Granular activated carbon is probably the most effective treatment for pesticides.

Table B Chemical and Physical Parameters

23. Pesticides – Total Max. allowed: 0.50 *μg*/litre Audit

What is meant by pesticides-total? This parameter is simply the combined total for all individual pesticides found in a water supply.

Are they in the source? Hopefully not, but there may have been some run-off from weed control on hard surfaces, gardening, agriculture or forestry.

Are they a major issue for Irish water supplies? No. There was one exceedance across 261 privately-sourced schemes tested in 2007, with 100% compliance for both privately-sourced and publicly-sourced schemes in the years 2008 and 2009. However, there is evidence of herbicides in drinking water supplies in some counties. Particular care is needed when controlling weeds in and around water services infrastructure, including sources, water treatment plants, reservoirs, meter boxes and valves.

What does their presence tell us? The presence of an individual pesticide at levels exceeding the maximum value tells us that there may have been careless or excessive use of a product in the source catchment or in the vicinity of (treated) water retaining infrastructure.

What risk do they pose? Some pesticides have been found to be toxic. The International Agency for Research on Cancer has concluded that some are possibly carcinogenic.

What to check? Check that a robust source protection plan is implemented and that information to the public (and to GWS operational staff) emphasises the potential dangers of pesticides to a drinking water supply.

Response: If detected, remedial action should be taken to stop contamination. Contact your Water Services Authority for advice. Granular activated carbon is probably the most effective treatment for pesticides.

Table B Chemical and Physical Parameters

24. Polycyclic Aromatic Hydrocarbons Max. allowed: 0.1 μg/litre Audit

What are polycyclic aromatic hydrocarbons [PAH]? These are defined as 'a group of organic compounds containing two or more fused aromatic rings of carbon and hydrogen atoms'. Apart from benzo(a)pyrene – which is a parameter in its own right – the EPA explains that four hydrocarbons are considered under the Drinking Water Regulations: benzo(b)fluoranthene, benzo(k)flouranthene, benzo(ghi)perylene and indeno(1,2,3-cd)pyrene. The maximum value allowed is the sum of all four.
Natural crude oil and coal deposits contain significant amounts of PAHs. They are also found in processed fossil fuels, tar and various edible oils.
PAHs are one of the most widespread organic pollutants. In addition to their presence in fossil fuels, they are formed by incomplete combustion of carbon-containing fuels such as wood, coal, diesel, fat, tobacco and incense.
Food is the major source of intake of PAHs. Highest concentrations occur in smoked foods, leafy vegetables and the burnt fat of meats.

Are they in the source? Hopefully not. Unless there has been a contamination incident, sources should not show any PAHs.

Are they a major issue for Irish water supplies? No. Privately-sourced and publicly-sourced schemes have achieved close to 100% compliance with this parameter in the three years 2007-2009, with just one privately-sourced GWS failing in 2009.

What does their presence tell us? PAH exceedances in water suggest that a carbon-based pollution incident has occurred, possibly because of contamination of the source, a rogue batch of chemicals used in treatment, or because of infiltration following treatment.

What risk do they pose? The International Agency for Research on Cancer has concluded that PAHs are probably carcinogenic, but the level of health risk varies from one PAH to another.

What to check? Check that there is no activitiy in the vicinity of the source that might lead to PAH contamination (e.g. lighting of bonfires]. Ensure that chemicals used in water treatment come from a reliable source and that they meet the required standard. Check that the distribution network is secure, particularly where works are being carried out.

Response: According to the Australian guidelines, coagulation, settling and filtration would significantly reduce the level of PAH contamination of a raw water source, as would granular activated carbon.

25. Selenium [Se] Max. allowed: 10 μg/litre Audit

What is selenium? A nonmetallic element, red in powder form, black in vitreous form and metallic gray in crystalline form, selenium and selenium salts are widespread in the Earth's crust, often in association with sulphur-containing minerals. Selenium is released from natural and human-made sources, with the main source being the burning of coal. The major use of selenium is in the manufacture of electronic components and in photography. Selenium compounds are used in some insecticides, in hair shampoos (as an anti-dandruff agent) and as a nutritional feed additive for poultry and livestock.
Cereal and grain products contribute most to intake, while fish and liver contain the highest selenium concentrations.

Is it in the source? As with any elementary substance, there is likely to be some trace of selenium in sources, but this will be very slight in surface waters where levels will generally be much less than the guideline value. However, groundwater concentrations as high as 6,000 μg/litre have been reported in the United States. Concentrations in the source will be accounted for by the level of the selenium in local soil and rocks, by pH and by the presence of iron salts.

Is it a major issue for Irish water supplies? No. There has been 100% compliance with this parameter across all drinking water supplies in the years 2007-2009.

What does its presence tell us? The presence of selenium in drinking water tells us that the source has been contaminated, either naturally or through an industrial effluent spill.

What risk does it pose? Selenium is a trace element in humans, so some of it is necessary and it is, in fact, good for the heart. It is toxic, however, and there have been ill effects attributed to short- and long-term exposure. Intakes above about 1,000 μg/day over prolonged periods may produce nail and hair deformities. Other features of excessive selenium intake include symptoms such as gastrointestinal disturbances, dermatitis, dizziness, lassitude and a garlic odour to the breath.

What to check? Check that raw water levels of selenium are low, particularly if the source is in the vicinity of an industrial operation.

Response: Selenium concentrations in drinking water can be reduced by coagulation with ferric chloride and by lime softening. Coagulation with alum is much less effective. Activated alumina absorption is the most effective means of treatment, but only at low pH.

Table B Chemical and Physical Parameters

26. Tetrachloroethene & Trichloroethane Max. allowed: 10 μg/litre* Audit

What are tetrachloroethene & trichloroethane? Tetrachloroethene [C_2Cl_4] is a colourless, nonflammable organic liquid used in dry-cleaning solutions, as an industrial solvent and as an agent for expelling or destroying parasitic intestinal worms. Trichloroethane [C_2HCL_3] is a heavy, colourless, toxic liquid used to degrease metals, to extract oil from nuts and fruit, as a refrigerant, in dry cleaning, and as a fumigant. It is also known as trichloroethylene (TCE).
Poor handling as well as improper disposal of these chemicals have been the main causes of source water contamination. Tetrachloroethene in anaerobic groundwater may degrade to more toxic compounds, including vinyl chloride.

Are they in the source? Levels of tetrachloroethene in surface water are generally below 3 μg/litre, while trichloroethane is normally less than 1μg/litre. Seepage from landfill or from a spill could lead to higher levels in groundwater sources.

Are they a major issue for Irish water supplies? No. There have been no exceedances of this parameter in Irish drinking water supplies in the years 2007-2009.

What do their presence tell us? The presence of these chemicals in water suggests that an industrial effluent is getting into your raw water supply.

What risk do they pose? At high concentrations, tetrachloroethene causes central nervous system depression. Lower concentrations have been reported to damage the liver and the kidneys. The International Agency for Research on Cancer has concluded that trichloroethane is probably carcinogenic.

What to check? Where there is a nearby landfill, carry out occasional monitoring for these parameters.

Response: Tetrachloroethene can be removed from drinking water by adsorption onto granular activated carbon or by aeration. Trichloroethane can be removed by aeration, or by adsorption onto granular activated carbon.

*The parametric value relates to the sum total of tetrachloroethene and trichloroethane in a supply.

Table B Chemical and Physical Parameters

27. Trihalomethanes [THMs] Max. allowed: 100 μg/litre Audit

What are THMs? These are chemical compounds formed during the water disinfection process when chlorine [Cl] or bromine [Br] combine with carbon [C] and hydrogen [H]. The term trihalomethanes is applied to four such compounds: chloroform ($CHCl_3$], bromodichloromethane [$CHBrCl_2$], dibromochloromethane [$CHBr_2Cl$] and bromoform [$CHBr_3$]. Chloroform is the most common THM.
What happens in the making of the THM compounds is that three of the hydrogen atoms are substituted by the halogen atoms, chlorine [Cl_2] or bromine (Br_2].
THMs are liable to form where chlorine reacts with organic molecules in water. If there is naturally-occuring bromide in the water, the chlorine will oxidise this to form bromine and this will also react with organic molecules.
As the EPA states, 'there is a fairly straightforward relationship between the degree of colour in water prior to chlorination and the quantity of THMs present following chlorination'.

Is it in the source? No, but a highly coloured source (including most surface waters) will be susceptible to THMs following disinfection.

Is it a major issue for Irish water supplies? Yes. THMs are an issue for surface water supplies and for groundwater supplies influenced by surface waters. Compliance has been poor in recent years, especially as the parametric value was lowered from 150 μg/litre to the present value in December 2008. In 2007, only five privately-sourced schemes failed to meet the parametric value, but this rose to twenty-three schemes in 2009. Two publicly-sourced schemes recorded non-compliances in 2007, but 27 failed in 2009. On public supplies, failures to meet the parametric value also increased, from 23 to 105 schemes!

What does its presence tell us? The presence of THMs tells us that a treatment system needs to be introduced/adjusted to reduce colour.

What risk do THMs pose? Trihalomethanes are central nervous system depressants and liver and kidney toxicants. Chloroform and bromoform are also known to cause central nervous system depression in humans. The International Agency for Research on Cancer has concluded that chloroform is possibly carcinogenic.
They are most likely to enter the body either by drinking water high in THMs or by breathing them in while showering or bathing. Indoor air exposure is particularly important in countries with low rates of ventilation in houses and high rates of showering and bathing.

What to check? Check colour levels following the filtration process. Check that chemicals being used in treatment aren't contributing to the problem. Seek technical advice.

Response: The concentration of THMs can be minimised by removing colour from raw water, by removing THMs after formation, or by using alternative disinfectants. Activated carbon, coagulation followed by filtration, or oxidation with ozone or potassium permanganate are means of reducing colour. THMs can be removed from chlorinated water by adsorption onto granular activated carbon. Alternative disinfection agents to chlorine (such as chloramines, ozone and chlorine dioxide), can substantially reduce trihalomethane concentrations, but may produce other by-products.

Note: Do not compromise disinfection, even where formation of THMs is a possibility.

Table B Chemical and Physical Parameters

28. Vinyl Chloride Max. allowed: 0.50 μg/litre Audit

What is vinyl chloride? Vinyl chloride is a colourless, organic gas with a sweet smell. It is used industrially in the production of poly vinyl chloride (PVC), which has wide application in the plastics, rubber, paper and glass industries.
The main source of vinyl chloride in drinking water is likely to be leaching from unplasticised (uPVC) piping and discharge from plastics factories. Water bottled and stored for long periods in PVC containers may contain very low concentrations of vinyl chloride. It has occasionally been detected in drinking water supplies in the United States and Germany that use uPVC pipes, with a maximum reported concentration of 10 μg/litre.

Is it in the source? Not unless there has been an industrial spill.

Is it a major issue for Irish water supplies? No. Vinyl chloride is one of three parameters (the others being along acrylamide and epichlorohydrin) not currently being monitored under the Drinking Water Regulations. The EPA assumes that the standards for these parameters have been met provided that the products that contain them have been approved by the Drinking Water Inspectorate in England and Wales or any equivalent European approval system. Therefore, where care is taken in purchasing water pipes, vinyl chloride is unlikely to be an issue.
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What does its presence tell us? Assuming that there have been no industrial spills that might account for it, the presence of vinyl chloride exceedances in drinking water tells us that there may be an issue with pipes in the distribution network.

What risk does it pose? Vinyl chloride is a narcotic agent and is a well-documented human carcinogen, with inhalation of high concentrations causing tumours in the liver, particularly angiosarcoma. Tumours in the brain and lung and malignancies of the lymphatic and haematopoietic tissues have also been reported. The International Agency for Research on Cancer has concluded that vinyl chloride is carcinogenic.

What to check? Check that products used in the distribution network (including pipes) meet the required standard.

Response: There are no published reports on methods for the removal of vinyl chloride from drinking water.

Table C Indicator Parameters

29. Aluminium [Al] Max. allowed: 200 μg/litre Check or Audit*

What is aluminium? It is the most abundant metallic element, constituting about 8% of the Earth's crust. Aluminium trihydroxide reacts with sulphuric acid to produce alum, used in water treatment as a coagulant to remove organic matter, colour, turbidity and micro-organisms. Carry-over from the treatment process may lead to increased concentrations of aluminium in finished water. Aluminium residuals can cause floc to form in the distribution system, leading to complaints because of undesirable colour and turbidity.

Is it in the source? There will be trace elements in any water source, generally less than 5 μg/litre in groundwater sources and less than 10 μg/litre in surface waters. According to Tworts, run-off from newly afforested areas can increase aluminium levels at source.

Is it a major issue for Irish water supplies? Yes. The parametric value is frequently exceeded on schemes with surface water supplies and using alum as a coagulant. However, compliance on privately-sourced group schemes has been relatively high and has improved in recent years, from 93.4% in 2007 to 95.6% in 2009. On publicly-sourced group schemes, more than 10% of schemes monitored were non-compliant in these three years.

What does its presence tell us? Aluminium exceedances tell us that there is a problem with the dosing of the alum coagulant used in water treatment.

What risk does it pose? According to the EPA, high aluminium intake poses a risk to people with kidney disorders and it causes neurological problems. The World Health Organisation states that a relationship between aluminium in drinking water and Alzheimer's disease 'cannot be totally discounted', but adds that it has strong reservations about inferring a causal relationship.

What to check? Ensure that the coagulant being used meets the required standard. Check that alum dosing levels are appropriate to the raw water quality and are capable of adjustment to deal with variations in the source (e.g following a storm event). Residual aluminium going into the supply after treatment should be less than 50 μg/litre.

Response: Where an aluminium exceedance occurs, the reason for it should be investigated and steps taken to prevent a reoccurrence. Where there are persistent exceedances, this should be discussed with your client's representative/service provider to assess if current treatment processes are adequate to deal with raw water variations. To properly understand problems with alum dosing, technical advice will be required. This will take into account such variables as turbidity, pH, temperature and dissolved oxygen. By using optimum pH in the coagulation process, avoiding excessive aluminium dosage, good mixing at the point of application of the coagulant, optimum paddle speeds for flocculation and efficient filtration of the aluminium floc, the problem of carry-over can be avoided. It is easier to control dosing in larger treatment facilities, where there is buffering, than in small treatment plants.

* This parameter needs to be measured as part of check monitoring only where alum is used as a flocculant (coagulant). Otherwise, it must be included as part of audit monitoring.

Table C Indicator Parameters

30. Ammonium Max. allowed: 0.30 mg/litre Check & Audit

What is ammonium? Ammonium [NH_4] is derived from ammonia [NH_3], a colourless, pungent gas that is extensively used to manufacture fertilisers and a wide variety of nitrogen-containing organic and inorganic chemicals. Ammonia products are widely used as cleaning agents and food additives.

Ammonia is rapidly oxidised in the environment and is typically found in natural waters at concentrations less than 0.1 mg/litre. Concentrations significantly above this (tens to hundreds of mg/litre) indicate gross microbial contamination of a supply.

Ammonia in water can result in the corrosion of copper pipes and fittings, causing copper stains on sanitary ware. It is also a food source for some micro-organisms, and can support nuisance growths of bacteria and algae, often with a resultant increase in the nitrite concentration.

Is it in the source? It may be. Ammonium in water supplies can originate from agricultural and industrial processes and from sewage systems. Elevated levels of ammonium may arise where there is intensive agriculture in a catchment. Most uncontaminated source waters have concentrations below 0.1 mg/litre. High concentrations (greater than 10 mg/litre) have been reported where water is contaminated with animal waste. Elevated levels are sometimes found in deeper lakes, where anoxic (reduced oxygen) conditions may arise.

Is it a major issue for Irish water supplies? No. Nine privately-sourced schemes failed to meet the parametric value in 2007, eight schemes failed in 2008 and four in 2009. On publicly-sourced group schemes, compliance levels were close to 100% in all three years.

What does its presence tell us? Ammonium at levels greater than 0.1 mg/litre indicate possible contamination of the raw water supply by sewage or animal waste pollution.

What risk does it pose? Ammonium is not a health risk of itself, but it serves as a valuable indicator of source pollution. Where present, ammonium will impact on the efficiency of a disinfection system, making it difficult to maintain a chlorine residual.

What to check? Check that animals are not standing in a water body from which the drinking water supply is replenished and that there is no run-off from farmyards. Check also that land-spreading in the area is kept back from vulnerable points and that septic tank systems are properly installed and maintained.

Response: Ammonium concentrations in drinking water supplies can be reduced by chemical or biological oxidation of ammonia to nitrate. However, the most effective long-term response is to devise a source protection plan that will stop contamination entering the supply in the first place.

Table C Indicator Parameters

31. Chloride Max. allowed: 250 mg/litre Audit

What is chloride? Chloride [Cl^-] is the charged or ionic form of the element chlorine. The best known form of chloride is sodium chloride [NaCl], known as salt! Sodium chloride is widely used in the production of industrial chemicals such as caustic soda, chlorine, sodium chlorite and hypochlorite. Potassium chloride is used in the production of fertilisers.
Chloride is present in natural waters from the dissolution of salt deposits and from sewage contamination, industrial effluent and de-icing salts.
Food is the major source of chloride intake. All plants and animals contain chloride. The addition of salt during processing or cooking can markedly increase the chloride content.

Is it in the source? In surface water, the concentration of chloride is usually less than 100 mg/litre and is frequently below 10 mg/litre. Groundwater can have higher concentrations, particularly where there is salt water intrusion.

Is it a major issue for Irish water supplies? No. There was only one non-compliance on a privately-sourced GWS in the years 2007 to 2009, while there was 100% compliance on publicly-sourced schemes.

What does its presence tell us? The presence of excessive chloride in water supplies more than 30 kms from the coast is an indicator of pollution.

What risk does it pose? Some chloride intake is essential for human health. This parameter is included not because it poses a risk to health, but because it may indicate other health risks. It should be noted, however, that the chloride content of water can affect corrosion of pipes and fittings and can also affect the solubility of metal ions.

What to check? Check that source catchments (and particularly the area around the abstraction point) are well protected.

Response: Chloride cannot be removed from drinking water by conventional water treatment processes. It can be removed by distillation or reverse osmosis, but such treatment is expensive to operate. The best response is to identify and deal with the cause of any contamination that may be occurring.

Table C Indicator Parameters

32. *Clostridium perfringens* **Max. allowed: 0/100ml** **Check or Audit***

What is *clostridium perfringens* *(C. perfringens)***?** Defined as 'a Gram-positive, rod-shaped, anaerobic, spore-forming bacterium', *C. perfringens* can be found as a normal component of decaying vegetation, in the intestinal tract of humans and other vertebrates, insects and in soil. It is normally present in faeces.
C. perfringens spores are resistant to environmental stress and can survive in water for longer than other bacteria, including *E.coli*. This makes this particular bacteria an important indicator of water pollution and a useful marker to alert water suppliers to the possible presence of other stress-resistant pathogens, such as viruses and protozoal cysts. In addition, its resistance to chlorination is useful in testing the effectiveness of water treatment processes.
Under the Regulations, where *C. perfringens* is discovered in a supply, an investigation shall be carried out to determine if cryptosporidium might also be present, although there is now considerable doubt as to its usefulness as an indicator of crypto.

Is it in the source? It is likely to be in a surface water supply and unlikely to be in groundwater, unless there is a pathway through fragmented rock and poor soil cover.

Is it a major issue for Irish water supplies? While compliance levels in respect to *C. perfringens* have improved on privately-sourced group water schemes in recent years, more than 15% of schemes were still failing to meet the parametric value in 2009. In the same year, compliance levels on publicly-sourced schemes was close to 100%, improving from 96.4% in 2007.

What does its presence tell us? The detection of *C. perfringens* in a groundwater supply where there is no *E.coli* or enterococci tells us that this supply experienced bacteriological pollution at some point in the past and that a pathway exists to have allowed this happen. In a surface water supply, *C. perfringens* in treated water suggests that the treatment system is inadequate. Clostridia spores are relatively resistant to disinfection and must be removed by filtration.

What risk does it pose? While *C. perfringens* contamination in food carries a health risk, the ingestion of the bacteria through drinking water doesn't appear to present a direct threat. The health risk lies in the fact that such a bacteria could get through the treatment process, suggesting that other (more harmful) organisms might also be getting through.

What to check? Check that filtration processes are adequate and are operating properly and that the source is secure.

Response: Ensure that a robust source protection strategy is in place to prevent faecal contamination entering the supply.

* This parameter need not be measured as part of check monitoring unless the water originates from, or is influenced by, surface water. Otherwise, it must be included as part of audit monitoring.

Table C Indicator Parameters

33. Colour Max. allowed: Acceptable to consumers & no abnormal change Check & Audit

What is colour? We all know what colour is, but what does the term mean when applied to drinking water quality? First, we need to understand that colour in water is caused by the interaction of light with suspended and dissolved particles. As supended particles (turbidity) are likely to have colour of their own, the more turbid the water the higher the colour will appear. Thus, we have two terms to describe colour in water; 'apparent colour' (which is what we actually see) includes the colour reflected from both suspended matter and dissolved matter, while 'true colour' is the reflection of light reflected from dissolved particles only. True colour is preferred analytically.
As a guide, tea has a true colour of about 2,500 HU (Hazen units). A true colour of 15 HU can be detected in a glass of water and a true colour of 5 HU can be seen in a white bath filled with water. Few people can detect a true colour level of 3 HU, and a true colour of up to 25 HU would probably be accepted by most people provided the turbidity was low.
The dissolution of metals in pipes and fittings can also discolour drinking water.
Variations in colour are likely to lead to more complaints than a high but consistent colour.

Is it in the source? Yes, due mainly to the presence of dissolved organic matter including humic and fulvic acids that originate from soil and decaying vegetable matter. Surface water can also be coloured by waste discharges. In borewells, 'red water' is a frequent problem, caused by the oxidation of iron. In addition, a black discolouration in reservoirs and distribution systems can result from the action of bacteria on dissolved manganese to produce insoluble oxides. Some of these compounds form fine suspensions, or are only partially dissolved and so contribute to apparent rather than true colour.

Is it a major issue for Irish water supplies? Yes. As many as 26% of privately-sourced group water schemes and 24% of public supplies exceeded the old parametric value (20 HU). There was a marginal improvement in privately-sourced group schemes in the years 2008 and 2009, while publicly-sourced schemes achieved 95.5% compliance in 2009.

What does its presence tell us? Colour change can provide warning of possible quality changes or maintenance issues. It may also reflect degradation of the water source, corrosion in the distribution system, or changes in the performance of treatment processes.

What risk does it pose? The impact is mainly aesthetic, but if colour is getting through, then micro-organisms might also be getting into the treated water supply. The effectiveness of UV will be reduced by high 'apparent colour' in raw water.

What to check? Raw water colour levels should be periodically checked to find out what normal colour values are and to what extent events (such as heavy rain) alter those values. If the colour is high at the time of disinfection then the water should be checked for disinfection by-products.

Response: Source water that is high in true colour can be treated by oxidation with ozone and adsorption onto activated carbon.

Table C Indicator Parameters

34. Conductivity Max. allowed: 2,500 µS cm^{-1} at 20^{0}C Check & Audit

What is conductivity? This physical parameter refers to the ability of water to conduct an electrical current. Conductivity is strongly influenced by total dissolved solids (TDS) in water as well as by temperature, warm mineralised water having high conductivity. TDS are usually composed of the sulphate, bicarbonate and chlorides of calcium, magnesium and sodium.
In terms of its relevance to water quality, conductivity is an invaluable indicator of the range into which hardness and alkalinity values are likely to fall, and also of the order of the dissolved solids content of the water. Conductivity is also a good measure of salinity [salt content], which affects the potential dissolved oxygen levels in the water. In addition, it is used as an indicator of how ion-free or impurity-free the sample is; the purer the water, the lower the conductivity. Having said that, a totally pure water is insipid and is potentially harmful, so a zero reading of conductivty would not be desirable.
Conductivity is measured in microsiemens per centimetre (µS cm^{-1}), where siemens is the unit of electric conductance.

Is it in the source? Yes. Conductivity will vary from source to source but, measured at 20^{0}C, it is generally much lower than 1,000 µS cm^{-1} and is highest in groundwaters. Conductivity in streams and rivers is affected by the geology of the area through which the water flows. Streams that run through granite bedrock will have lower conductivity, while those that flow through limestone and clay soils will have higher values. High readings can also come from industrial pollution or run-off from roads. Extended dry periods and low flow conditions also contribute to higher conductivity readings.

Is it a major issue for Irish water supplies? No. There has been 100% compliance with this parameter on all drinking water supples in the three years 2007-2009.

What does an exceedance of the parametric value tell us? In terms of water quality, conductivity above the maximum indicates a source that is subject to rapid change and the possible ingress of pollutants.

What risk does it pose? There is no health risk from high conductivity, but elevated levels of dissolved solids can cause 'mineral tastes' in drinking water. Corrosion or encrustation of metallic surfaces by waters high in dissolved solids causes problems with industrial equipment and boilers, as well as with domestic plumbing systems. Agricultural use of water for livestock watering is limited by excessive dissolved solids and can also be a problem when water is used for irrigation.

What to check? Schemes with groundwater sources, including borewell, springs and shallow wells should check conductivity in the raw water supply on a regular basis as part of field sampling.

Response: Where conductivity is excessive, a full hydrogeological analysis of the supply would be appropriate, while steps should also be taken (with technical advice) to adjust treatment processes, as necessary.

Table C Indicator Parameters

35. Hydrogen ion concentration (pH) Range allowed: 6.5 to 9.5* Check & Audit

What is pH? This is one of the most important parameters in that it determines whether a liquid is acid or alkaline. pH ranges from 0 to 14 (pH units), the lower end of the scale being acid and the upper end alkaline. The most desirable value for pH is 7 (neutral) and a value in or around this can be achieved through adjustment in water treatment. A low (acid) pH is likely to lead to greater leaching of inorganic constituents from rocks and soil, thereby increasing the probability that naturally-occurring inorganic substances will be present at higher concentrations than would otherwise be expected.
When groundwater or surface water used for a drinking water supply has a pH of less than 4.5 and where there are nearby mineral deposits containing metals, it would be appropriate to consider those metals in particular.

Is it in the source? Yes. The range of natural pH in fresh waters extends from around 4.5, for acid, peaty upland waters, to over 10.0 in waters where there is intense photosynthetic activity by algae. However, the most frequently encountered range is 6.5-8.0.

Is it a major issue for Irish water supplies? Yes. pH values on many supplies fall outside the allowable range. Compliance levels on privately-sourced group schemes improved slowly, if steadily, from 2007 (87.2%) to 2009 (89%), while compliance on publicly-sourced schemes rose to 96.6% in 2009 from about 95% in the previous two years. By contrast, public schemes recorded relatively poor compliance levels, with about 25% of schemes failing to meet the parametric value in these years.

What does the result for pH tell us? High or low values will show excessive acidity/alkalinity in a water supply. Changes in the pH of source water should be investigated as it is a relatively stable parameter over the short term and any unusual change may reflect a major event.

What risk does it pose? Extremes of pH can affect the taste of water, but the corrosive effect on distribution systems is a more urgent problem. The pH of water affects treatment processes, especially coagulation and disinfection.

What to check? Schemes should monitor pH on a continuous basis, if possible. Otherwise, field monitoring of raw water samples should be conducted on a regular basis and following events (such as the appearance of an algal bloom). Simple paper strip or colorimetric tests are available. While these are less precise, they can provide valuable information.

Response: pH is commonly adjusted as part of the treatment process. Get technical advice on this issue.

* The Regulations state that water should not be aggressive.

Table C Indicator Parameters

36. Iron [Fe] **Max. allowed: 200 μg/litre** **Check or Audit***

What is iron? An elementary substance, iron occurs commonly in soil and rocks as the oxide, sulfide and carbonate minerals. In water, it is present in oxidised forms as ferric (Fe(III)) or ferrous (Fe(II)) compounds.
Iron has many domestic and industrial applications, ranging from iron and steel products and pigments in paints to food colours and preparations for preventing iron deficiency in humans.
Iron sulphate (hydroxylated ferrous sulphate) is used as a flocculant in water treatment. Food is the major source of iron intake and iron is a natural constituent in plants and animals. Fish, green vegetables and tomatoes have high iron content.

Is it in the source? Yes. Iron concentrations in uncontaminated surface waters are usually less than 1,000 μg/litre. Much more significant amounts of iron may be found in groundwater. In oxygen-depleted groundwater, iron concentrations of up to 100,000 μg/litre have been recorded. Some of the exceedances in treated water arise from naturally-occurring high levels of iron in both surface and groundwater sources where they can be elevated.

Is it a major issue for Irish water supplies? Yes. Upwards of 10% of privately-sourced and publicly-sourced group water schemes failed to meet this parametric value in the years 2007-2009.

What does its presence tell us? Where iron concentrations in the source are acceptable, the detection of exceedances in treated water points to problems with rusting on the distribution network or the carry over of ferric where it is used as a coagulant in treatment. Rising levels of iron in a source might suggest pollution from effluent discharges.

What risk does it pose? Iron is an aesthetic parameter, rather than an obvious threat to health (although medical concerns have been expressed in relation to the issue of iron exceedances in water). It has a taste threshold of about 300 μg/litre in water and becomes objectionable above 3,000 μg/litre. High iron concentrations give water an undesirable rust-brown appearance and can cause staining of laundry and plumbing fittings. Growths of iron bacteria, which concentrate iron, may cause taste and odour problems and lead to pipe blockages and corrosion.

What to check? Where the source does not indicate a high iron content, check the distribution network from the intake pipes to the consumer's tap for evidence of rusting screens, pipes and fixtures.

Response: Iron salts can be effectively removed by coagulation followed by filtration. Groundwater supplies with a high iron content can be treated to form iron precipitates using aeration, oxidation with chlorine, pH adjustment or lime softening.

* This parameter is only subject to check monitoring where ferric is used as a flocculant (coagulant). Where ferric is not used, then iron is to be sampled as part of audit monitoring.

Table C Indicator Parameters

37. Manganese [Mn] Max. allowed: 50 μg/litre* Check

What is manganese? This is an elementary substance and is present in the environment in the divalent (Mn(II)), tetravalent (Mn(IV)) and heptavalent (Mn(VII)) states. Manganese is an essential element and is required by mammals and birds for normal growth. Most divalent compounds are soluble in water, as is heptavalent permanganate. The most common tetravalent compound, manganese dioxide, is insoluble.
Manganese is principally used in the manufacture of iron, steel and alloys.
Highest concentrations of manganese in food have been reported in grains, nuts and vegetables, while tea leaves can have extremely high concentrations.

Is it in the source? Uncontaminated rivers and streams generally have low concentrations of manganese (according to the Australian guidelines). High concentrations may occur in polluted rivers or under anoxic conditions such as at the bottom of deep reservoirs or lakes, or in groundwater. Some of the exceedances in treated water arise from naturally-occurring high levels in both surface and groundwater sources where they can be elevated.

Is it a major issue for Irish water supplies? Yes. However, rates of compliance with this parameter have steadily improved on privately-sourced group schemes, ranging from 90.1% in 2007 to 93.6% in 2009. Compliance has remained fairly static (but high) on publicly-sourced group schemes at between 97.2% and 98%.

What does its presence tell us? Manganese exceedances in a drinking water supply may point to pollution of the source.

What risk does it pose? This is regarded as the least toxic elementary substance and the risk in drinking water is mainly aesthetic because waters with high levels of manganese will be rejected by consumers long before any danger threshold in reached. It has been suggested that manganese deficiency may be associated with anaemia and bone disorders in children. At concentrations exceeding 100 μg/litre, manganese imparts an undesirable taste to water and stains plumbing fixtures and laundry. Even at concentrations of 20.0 μg/litre, it will form a coating on pipes that can slough off as a black ooze. Some nuisance micro-organisms can concentrate manganese and give rise to taste, odour and turbidity problems in distribution systems.
Manganese interferes with the commonly-used method for determining chlorine residual, resulting in an overestimation of the residual so that chlorine appears to be present when it may not be.

What to check? Have manganese levels checked in the raw water and where it is an issue, monitor levels frequently and try to identify their source.

Response: Manganese concentrations in drinking water can be reduced by converting soluble forms to insoluble precipitates, followed by filtration. Chlorine can be used to oxidise some forms of manganese, while lime softening at high pH may be effective in removing others.

Table C Indicator Parameters

38. Odour **Max. allowed: Acceptable to consumers & no abnormal change** **Check & Audit**

What is odour? This is what is termed an organoleptic parameter, as it refers to what our sense of smell tells us about a water supply.

Is it in the source? It may be, depending on what organic or chemical compounds are present. For example, a surface water with rotting organic matter may have a strong smell, as might a groundwater source where the aquifer is rich in sulphur.

Is it a major issue for Irish water supplies? It may be. Compliance on privately-sourced schemes ranged from almost 95% in 2007 to 99.6% in 2008, falling back to 93% in 2009. On publicly-sourced schemes, there was 96.4% compliance in 2007, 100% in 2008, but only 88.3% in 2009, while public schemes showed a similar trend, with 2009 being a poor year for compliance at only 91.5%.

What does its presence tell us? A strong smell from water may indicate a problem in the treatment process (possibly because of chemicals used in treatment), or a build-up of rotting material or biofilms in the distribution network. However, its cause is normally dissolved volatile organic compounds, small concentrations of which may cause a strong smell. In polluted sources a very common cause is the presence of hydrogen sulphide gas produced from the reduction of sulphates in the anaerobic conditions which can prevail after a heavy organic discharge to the water. Likewise, the formation of a putrid sludge on the bed of a source by deposition of organic solids can give rise to sulphide odours. Algal blooms in surface lakes are a source of odour and taste in water. Particular chemicals may become gradually noticable in an aquifer, so that odour increases over time.

What risk does it pose? A strong odour from drinking water will obviously cause revulsion or rejection on the part of the consumer, but there are no health implications, as such.

What to check? Ensure that all products used in drinking water production conform to international best standards. Check raw water for smell to provide an early warning of potential problems.

Response: The source of the odour should be determined without delay so that appropriate action can be taken. Where the odour is present as a result of a deterioration in raw water quality (e.g. because of eutrophication), treatment systems may have to be designed to deal with it. Technical advice should be secured before any investment is made.

Table C Indicator Parameters

39. Oxidisability Max. allowed: 5.0 mg/litre O_2 Audit

What is oxidisability? This is a measure of the organic content of water, and of those inorganic constituents that are amenable to oxidation, whether naturally or from added wastes. This parameter need not be measured if the parameter Total Organic Carbon is analysed [see parameter 45].

Is it in the source? There will be considerable organic content in any surface water and much less in groundwaters, apart from those that are influenced by surface water. The more organic matter is present, the more it will feed bacteria that are likely to use up the dissolved oxygen in the water as it degrades.

Is it a major issue for Irish water supplies? No. Only six privately-sourced group schemes were tested for this parameter in the period 2007-2009. All samples were compliant. There was no sampling of publicly-sourced group schemes in the same period, but those public supplies monitored were 100% compliant.

What does its presence tell us? It indicates overall water quality, suggesting pollution of the source and (in treated water) the success, or otherwise, of filtration processes.

What risk does it pose? There is no direct health risk, but there are clear risks associated with the presence of organic content in water, not least from the potential formation of THMs, such as chloroform, following the interaction of unfiltered raw water with chlorine.

What to check? Ensure that there is adequate source protection, that filters are appropriate for the raw water and that there is adequate back-washing and cleaning of filters.

Response: Improve source protection, pre-filtration and filtration processes.

Table C Indicator Parameters

40. Sulphate Max. allowed: 250 mg/litre* Audit

What is sulphate? This is a chemical unit [SO_4], combining sulphur [S] with oxygen [O]. It occurs naturally in a number of minerals and is used commercially in the manufacture of numerous products including chemicals, dyes, glass, paper, soaps, textiles, fungicides and insecticides. Barium sulphate is used as a lubricant in drilling rigs for groundwater, while aluminium sulphate (alum) is used as a flocculant in water treatment and copper sulphate has been used for the control of blue-green algae (cyanobacteria).

Is it in the source? Yes, sulphates are in nearly all natural waters, but the concentration will be affected by local geological factors or by discharges from industrial processes. In source waters, concentrations are typically much less than 100 mg/litre, but values of up to 2,200 mg/litre have been recorded internationally.

Is it a major issue for Irish water supplies? No. There was close to 100% compliance on all Irish drinking water supplies tested in 2007, while there was full compliance in 2008 and 2009.

What does its presence tell us? Excessive sulphate will suggest that water is aggressive and this is unacceptable. If sulphate is not normally an issue in the raw water supply, its presence may indicate pollution of the source.

What risk does it pose? The main risk posed by sulphate is that it is a laxative, particularly where there are high levels of magensium and/or sodium in the water supply. A taste issue will arise where there is excessive sulphate and in sources with depleted dissolved oxygen sulphate will reduce to sulphide, resulting in an unpleasant smell due to the release of hydrogen sulphide. This can increase corrosion in pipes.

What to check? Raw water sampling will indicate if there is an underlying problem with this parameter. Values will range from <1 mg/litre upwards.

Response: Sulphate salts are very soluble and can’t be removed by conventional treatment processes. Desalination methods, such as reverse osmosis or distillation, are required for sulphate removal.

* The Regulations state that water should not be aggressive.

Table C Indicator Parameters

41. Sodium [Na] Max. allowed: 200 mg/litre Audit

What is sodium? This is an elementary chemical that is common in rocks and soils. Sodium salts are used in the paper, glass, soap, pharmaceutical and general chemical industries and for a variety of other purposes. Sodium is also used in the food industry and for domestic cooking. Food is the major contributor to sodium intake. Sodium sulphate is used as a laxative.
Considerable amounts of sodium are excreted by humans and it is a common constituent of domestic sewage.

Is it in the source? Given its abundance in the environment, some sodium will be present in nearly all water supplies. The majority will contain less than 20 mg/litre, but values of 250 mg/litre have been found. The problem is likely to be higher in coastal areas, where sea spray can contribute to sodium levels. Apart from contamination by salt water and from natural leaching of rocks and soils, sewage effluent can contribute to sodium levels in drinking water sources.

Is it a major issue for Irish water supplies? No. Monitoring over the three years 2007-2009 has shown compliance levels greater than 99% in both privately-sourced and publicly-sourced group water schemes.

What does its presence tell us? Where source values are normally low, excessive sodium might indicate pollution of the source by wastewater treatment systems.

What risk does it pose? Sodium is an essential dietary requirement, but it causes hypertension when taken in excess. For patients suffering from severe hypertension or congestive heart failure, sodium values over 20 mg/litre are not recommended. A taste issue will arise where the value is over 135 mg/litre and this taste issue is appreciable over 180 mg/litre (the parametric value in Australia).

What to check? Compliance audit sampling will reveal if sodium is an issue on your scheme. Where your scheme supplies less than 100 m^3/day (and audit sampling is not required), sodium should be sampled annually as part of operational sampling.

Response: Sodium salts cannot be easily removed from drinking water. However, any steps to reduce sodium concentrations are encouraged (such as the use of alternative salts in domestic water softeners). Processes such as reverse osmosis or distillation can be employed, but these are costly to operate. Where pollution is suspected as the source of excessive sodium, the root problem needs to be addressed.

Table C Indicator Parameters

42. Taste **Max. allowed: Acceptable to consumers & no abnormal change** **Check & Audit**

What is taste? Well, we all know what taste is, but what bearing does it have on water quality? Quite simply, taste (like odour) is an immediate way of telling if there might be something wrong with a supply. Where there are algal blooms in a raw water supply or where there is too much chlorine in the treated water, our sense of taste will tell us that treatment needs to be adjusted. For example, a phenol contamination incident on several schemes in the East Cavan DBO bundle in 2007 was detected in the first instance because of the water's unpalatable taste (as well as its smell), likened to TCP.

Is it in the source? Source water will always have a taste, reflecting the natural environment in which it is located and the organic matter and minerals that may have been picked up. The presence of a natural substance, such as sulphur or algae, will impact on taste.

Is it a major issue for Irish water supplies? No. There was 100% compliance with this parameter on both privately-sourced and publicly-sourced group water schemes in 2007 and 2008, with over 99% compliance in 2009.

What does its presence tell us? Taste that is unacceptable to consumers or that changes abnormally tells us that there is either a problem with our source, with chemicals used in the treatment process, or with the condition of the distribution network.

What risk does it pose? None of itself, but it may indicate an underlying problem and may persuade consumers to use an alternative, untreated water supply.

What to check? Check that the source is protected. Ensure that all chemicals used in water treatment are purchased from a reliable source and that they meet the required standard. Check that the entire distribution network is scoured periodically, with additional scouring of dead ends.

Response: Where a serious taste issue emerges in a water supply, take immediate steps to identify the source. In consultation with your Water Services Authority, agree a plan to deal with the issue.

Table C Indicator Parameters

43. Colony count 22°C Max. allowed: No abnormal change Audit

What is colony count 22°C? This is where a count is made of bacteria after they have been incubated in water heated to 22°C for a fixed period. This bacteria is aerobic and is not related to faecal contamination. The objective of water treatment systems should be to ensure that bacteriological colonies are kept as low as possible. Therefore, the detection of large numbers of colonies is useful in assessing the efficiency of a water treatment system, while an abnormal change in numbers may warn of significant developments. They may also be used to assess the cleanliness and integrity of the distribution system and the suitability of the water for use in the manufacture of food and drink products where high counts may lead to spoilage.

Is it in the source? Yes, there will always be bacteria in a water supply.

Is this a major issue for Irish water supplies? Yes. One fifth of all privately-sourced group water schemes sampled failed to comply with this parameter in 2007, but performance has improved since then and in 2009 there was almost 92% compliance, similar to that on publicly-sourced group schemes and public supplies, which recorded between 93-94% compliance levels in 2009.

What does the presence of a large number of bacterial colonies tell us? It tells us that a disinfection system isn't working as well as it should be, or that there is insufficient residual to deal with any bacteria that may be in the network.

What risk does this pose? There is no direct health risk from the numbers of bacteria colonies in drinking water, but it points to a potential risk from inadequate disinfection procedures. The lower the concentration of bacteria in drinking water, the better.

What to check? Ensure that duty and stand-by disinfection pumps are in place, with automatic switch-over and that the dosing levels are sufficent to kill the bacteria present in the raw water and that it generates sufficient residual to deal with bacteria in the distribution network.

Response: Assess the intregrity of the disinfection system and adjust as necessary.

Table C Indicator Parameters

44. Coliform bacteria Max. allowed: 0/100ml Check & Audit

What are coliform bacteria? These are a diverse group of gram-negative non-sporing rod-shaped bacteria, some of which are of faecal origin (e.g. *E. coli*). However, there are many species that occur naturally in the environment and are not harmful of themselves.
A water sample is heated to 37^{o}C for a fixed period and is then analysed using a membrane filtration procedure. This identifies whether there are coliform bacteria present and systems exist to determine if any of these are *E. coli*. Coliform bacteria (excluding *E. coli*) are not considered useful as indicators for the presence of faecal contamination and enteric pathogens.

Are they in the source? Yes.

Are they a major issue for Irish water supplies? Yes. This parameter accounts for the vast majority of parametric failures on Irish drinking water supplies. Amongst privately-sourced group schemes, compliance has improved from just 46.3% in 2007 to 62% in 2009, while on publicly-sourced group water schemes compliance levels of between 91-94% were recorded in the same period.

What does their presence tell us? Coliform bacteria in a drinking water supply indicate that the disinfection system may be deficient, or that there is a problem at the sampling point, or that there may be a fault in the distribution network that is allowing contaminants to enter. In this case, their presence might result from release from pipe or sediment biofilms or ingress of soils as a result of faults or repairs.

What risk do they pose? They are not a direct health risk, but the fact that they can get through the treatment system and/or into the distribution network points to a risk from other more harmful microbiological contaminants, such as *E.coli*.

What to check? The chlorination system should be regularly checked to ensure effective dosing, not least following a severe weather event that might impact on raw water quality. Chlorine in the network (both total and residual) should be checked, particularly at ends of lines and at other vulnerable sections of the distribution mains. A test for coliform bacteria should be taken after works on the network.

Response: Where an exceedance is detected, the point at which the sample was taken should be investigated to determine if the problem might be within the premises. In addition, samples should be taken at neighbouring premises. If an exceedance is detected as part of operational monitoring, the Water Services Authority should be informed in writing and without delay and immediate action should be taken to investigate the incident. Scouring will be required following a confirmed contamination of the network or a section of the network.
Where not already in place, duty and stand-by disinfection dosing pumps, with automatic switch-over and alarms, should be installed.

Table C Indicator Parameters

45. Total organic carbon Max. allowed: No abnormal change Audit

What is total organic carbon [TOC]? This is a measurement of natural organic matter in water that is derived from decaying vegetation, bacterial growth and the metabolic activities of living organisms or chemicals. As a measure of water quality, it provides an indication of the potential for the regrowth of bacteria in reservoirs and distribution systems.
TOC provides an important role in quantifying the amount of organic matter in a water supply. When the raw water is chlorinated, active chlorine compounds may react with this organic matter to produce chlorinated disinfection by-products. Changes in the levels of TOC are, therefore, of significance in ensuring the integrity of the disinfection system.

Is it in the source? Yes. There will always be some organic matter in a source, but levels would naturally be expected to be much higher in surface water supplies than in ground water.

Is it a major issue for Irish water supplies? No. There was close to 100% compliance on privately-sourced schemes in the years 2007-2009, while publicly-sourced schemes have achieved 100% compliance in 2008 and 2009. Compliance amongst public supplies slipped back, however, from 97.7% in 2008 to 96.5% in 2009.

What does its presence tell us? The presence of TOC simply tells us that there is natural decaying matter in our source. However, an abnormal rise in this parameter might suggest that a surge of organic pollutants is entering the supply, with implications for filtration and disinfection processes.

What risk does it pose? While TOC of itself does not pose an immediate health risk, an increase in TOC levels is likely to impact on the efficiency of treatment and this poses a real risk of microbiological contaminants entering the supply. There is also the danger of carbon combining with chlorine to produce chlorination by-products (including THMs), which are carcinogenic.

What to check? Ensure that the source (and particularly the area around the abstraction point), is protected from excessive infiltration by organic matter. Where works are underway (e.g. construction) ensure that a boom is in place at the abstraction point. Within the treatment plant, check the efficiency of filtration systems.

Response: Where TOC levels are fluctuating, improve source protection measures. Filtration processes will have to be improved to cope with wide variations in TOC.

Table C Indicator Parameters

46. Turbidity **Max. allowed: Acceptable to consumers & no abnormal change** **Check & Audit**

What is turbidity? Turbidity is a measurement of the light-scattering property of water, the degree of which depends on the amount, size and composition of suspended solids such as clay, silt, algae and other microscopic organisms in the water. It is not associated specifically with faecal material, but increases in turbidity are often accompanied by increases in pathogen numbers, including cysts and oocysts (such as Cryptosporidium). The amount of light scattered by the suspended solids in water is measured using a nephometer. Thus, the unit of measurement is the Nephelometric Turbidity Unit (NTU). The lowest level of measurement is about 0.02 NTU.
As a guide, water with a turbidity of 5 NTU would appear slightly muddy or milky in a glass. It would not be possible to see through the glass if the turbidity was over 60 NTU. 'Crystal' clear water usually has a turbidity of less than 1 NTU.

Is it in the source? Yes, it will be a factor in all surface supplies and in groundwater bodies that are influenced by surface waters. Turbidity in surface waters is likely to increase following heavy rainfall events or algal growth. Most groundwaters have a low and relatively stable turbidity. Catchment management practices can have a marked impact on turbidity. Water coming from undisturbed or protected areas will generally have lower turbidity than from areas under intensive cultivation.

Is it a major issue for Irish water supplies? Yes. Turbidity is tested at the water treatment works and at the consumer's tap. A maximum level of 1 NTU is preferred at the plant. There has been a high incidence of failure in all water supplies in the years 2007-2009.
As for testing at the consumer's tap, a maximum value of 4 NTU is preferred. Again, there was a high rate of non-compliance in all drinking water supplies. However, there was a notable improvement in regard to privately-sourced schemes in 2009 compared to the previous two years, suggesting improved management of distribution networks.

What does its presence tell us? High or abnormal change to turbidity at the treatment works tells us that effective filtration is required prior to disinfection, given that the turbidity of water affects treatment processes and especially disinfection, whether by chlorine or UV. At the consumer's tap, it is telling us that there is particulate matter in the distribution network and that maintenance, including scouring, is required.

What risk does it pose? There is no immediate health risk from turbid water, but high or variable turbidity levels indicate that contaminants may be getting through the treatment plant and into the water supply, as turbidity provides them with a shield.

What to check? Checks should be maintained on raw water turbidity levels and, where it is an issue, at each stage of a filtration system. Chlorine residual levels should be checked in the distribution network, so that timely scouring can be carried out.

Response: In consultation with your Water Services Authority, get competent technical advice. A system to deal with high or variable turbidity is likely to include an on-line monitoring/early warning system, automatic shutdown of the intake and appropriate filtration. Raw water and treated water storage will help to reduce turbidity levels. Regular scouring of the network will also be required.

Table C Radioactivity

47. Tritium Max. allowed: 100 Bq/litre Audit

What is tritium? This is a radioactive form of hydrogen used commercially as a light source in flares, emergency lights, exit signs and luminous dials (watches and clocks); tritium is also an essential fuel for experimental nuclear "fusion" and has been used for nuclear weapons production. Less than 1% of tritium occurs naturally (e.g. through the interaction of cosmic rays with molecules of certain elements in the upper atmosphere). Most is man made. Tritium is measured in becquerels per litre (Bq/litre), a becquerel being an international unit to measure the activity of a radioactive nuclide.

Is it in the source? The International Institute of Concern for Public Health states that naturally-occurring tritium in water sources will be less than 10 Bq/litre. According to the Bruce Centre for Energy Research and Information in Ontario, man-made tritium gets into water sources as fallout from thermonuclear weapons testing begun in the 1940s, or as effluent release from nuclear power reactors. In a noted past accidental release into Lake Huron from the Bruce nuclear complex in Ontario, concentrations of tritium in drinking water at Port Elgin, a town 15 miles north, reached in excess of 1,500 Bq/litre. Two radioactive waste storage sites at the Bruce complex were leaking tritium into groundwater monitoring wells, one of which had levels of 203,500 Bq/litre for tritium!

Is it a major issue for Irish water supplies? No. Testing (albeit limited) in the years 2007-2009 has shown 100% compliance on water supplies sampled.

What does its presence tell us? The presence of tritium in drinking water may indicate source pollution by other artificial radionuclides. As such, tritium is a screening parameter, but monitoring is only required if there is a source of tritium in the catchment and it cannot be shown by other means that the level of tritium is well below 100 Bq/litre.

What risk does it pose? Tritium is classified as a human carcinogen. In addition, there is a growing body of evidence which suggests that tritium is mutagenic (i.e. mutates genes causing hereditary defects) and teratogenic (i.e. causes malformations of an embryo or foetus). The most sensitive populations to tritium are considered to be foetuses, young children and women of child-bearing age.

What to check? There is little or nothing that a group water scheme can do in terms of monitoring for tritium. Indeed, the frequency of monitoring for radioactive substances by the authorities is likely to be very limited given the EPA's guidance that where other monitoring indicates no problem with tritium or total indicative dose in a catchment, there will be no need to sample for either of these parameters in drinking water.

Response: In the highly unlikely event that excessive levels of tritium are found in your catchment, consult with your Water Services Authority.

Note – The Drinking Water Regulations state as follows:
Drinking water need not be monitored for tritium or radioactivity to establish total indicative dose where it is satisfied that, on the basis of other monitoring carried out, the levels of tritium of the calculated total indicative dose are well below the parametric value.

Table C Radioactivity

48. Total indicative dose Max. allowed: 0.10 mSv/year Audit

What is total indicative dose? This is a measurement of combined radioactivity (i.e. gross alpha and/or beta activity) from several natural substances, including potassium-40, lead-210 and radium-228, artificial radionuclides such as caesium-137 and strontium-90, as well as tritium, which can be both natural and man-made. While the vast bulk of radioactive exposure comes from natural sources such as the ingestion of radon, the Chernobyl incident provided stark evidence that nuclear accidents can have potentially catastrophic and global environmental consequences. However, the screening and guidance levels for total indicative dose apply to normal operational conditions and do not apply to a water supply contaminated during an emergency involving the release of radionuclides into the environment.
Total indicative dose is measured in sieverts (Sv), where 1 Sv = 1 Joule/kg.

Is it in the source? As with other elements, there will be traces of natural radioactive material in most sources. The Australian guidelines suggest that in the absence of a nuclear power industry 'these nuclides are likely to be present in significant concentrations ... only as a result of transient contamination following an event such as a nuclear accident'.

Is it a major issue for Irish water supplies? No. This parameter has not been tested on either privately-sourced or publicly-sourced group water schemes in the years 2007-2009 [see note below]. Very limited testing on public supplies in the same period has shown 100% compliance.

What does its presence tell us? An exceedance in the total indicative dose might point to natural problems underlying the source (e.g. uranium in the local bedrock and soils), or contamination due to human activity.

What risk does it pose? Acute health effects of radiation are not a concern for drinking-water supplies. Having said that, radiation exposure at low to moderate doses may increase the long-term incidence of cancer. Animal studies suggest that the rate of genetic malformations may be increased by radiation exposure.

What to check? There is no practical measure that a group water scheme can take in respect of this parameter.

Response: Where an exceedance is discovered, there will be investigation of the concentrations of individual radionuclides and comparison with specific guidance levels. According to the Australian guidelines, treatment processes involving ion exchange or reverse osmosis will effectively remove radionuclides such as lead-210, strontium-90 and caesium-137. There is no suitable treatment to remove tritium.

Note – The Drinking Water Regulations state as follows:
Drinking water need not be monitored for tritium or radioactivity to establish total indicative dose where it is satisfied that, on the basis of other monitoring carried out, the levels of tritium of the calculated total indicative dose are well below the parametric value.

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