Drinking-water Standards for New Zealand 2005

Citation: Ministry of Health. *Drinking-water Standards for New Zealand 2005*.
Wellington: Ministry of Health.

Published in August 2005 by the
Ministry of Health
PO Box 5013, Wellington, New Zealand

ISBN 0-478-28392-X (Book)
ISBN 0-478-28395-4 (Internet)
HP 4124

This document is available on the Ministry of Health's website:
http://www.moh.govt.nz

Foreword

I am pleased to release the *Drinking-water Standards for New Zealand 2005.* These come into effect on 31 December 2005.

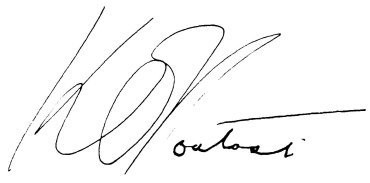
The availability of safe drinking-water for all New Zealanders, irrespective of where they live, is a fundamental requirement for public health. The revised Drinking-water Standards are a significant achievement in New Zealand's endeavours to maintain and improve drinking-water quality.

Since the publication of the *Drinking-water Standards for New Zealand 2000* there has been a shift in the approach to drinking-water quality management. We have moved the focus from 'quality control' to a broader approach of 'quality assurance'. This has been necessary due to changes in technology, an improvement in our scientific knowledge and the requirement to address a broader range of issues not previously covered.

Underpinning the new quality assurance approach will be a requirement for drinking-water suppliers to develop a Public Health Risk Management Plan (PHRMP). Water suppliers have a public health responsibility to ensure the provision of safe drinking-water to their communities. A PHRMP systematically assesses the requirements for providing safe drinking-water. It is a management tool for suppliers that will aid them to identify, manage and minimise events that could cause water quality to deteriorate.

The *Drinking-water Standards for New Zealand 2005* contain comprehensive information for owners and operators to assist in the management of public and private drinking-water suppliers and we strongly encourage you to become familiar with all aspects of them.

I wish to extend my appreciation to all those involved in the revision process. I especially wish to thank members of the Expert Working Groups for their efforts in reviewing and revising the many technical draft proposals that were part of this process. The result has significantly contributed to improving and protecting the public health of all New Zealanders.



Karen O Poutasi (Dr)
Director-General of Health

Expert Committee on Drinking-water Quality

Drinking-water Standards for New Zealand 2005 is the result of a consensus among members of the Expert Committee on Drinking-water Quality set up to advise the Ministry of Health. Consensus means general agreement by all interested parties. Consensus includes an attempt to remove all objections and implies much more than the concept of a simple majority, but not necessarily unanimity. It is consistent with this meaning that a member may be included in the committee list and yet not be in full agreement with all the clauses of this standard.

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1.1 Introduction

Safe **drinking-water**, available to everyone, is a fundamental requirement for public health.

Drinking-water Standards for New Zealand 2005 (**DWSNZ**) replaces *Drinking-water Standards for New Zealand 2000* (Ministry of Health 2000). It details how to assess the quality and safety of drinking-water using the revised **water quality standards** and **compliance criteria** (collectively called the DWSNZ) that come into effect from 31 December 2005. The drinking-water standards apply to drinking-water, that is, water intended to be used for human consumption, food preparation, utensil washing, oral hygiene or personal hygiene. The criteria are applicable to all drinking-water except bottled water, which must comply with the Food Act 1981.

Drinking-water Standards for New Zealand 2005 is made up of the following sections.

- Section 2 contains the water quality standards, which specify the maximum concentrations of microbial, chemical and **radiological determinands** in drinking-water that are acceptable for public health. These are the **maximum acceptable values (MAVs)** of the determinands. The water quality standards are the yardstick by which water's suitability for drinking is assessed.
- Section 3 discusses **compliance** with, and **transgressions** of, the DWSNZ.
- Sections 4–12 contain the compliance criteria, which specify the sampling protocols and other criteria that need to be satisfied to demonstrate the drinking-water complies with the DWSNZ.
- Two appendices explain the units used in the DWSNZ (Appendix 1) and **guideline values** (Appendix 2); **referee methods** of analysis appear in Appendix 3 and the Ministry of Health's *Guidelines for Drinking-water Quality Management in New Zealand* (referred to as the *Guidelines* throughout this publication) (Ministry of Health 2005(a)).
- Key terms used in this publication are defined in the Definitions section. They are also highlighted in bold type on their first use in the main text.
- References are listed at the end of the publication.

The DWSNZ are intended to:

- protect public health
- minimise unnecessary **monitoring**
- be appropriate for large and small, publicly- and privately-owned drinking-water supplies.

Drinking-water Standards for New Zealand 2005 sets out the requirements for compliance with the DWSNZ and facilitates consistency of their application throughout New Zealand. It includes the following significant changes from *Drinking-water Standards for New Zealand 2000* (Ministry of Health 2000):

- a section on the use of **ultraviolet light (UV) disinfection** to inactivate **bacteria** and **protozoa** (section 5.16)
- restructured sections relating to protozoal criteria (section 5)
- a section on cyanotoxins (section 7)
- a section on small supplies (section 10)
- a section on **tankered water** (section 11).

1.2 Scope of DWSNZ

The DWSNZ are applicable to water intended for drinking irrespective of its source, treatment or **distribution system**, whether it is from a public or private supply, or where it is used. The exception is bottled water, which is subject to different standards set under the Food Act 1981.

For people with special medical conditions, or for uses of the water for purposes other than drinking, additional or other water quality criteria may apply (such as the special requirements of the Animal Products Act 1999, Food Act 1981, Dairy Industry Act 1952 and Meat Act 1981). The Ministry of Agriculture and Forestry's Standard D106.2, *Farm Dairy Water* (MAF 2002) also covers water quality. It concerns water used in farm dairies for milking and cleaning equipment that comes in contact with milk.

The DWSNZ specify maximum acceptable values (MAVs) for the microbial, chemical and radiological determinands of public health significance in drinking-water and also provide compliance criteria and procedures for verifying the water supply is not exceeding these values. The actions to be followed when a transgression occurs are described.

The companion *Guidelines* provide additional information about the:

- determinands listed in this publication
- management of drinking-water quality
- derivation of the concepts used in this publication
- publications on which the DWSNZ are based.

The DWSNZ do not specify MAVs or compliance requirements for **aesthetic determinands**. However, Guideline Values (GVs) for determinand concentrations that should avoid public complaints are in Appendix 2 and are discussed in the *Guidelines*.

The DWSNZ alone are not sufficient to protect against the public health risks from contaminated drinking-water. They provide a check on the final quality of the water delivered to consumers. The contamination of a water supply is guarded against by the treatment and delivery processes being managed as specified in the **Public Health Risk Management Plan (PHRMP)** for the supply.

Confidence in the public health safety of the water is increased if multiple barriers to contamination are in place. These barriers include:

- protection of source waters to minimise the number of determinands of health significance in the abstracted water that must be dealt with by the treatment process
- **filtration** to remove particulate matter
- **disinfection** to inactivate any pathogenic organisms present
- protection of treated water from subsequent contamination.

The Ministry of Health developed the DWSNZ with the assistance of the Expert Committee on Drinking-Water Quality. Extensive use was made of:

- *Guidelines for Drinking-water Quality 2004* (referred to as the WHO Guidelines throughout this publication) (WHO 2004)
- *Drinking-water Standards for New Zealand 1984; 1995; 2000* (Ministry of Health 1984, 1995, 2000 respectively)
- *Australian Drinking Water Guidelines 1996* (NHMRC and ARMCANZ 1996)
- *National Primary Drinking Water Regulations: Long Term 2 Enhanced Surface Water Treatment Rule: Proposed rule* (USEPA 2003d).

The DWSNZ are based on the following principles.

1. The DWSNZ define the concentrations of chemicals of health significance (MAVs) in water that, based on current knowledge, constitute no significant risk to the health of a person who consumes 2 L of that water a day over their lifetime (usually taken as 70 years). In most cases, the calculation is based on a national average body weight of 70 kg. It is usually not possible to define a concentration of **contaminant** at which zero risk exists because a degree of uncertainty over the magnitude of the risk always exists. See the **data sheets** in the *Guidelines* for details of each determinand.
2. The DWSNZ give highest priority to health risks arising from microbial contaminants. Control of microbial contamination is of paramount importance and must not be compromised in an attempt to correct chemical problems, such as **disinfection by-product (DBP)** formation.
3. The DWSNZ set priorities to ensure, while public health is protected, scarce resources are not diverted to monitoring substances of relatively minor importance.
4. The DWSNZ are set to protect public health and apply only to health-significant determinands. However, as the public generally assesses the quality of its water supply on aesthetic perceptions, guideline values for aesthetic determinands are also provided. See the *Guidelines* for more details.

Overview of Drinking-water Standards

5. To demonstrate compliance with the MAVs, **water suppliers** need to follow the sampling and testing programmes detailed in sections 4, 5, 7, 8, 9, 10 and 11.
6. When feasible, the sampling protocols are designed to give 95 percent confidence that no determinand in a supply has exceeded its MAV for more than 5 percent of the time.

1.3 Content

Drinking-water Standards for New Zealand 2005 sets out the standards for drinking-water constituents or properties (determinands) and contains the information necessary to demonstrate whether a water supply complies with these Standards. The DWSNZ cover three types of compliance: microbial, chemical and radiological.

The DWSNZ specify the MAV for each determinand. MAVs are discussed in section 1.4.

The determinands have been classified into four **priority classes**, which are discussed in section 3.3.

The monitoring and analytical conditions needed to demonstrate compliance for determinands in priority classes 1 and 2 are given in sections 4, 5, 7, 8 and 9 for bacterial, protozoal, cyanotoxin, chemical and radiological determinands respectively. MAVs for each individual health significant chemical determinand are listed in section 2.

Compliance requirements for small drinking-water supplies (serving fewer than 500 people) are given in section 10.

The *Guidelines* provide background and supporting information for the DWSNZ.

1.4 Maximum acceptable values (MAVs)

The MAV of a determinand in drinking-water represents the concentration of a determinand in the water that, on the basis of present knowledge, is not considered to cause any significant risk to the health of the consumer over their lifetime of consumption of that water.

Note the following.

1. The MAVs set in the DWSNZ define water suitable for human consumption and hygiene. Water of higher quality may be required for special purposes, such as **renal dialysis**, for people who are immunocompromised or for certain industrial or agricultural purposes. The DWSNZ do not address these issues.
2. For most **carcinogens** the MAVs in the DWSNZ are the concentrations of substances in drinking-water that have been estimated to cause one additional incidence of cancer in a population of 100,000, each member of which ingests 2 L per day of water containing the substance at the MAV over 70 years.

3. For most other chemicals, MAVs have been calculated using a tolerable daily intake (TDI) approach that identifies the dose below which no evidence exists that significant adverse effects will occur and that will represent no significant risk to a consumer from a lifetime of consumption of 2 L of the water per day. (For a detailed discussion of the derivation of the MAVs see *Guidelines*.)

4. MAVs for chemical determinands of health significance are given in Tables 2.2 and 2.3.

5. The MAVs for **micro-organisms** are determined differently from the chemical MAVs.

    a. Because of the limitations of existing microbial technology, MAVs are not given for all micro-organisms of health significance (eg, all **pathogens**). Instead MAVs are given for the representative organisms ***Cryptosporidium*** (representing the protozoa).

    b. ***Escherichia coli* (*E. coli*)**, a bacterium that indicates the presence of faecal material and, therefore, the potential presence of pathogenic organisms.

    c. A maximum indicator value (MIV, see *Guidelines*) is a more appropriate **parameter** to use for micro-organisms than a MAV. However, for consistency with general usage the term MAV is used throughout the DWSNZ. See Table 2.1.

    d. For radioactive substances, screening values for total alpha and total beta activity are given, based on a reference level of dose. See Table 2.4.

1.5 Operational requirement values

For compliance criteria based on **surrogate** determinands, or an estimation of the efficacy of a treatment process, the DWSNZ specifies **operational requirements** (sometimes called performance MAVs) rather than determinand MAVs. **Free available chlorine (FAC)**, **FAC equivalent (FACE)**[1] and **filter** performance parameters such as the **turbidity** of the filter effluent are examples of this.

1.6 Population data

Throughout these Standards monitoring frequency requirements for a supply are based on the population serviced by the supply. Where the population fluctuates seasonally, the seasonal monitoring frequency must be adjusted to reflect known changes in population (see *Guidelines*).

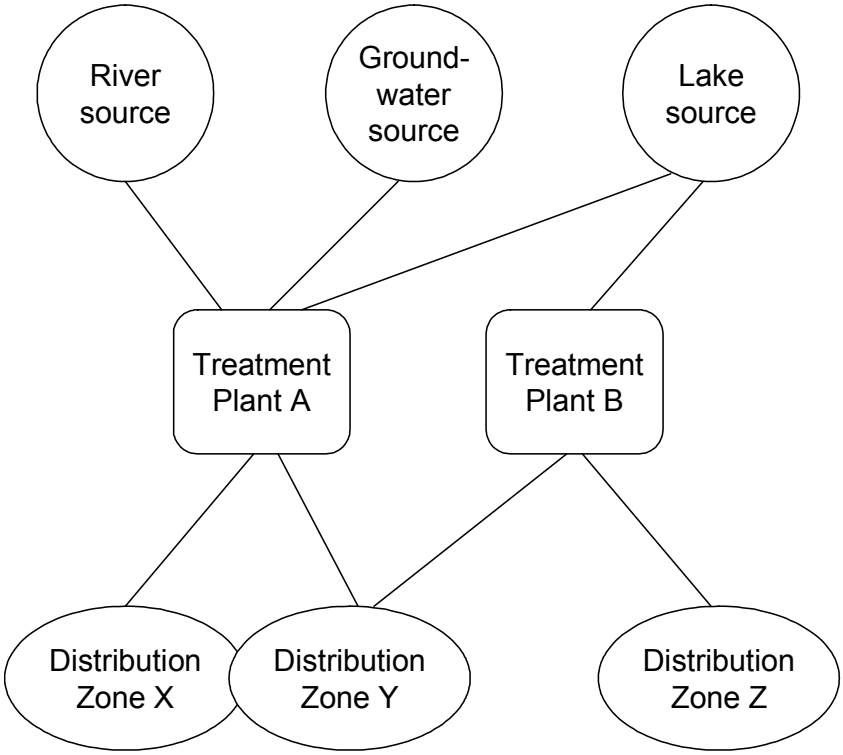
[1] FACE: see section 4.3 page 22.

1.7 Components of drinking-water supply

A **community drinking-water supply** comprises one or more of each of the following (Figure 1.1, below):

- the source or **raw water**
- the treatment plant
- the distribution system.

Figure 1.1: Schematic diagram of drinking-water supply system



Compliance criteria are given for water leaving the treatment plant and in the distribution system. The supplier's PHRMP deals with source water quality issues.

2 Water Quality Standards

2.1 Introduction

The DWSNZ (Tables 2.1–2.4) and the associated compliance criteria (sections 4, 5, 7, 8, 9, 10, 11 and 12) come into effect from 31 December 2005.

2.2 Abbreviations

The following abbreviations are used in Tables 2.1–2.4 or Appendix 3.

ATO	Concentrations of the substance at or below the health-based guideline value that may affect the water's appearance, taste or odour.
ADDA	3-amino-9-methoxy-2,6,8-trimethyl-10-phenyldeca-4,6-dienoic acid
DBP	Disinfection by-product. Any difficulty meeting a DBP MAV must never be a reason to compromise adequate disinfection. Trihalomethanes and haloacids are DBPs. Some DBPs may also have other sources.
ELISA	Enzyme linked immunosorbent assay.
FLD	Fluorescence detection.
HPLC	High performance liquid chromatography.
MAV	Maximum acceptable value.
MC-LR	Microcystin-LR
PMAV	Provisional MAV (because it is provisional in the WHO Guidelines (WHO 2004) or WHO has no guideline value but the DWSNZ has retained a MAV or developed its own).
STX-eq	Saxitoxin-equivalent.
THM	Trihalomethane, of which there are four: bromoform, bromodichloromethane, chloroform and dibromochloromethane.
WHO	World Health Organization.

See the *Guidelines* for an index of compound abbreviations and synonyms.

2.3 Standards

Table 2.1: Maximum acceptable values (MAV) for microbial determinands

Micro-organism	MAV[1]
Escherichia coli (*E. coli*)[2]	Less than 1 in 100 mL of sample
viruses	No value has been set due to lack of reliable evidence
total pathogenic protozoa	Less than 1 (oo)cyst per 100 L of sample

Notes

1 These are maximum acceptable values (MAVs) for regulatory purposes. They do not represent a dose/response relationship that can be used as the basis for determining acceptable concentrations of pathogens in drinking-water.

2 Indicator organism.

Table 2.2: Maximum acceptable values (MAVs) in mg/L for inorganic determinands of health significance

Name	MAV	Remarks
antimony	0.02	
arsenic	0.01	For excess lifetime skin cancer risk of 6×10^{-4}. PMAV, because of analytical difficulties
barium	0.7	
beryllium[1]	0.004	PMAV
boron[2]	1.4	
bromate	0.01	For excess lifetime cancer risk of 7×10^{-5}. PMAV
cadmium	0.004	
chlorate	0.8	PMAV. Disinfection must never be compromised. DBP (chlorine dioxide)
chlorine	5	Free available chlorine expressed in mg/L as Cl_2. ATO. Disinfection must never be compromised
chlorite	0.8	Expressed in mg/L as ClO_2. PMAV. Disinfection must never be compromised. DBP (chlorine dioxide)
chromium	0.05	PMAV. Total. Limited information on health effects
copper	2	ATO
cyanide	0.08	Total cyanides
cyanogen chloride	0.08	Expressed in mg/L as CN. Total. DBP (chloramination)
fluoride[3]	1.5	
lead	0.01	
lithium[1]	1	PMAV
manganese	0.4	ATO
mercury	0.002	Total
molybdenum	0.07	
monochloramine	3	DBP (chlorination)
nickel	0.02	PMAV
nitrate, short term[4]	50	Expressed in mg/L as NO_3. The sum of the ratio of the concentrations of nitrate and nitrite to each of their respective MAVs should not exceed one
nitrite, long term	0.2	Expressed in mg/L as NO_2. PMAV (long term)
nitrite, short term[14]	3	Expressed in mg/L as NO_2. The sum of the ratio of the concentrations of nitrate and nitrite to each of their respective MAVs should not exceed one
selenium	0.01	
silver	0.1	PMAV
uranium	0.02	PMAV

Notes: Where WHO Guideline values are based on 60 kg bodyweight, the DWSNZ uses 70 kg bodyweight. See the datasheets for calculations (WHO 2004).

1 MAV retained despite no WHO guideline value.

2 WHO guideline PMAV is 0.5 mg/L.

3 For oral health reasons the Ministry of Health recommends that the fluoride content for drinking-water in New Zealand be in the range of 0.7–1.0 mg/L. This is *not* a MAV.

4 Now short term only. The short-term exposure MAVs for nitrate and nitrite have been established to protect against methaemoglobinaemia in bottle-fed infants.

Table 2.3: Maximum acceptable values (MAVs) in mg/L for organic determinands of health significance (including cyanotoxins and pesticides)

Name	MAV	Remarks
acrylamide	0.0005	For excess lifetime cancer risk of 10^{-5}
alachlor	0.02	Pesticide. For excess lifetime cancer risk of 10^{-5}
aldicarb	0.01	Pesticide
aldrin + dieldrin	0.00004	Pesticide. The sum of, not each
anatoxin-a	0.006	Cyanotoxin. PMAV
anatoxin-a(s)	0.001	Cyanotoxin. PMAV
atrazine	0.002	Pesticide. Cumulative for atrazine and congeners DEA, DIA, and DACT
azinphos methyl	0.004	Pesticide. PMAV
bentazone	0.4	Pesticide. PMAV
benzene	0.01	For excess lifetime cancer risk of 10^{-5}
benzo(α)pyrene	0.0007	For excess lifetime cancer risk of 10^{-5}
bromacil	0.4	Pesticide. PMAV.
bromodichloromethane	0.06	For excess lifetime cancer risk of 10^{-5}. THM
bromoform	0.1	THM
carbofuran	0.008	Pesticide
carbon tetrachloride	0.005	
chlordane	0.0002	Pesticide
chloroform	0.2	THM
chlorotoluron	0.04	Pesticide
chlorpyriphos	0.04	Pesticide
cyanazine	0.0007	Pesticide
cylindrospermopsin	0.001	Cyanotoxin. PMAV
2,4-D	0.04	Pesticide
2,4-DB	0.1	Pesticide
DDT + isomers	0.001	Pesticide. Sum of all isomers
di(2-ethylhexyl)adipate	0.1	PMAV
di(2-ethylhexyl)phthalate	0.009	
diazinon	0.01	Pesticide. PMAV
1,2-dibromo-3-chloropropane	0.001	Pesticide. For excess lifetime cancer risk of 10^{-5}
dibromoacetonitrile	0.08	DBP (chlorination)
dibromochloromethane	0.15	THM
1,2-dibromoethane	0.0004	PMAV. For excess lifetime cancer risk of 10^{-5}
dichloroacetic acid	0.05	PMAV. DBP (chlorination)
dichloroacetonitrile	0.02	PMAV. DBP (chlorination)
1,2-dichlorobenzene	1.5	ATO
1,4-dichlorobenzene	0.4	ATO
1,2-dichloroethane	0.03	For excess lifetime cancer risk of 10^{-5}
1,1-dichloroethene	0.03	
1,2-dichloroethene	0.06	Total of cis and trans isomers

Name	MAV	Remarks
dichloromethane	0.02	
1,2-dichloropropane	0.05	Pesticide. PMAV
1,3-dichloropropene	0.02	Pesticide. Total of cis and trans isomers. For excess lifetime cancer risk of 10^{-5}
dichlorprop	0.1	Pesticide
dimethoate	0.008	Pesticide
diquat	0.01	Pesticide. PMAV
diuron	0.02	Pesticide. PMAV
EDTA (editic acid)	0.7	
endosulfan	0.02	PMAV
endrin	0.001	Pesticide
epichlorohydrin	0.0005	PMAV
ethylbenzene	0.3	ATO
fenoprop	0.01	Pesticide
fluoranthene	0.004	PMAV
formaldehyde	1	DBP
heptachlor and its epoxide	0.00004	Pesticide. PMAV. Mainly occurs as the epoxide
hexachlorobenzene	0.0001	Pesticide. PMAV.
hexachlorobutadiene	0.0007	
hexazinone	0.4	Pesticide. PMAV
homoanatoxin-a	0.002	Cyanotoxin. PMAV
isoproturon	0.01	Pesticide
lindane	0.002	Pesticide
malathion	1	Pesticide. PMAV
MCPA	0.002	Pesticide
MCPB[1]	0.03	Pesticide. PMAV
mecoprop	0.01	Pesticide
metalaxyl	0.1	Pesticide. PMAV
methoxychlor	0.02	Pesticide
methyl parathion	0.01	Pesticide. PMAV
metolachlor	0.01	Pesticide
metribuzin	0.07	Pesticide. PMAV
microcystins	0.001	Cyanotoxin. PMAV Expressed as MC-LR toxicity equivalents)
molinate	0.007	Pesticide
monochloroacetic acid	0.02	DBP (chlorination)
monochlorobenzene	0.3	PMAV. ATO
nitrilotriacetic acid (NTA)	0.2	
nodularin	0.001	Cyanotoxin. PMAV
oryzalin	0.4	Pesticide. PMAV
oxadiazon	0.2	Pesticide. PMAV
pendimethalin	0.02	Pesticide
pentachlorophenol	0.009	Pesticide. PMAV

Name	MAV	Remarks
permethrin	0.02	Pesticide. PMAV
phenylphenol	1.4	Pesticide. PMAV
picloram	0.2	Pesticide. PMAV
pirimiphos methyl	0.1	Pesticide. PMAV
primisulfuron methyl	0.9	Pesticide. PMAV
procymidone	0.7	Pesticide. PMAV
propanil	0.02	Pesticide. PMAV. Some degradation products may be toxic
propazine	0.07	Pesticide. PMAV
pyridate	0.1	Pesticide. PMAV
pyriproxifen	0.4	Pesticide
saxitoxins	0.003	Cyanotoxin. Expressed as STX equivalent. PMAV
simazine	0.002	Pesticide
styrene	0.03	ATO
2,4,5-T	0.01	Pesticide
terbacil[1]	0.04	PMAV.
terbuthylazine	0.008	Pesticide
tetrachloroethene	0.05	
thiabendazole	0.4	Pesticide. PMAV
toluene	0.8	ATO
tributyltin oxide	0.002	PMAV
trichloroacetaldehyde	0.01	PMAV
trichloroacetic acid	0.2	DBP (chlorination)
trichlorobenzenes	0.03	PMAV. Total concentration of all isomers. ATO
1,1,1-trichloroethane	2	PMAV
trichloroethene	0.08	PMAV
2,4,6-trichlorophenol	0.2	For excess lifetime cancer risk of 10^{-5}. ATO
triclopyr	0.1	Pesticide. PMAV
trifluralin	0.03	Pesticide. Technical grade may contain carcinogens
trihalomethanes (THMs)		The sum of the ratio of the concentration of each THM to its respective MAV should not exceed one. The individual members of this group are indicated in the table as THM
vinyl chloride	0.0003	For excess lifetime cancer risk of 10^{-5}
xylenes (total)[1]	0.6	ATO
1080	0.0035	Pesticide. PMAV

Notes:

- DBP indicates a disinfection by-product. Any difficulty in meeting a MAV must never be a reason to compromise adequate disinfection. Trihalomethanes are DBPs. Some DBPs may also have other sources.
- Where WHO Guideline values are based on 60 kg bodyweight, the DWSNZ uses 70 kg bodyweight. See datasheets for calculations (WHO 2004).

1 Institute of Environmental Science and Research report Gallagher LM and Fowles JF 22.03.05.

Water Quality Standards

Table 2.4: Maximum acceptable values (MAVs) in Bq/L for radiological determinands

Radioactive constituents	MAV	Unit
total alpha activity	0.10	Bq/L excluding radon
total beta activity	0.50	Bq/L excluding potassium-40
radon	100	Bq/L

3 Compliance and Transgressions

3.1 Introduction

The DWSNZ specify criteria for bacteria, protozoa, cyanotoxins, chemicals and radioactive materials of public health significance in drinking-water, including MAVs for determinands and operational requirements for associated treatment processes.

The level of treatment that a raw water requires depends upon the health risk arising from the microbiological quality of the source water from which the raw water is abstracted. Poor quality raw water will require a greater degree of treatment than a good quality water. Source waters are classified according to the health risk from the protozoa that are present. The procedures for classifying source waters are given in section 5.2.1. Raw water from surface sources or non-secure groundwater will require treatment that qualifies for 3, 4 or 5 protozoa log credits, depending on the protozoal risk arising from the quality of the raw water. The number of protozoa log credits that different treatment processes may qualify for is given in section 5.2. If water treatment fails to qualify for the required number of log credits, the supply is non-compliant.

The assessment of bacterial, chemical and radiological compliance requires that the determinands or operational requirements specified in the DWSNZ are monitored.

The assessment of protozoal compliance does not require the monitoring of protozoa in the treated water but requires the monitoring of the operational requirements specified in the DWSNZ.

3.1.1 Transgressions

A transgression occurs when:

- the **result**[2] of the determination of the concentration of a determinand in a sample of the drinking-water exceeds the MAV (a *MAV transgression*)
- a specified performance parameter for a treatment process makes an excursion beyond the operational requirement limits for that parameter for more than the allowed extent or duration (a *performance transgression*).

For MAV transgressions if the number of transgression(s) exceeds the limit specified in Appendix A1.8, Tables A1.3 or A1.4 as appropriate, the drinking-water supply is **non-compliant**. A transgression does not result in the loss of log credits. Loss of log credits requires full non-compliance.

[2] The result of a determination is the actual analytical result. From 1 January 2008, the **adjusted result** will be used for chemical determinands to determine whether or no a transgression has occurred. See Appendix A1.2.

If a performance transgression occurs it provides a warning to the supplier that the treatment process is approaching non-compliance and the Drinking-Water Assessor (DWA) must be informed. Remedial action should be commenced. A performance transgression does not automatically result in non-compliance.

The term 'transgression' applies to a single sample or event.

A *major transgression* is one that immediately threatens the safety of the consumers of the drinking-water. Most transgressions are likely to result from inadequate control of a treatment process. Major transgressions can be identified by any of the following signs:

- the presence in the treated drinking-water of:
  - excessive concentrations of *E. coli* (more than 10/100 mL), or
  - protozoa, or
  - cyanotoxins, or
  - chemical determinands at a concentration sufficient to cause acute adverse health effects
- the treatment system's inability to disinfect to the level necessary to achieve satisfactory disinfection
- the treatment system's inability to provide an adequate barrier to particles in the water.

Possible causes of the treatment system's inability to provide adequate water quality include power failure and the exhaustion of the supply of treatment chemicals. Other causes are discussed in more detail in the Ministry of Health's Public Health Risk Management Plan (PHRMP) Guides (Ministry of Health 2001, and Ministry of Health forthcoming (b)).

Water suppliers must not wait until a transgression limit has been exceeded before applying any **remedial action**. The supplies' Public Health Risk Management Plan (PHRMP) must define a **control limit** for each compliance criterion. The PHRMP must specify the actions to be taken if there is an excursion beyond the control limit, for example, when dosing equipment fails or when a determinand or operational requirement reaches or breaches the control limit. Control limits are often set at about two-thirds of the MAV or requirement.

Major transgressions are serious. The actions specified by the PHRMP must be immediately carried out and must include informing the **Drinking-water Assessor (DWA)** so that the DWA can help to identify the steps needed to protect consumers. For the purposes of this document, DWA refers to a designated Health Protection Officer who has been accredited by International Accreditation New Zealand (IANZ) to perform drinking water assessment functions. In this and all subsequent references to the DWA, the DWA is acting on behalf of the Medical Officer of Health.

3.1.2 Compliance

The steps that are necessary to demonstrate that a drinking-water supply is in bacterial, protozoal, cyanotoxin, chemical and radiological compliance with the DWSNZ are specified in specific **compliance criteria** sections.

Different procedures apply depending on whether non-compliance results from:

- exceedence of MAVs
- excursions beyond the transgression limits specified for operational requirements
- incorrect monitoring procedures (eg, inadequate sampling, incorrect calibration of metering equipment, analyses not being carried out by a laboratory recognised for the purpose, etc).

For compliance criteria based on the concentration of a determinand not exceeding the MAV (a MAV transgression) a certain number of transgressions are allowable. However, if the number of transgression(s) occurring in the compliance monitoring period exceeds the limit specified in Appendix A1.8 the drinking-water supply is **non-compliant**. Appendix A1.8, Table A1.3 gives the number of permissible exceedences for 95 percent compliance, Table A1.4 gives the number of permissible exceedences for 98 percent compliance.

The **compliance monitoring period** is the period of monitoring over which the allowable number of MAV exceedences are calculated. The allowable number of exceedences is calculated on the basis that there is 95 percent confidence that the supply complies with the DWSNZ for 95 percent of the time.

The compliance monitoring period varies from a day to a year, depending on the determinand and the circumstances.

The **compliance criterion**. If the operational requirements do not comply with the compliance criterion for the process, the process will not achieve the requisite number of log credits. The supply itself may achieve compliance if it can achieve the necessary log credit total (see section 5.2.1) through the accumulation of log credits from other processes.

A drinking-water supply complies with the DWSNZ when the following occur.

- The number of measurements made for each compliance criterion is equal to or greater than that specified in the DWSNZ.
- The requirements of the compliance criterion have been met throughout the previous 12 months (the **compliance assessment period**).[3]
- The remedial actions specified in the DWSNZ have been carried out whenever there has been an excursion beyond a transgression limit.

[3] In the event of an existing supply being augmented by a new supply the combined supply will be deemed to be in compliance provided that it continues to meet the compliance requirements.

Any failure to take or deliver samples or to adhere to the specified sampling requirements must be reported immediately to the DWA and a repeat sample taken as soon as possible. The DWA may grant an exemption if the following procedures have been complied with.

To avoid the risk of non-compliance on the grounds that the monitoring regime does not satisfy the compliance criteria, the supplier should enter into a written agreement about the monitoring programme[4] with the appropriate **designated officer** (referred to in this publication as a drinking-water assessor (DWA)). This agreement may be combined with the PHRMP. The agreed monitoring programme must include sufficient additional samples to meet any deficiencies that arise from a failure to comply with the programme prescribed in the DWSNZ. These additional sample results may offset any subsequent failure to carry out adequate monitoring, provided the DWA considers the circumstances giving rise to the deficit are justifiable. Records must be kept for at least 10 years to enable trends to be detected and to establish the statistical significance of results (Regulation 5 of the Health (Retention of Health Information) Regulations 1996). Laboratories recognised for the purpose by the Ministry of Health must be used for all analyses carried out to assess compliance with the DWSNZ, except where special procedures[5] are authorised by a DWA for small remote drinking-water supplies or for analyses in the field or treatment plant.

If it is not feasible to use a recognised laboratory, the Ministry of Health may accept alternative evidence of another laboratory's competence. This requires the selected laboratory to demonstrate compliance with the relevant clauses of the *General Requirements for the Competence of Testing and Calibration Laboratories* (NZS/ISO/IEC/EN 17025: 2000) (IANZ 2000).

The referee methods specified in Appendix 3 are the definitive methods for demonstrating compliance with the DWSNZ. Alternative methods are acceptable but must have been calibrated against the referee methods. In the event of any dispute about differences in analytical results, results obtained using the referee method will be deemed to be correct.

The tables in Appendix 3 will assist in selecting the appropriate sampling and analytical methods for the chemicals with MAVs.

[4] The Ministry of Health's Water Information New Zealand (WINZ) can be used to check that a monitoring programme will be compliant.

[5] See section 4.3.6.

3.2 Continuous monitoring requirements

Parameters continuously monitored to assess the performance of treatment processes must meet the following requirements except where specifically authorised otherwise (eg, in Table 5.3).

1. The separation between data records is not to be more than:
   - one minute for measurements of:
     - turbidity
     - ozone concentration
     - differential pressure
     - flow
     - all continuously monitored parameters for **UV disinfection** (section 5.16.3, Table 5.7b)
     - any parameter used for **indirect integrity testing** for membrane filtration
   - five minutes for measurements of:
     - chlorine concentration
     - pH
     - chlorine dioxide concentration.

   As an interim measure, in situations where filters share turbidimeters until one turbidimeter is installed on each filter, monitoring must be carried out in such a way as to give the greatest period of continuous monitoring possible with the existing configuration.

   The data records may be compressed using a procedure that preserves the **accuracy** of raw data and must be reported as a percentage of the time the value was exceeded (or met) during the compliance monitoring period and the maximum excursions beyond the transgression limit.

2. In supplies serving more than 100 people, continuous monitors, where installed, must be calibrated at least as frequently as recommended by the equipment suppliers and must provide an **alarm** system (eg, for disinfectant residual, turbidity, or dosage monitor) that can prompt a site visit, without delay, to service the fault or condition.

3. When equipment providing continuous disinfectant dosing fails, there is no longer confidence that the water supply is safe. The following immediate actions must be taken if equipment that carries out disinfection fails for more than one hour.

   a. Advise the DWA.

   b. Carry out the remedial actions specified in the PHRMP to be taken in the case of a dosing failure. These may include:
      - investigating the cause of the fault and remedying it
      - temporarily using an alternative disinfection system and/or method
      - switching to a different supply
      - discharging the non-disinfected water to waste.

4. For bacterial compliance, if online monitoring for compliance with the operational requirements ceases for more than one hour:

   either

   a. immediately start *E. coli* monitoring (criterion 1) at the frequency appropriate to the population and treatment process (Table 4.3a)

   or

   b. carry out twice-daily manual measurement of the disinfectant, and pH, turbidity or flow, as necessary to demonstrate compliance.

5. For protozoal compliance, if online monitoring for compliance with the operational requirements ceases for more than one hour, the compliance parameter(s) must be measured on an hourly basis unless the DWA agrees to a lower frequency on the grounds that previous monitoring evidence indicates that the treatment processes will continue to be satisfactory.

6. After online monitoring has been restored:

   for 4 continue with 4a or 4b for the day the monitoring has been restored and for the following day

   for 5 continue manual testing for four hours after the online monitoring recommences. One further manual test must be carried out the next day for validation against the online instrument.

7. If a filter or disinfection unit is off-line for more than 21 days in a month, consecutive data from the previous month may be used to make up data for the remainder of the compliance period in order to demonstrate compliance, provided the water produced by the treatment plant has been treated by a filtration or disinfection process shown to be compliant by actual measurement for the whole compliance monitoring period.

Thus, if there is one chlorinator at a TP, and it is taken off line, the above cannot be used to demonstrate compliance as the water is not being produced by a chlorination unit that achieves compliance by direct measurement.

3.3 Priority classes for drinking-water determinands

The determinands of public health significance have been divided into four priority classes to minimise monitoring costs without compromising public health. To demonstrate compliance, only those relatively few determinands that fall into the classes with highest potential risk, Priorities 1 and 2, must be monitored. Monitoring of determinands in the lower potential risk categories, Priorities 3 and 4, is at the supplier's discretion, unless the DWA requires it for public health reasons.

3.3.1 Priority 1 determinands

Priority 1 determinands are those whose presence can lead to rapid and major outbreaks of illness.

Contamination of water supplies by pathogens usually arises from faecal material or wastes containing such materials. Humans, birds, or animals may be the source. The determinands known to fall into this category in New Zealand include the pathogenic bacteria, protozoa and **viruses**. This may change as new evidence becomes available.

E. coli, a common gut bacterium living in warm-blooded animals, is used as an indicator of the contamination of water by excrement. It is a generally accepted indicator for faecal material, indicating the potential presence of pathogenic micro-organisms.

Priority 1 determinands are:

- *E. coli*
- protozoa (*Cryptosporidium*[6] and ***Giardia***).

Priority 1 determinands apply to all community drinking-water supplies in New Zealand and must be monitored in all supplies because they constitute major public health risks.

In the DWSNZ, the criteria used for protozoal compliance are based on the use of:

1. turbidity to assess the effectiveness of conventional treatment using **coagulation** plus filtration (direct or with **sedimentation/flotation**), **diatomaceous earth filtration** and **slow sand filtration, measured either by turbidimetry or (once a relationship between particle counts and filtration efficiency has been established), particle counting**.
2. **direct integrity testing** of **membrane filtration** plants
3. indirect integrity testing (such as pressure drop, turbidity and some operating conditions) for **bag filters**, **cartridge filtration** and membrane filtration
4. contact-time (C.t) values, monitoring the chemical disinfectant's residual and operating conditions to assess the adequacy of disinfection
5. specification of dosage and operating conditions for effective UV disinfection
6. demonstrations that the water has come from a secure **groundwater** source free from these organisms.

[6] *Cryptosporidium* is the reference protozoan. It is more difficult to treat than *Giardia*, and any measures taken to manage risks from *Cryptosporidium* will also manage risks from *Giardia*.

3.3.2 Priority 2 determinands

Priority 2 determinands are those determinands of public health significance in a specific supply or **distribution zone** that are present at concentrations that exceed 50 percent of the MAV and, for micro-organisms, are present at concentrations that represent an unacceptable risk to health. Determinands specified by the Ministry of Health to be Priority 2 determinands for the drinking-water supply under consideration must be monitored to establish compliance with the DWSNZ. Information about the compliance criteria and the sampling and analytical conditions for microbial, chemical and radiological determinands is contained in sections 4, 5, and 7, 8, 9. The designation of a Priority 2 determinand to a given supply is based on monitoring and knowledge of the sources of health-significant determinands in the catchment, treatment processes and distribution system. The DWA responsible for assessing the supply notifies the water supplier of the designation after consulting the supplier and reviewing any contrary evidence.

The Priority 2 determinands for individual supplies are also listed in the Ministry of Health's *Register of Community Drinking-Water Supplies and Suppliers in New Zealand* (Ministry of Health 2002). The requirement to monitor a Priority 2 determinand starts from the date the Ministry of Health formally notifies the supplier of the determinand's designation as Priority 2, *not* with the date of its publication in the register.

Priority 2 determinands are divided into three types: 2a, 2b and 2c.

- **Priority 2a:** Chemical and radiological determinands that could be introduced into the drinking-water supply by the treatment chemicals at levels potentially significant to public health (usually greater than 50 percent of the MAV).

  Priority 2a does not include disinfection by-products or determinands introduced into the drinking-water from piping or other materials.

- **Priority 2b:** Chemical and radiological determinands of health significance that have been demonstrated to be in the drinking-water supply at levels potentially significant to public health (usually greater than 50 percent of the MAV).

  Priority 2b includes chemicals present in the raw water that may not be removed by the treatment process, any disinfection by-products and determinands introduced into drinking-water from the distribution system other than the consumer's plumbing, or other materials present in the water when sampled under normal (flushed) protocols.

  Priority 2b does not include determinands introduced by treatment chemicals.

  Note: **Plumbosolvency** is not a Priority 2 determinand. It is a separate category of drinking-water in which metals of health concern are found only in the first flush of water collected from the tap (ie, they are not present at excessive levels in samples collected after flushing). These determinands are produced by the corrosion of the consumer's plumbing when water stands in contact with taps or other fittings, so that one or more metals, for example, lead, nickel, cadmium or antimony, dissolve from the fitting.

- **Priority 2c:** Micro-organisms of health significance that have been demonstrated to be present in the drinking-water supply.

  Any pathogenic micro-organism may be listed as a Priority 2c determinand if there is reason to suspect it is likely to be present in the drinking-water supply at a concentration that represents an unacceptable risk to health. This may occur, for example, when high numbers of these organisms are present in the raw water and *E. coli* is present in water leaving the treatment plant. The DWA may declare such organisms as Priority 2c if a specific contamination situation or epidemiological grounds exist for suspecting the drinking-water supply.

  The monitoring protocols that will apply will be specified when the micro-organisms are assigned Priority 2c status and will usually include a **sanitary inspection** to try to identify the source of the contamination.

- **Priority 2 (cyanotoxins):** Cyanotoxins can appear very rapidly, and there is no simple relationship between their appearance and the concentrations of the **cyanobacteria** (blue-green **algae**) that produce them. Because of this, and because they are very toxic, the monitoring requirements differ from those of most other Priority 2 chemical determinands.

A Priority 2 determinand may be relegated to Priority 3 or Priority 4 with the Ministry of Health's consent when monitoring has demonstrated it should be assigned a lower priority. See section 8.2.2.

3.3.3 Priority 3 determinands

The water supplier does not have to monitor Priority 3 determinands. The Ministry of Health will carry out investigations on water supplies from time to time to assess whether Priority 3 determinands should be elevated to Priority 2 until such time as the drinking-water suppliers' water supply risk assessment procedures are adequate for the supplier to do such investigations themselves.

Priority 3 determinands are divided into four types: 3a, 3b, 3c and 3d.

- **Priority 3a:** Chemical and radiological determinands of health significance arising from treatment processes in amounts not known to exceed 50 percent of the MAV.

- **Priority 3b:** Chemical and radiological determinands of health significance not known to occur in the drinking-water supply at greater than 50 percent of the MAV.

  Most chemicals or attributes listed in Tables 2.2–2.4 are Priority 3a or Priority 3b, unless they have been assigned to Priority 2a or Priority 2b for a particular supply; a few are Priority 4.

- **Priority 3c:** Micro-organisms of health significance that could be present in the drinking-water supply.

  Any or all pathogenic micro-organisms are Priority 3c unless they have been assigned to Priority 2c for a particular supply. Although Priority 3c micro-organisms may have a MAV, like all Priority 3 determinands, no related compliance criteria exist until they are assigned to Priority 2 when the DWA will set compliance criteria depending on the circumstances.

- **Priority 3d:** Determinands of aesthetic significance known to occur in the drinking-water supply.

  Aesthetic determinands are classified as Priority 3d because, although they do not pose a direct threat to public health, people judge drinking-water mainly on the aesthetic characteristics of appearance, taste and smell. Therefore, an aesthetically unacceptable drinking-water supply may cause them to change to an alternative and potentially unsafe supply or treatment process. For this reason, it is preferable water supply authorities monitor these determinands, although they are not required to do so to comply with the DWSNZ.

3.3.4 Priority 4 determinands

Priority 4 determinands are divided into three types: 4a, 4b and 4c.

- **Priority 4a:** Chemical and radiological determinands of health significance known not to be likely to occur in the drinking-water supply.
- **Priority 4b:** Micro-organisms of health significance known not to be likely to be present in the drinking-water supply.
- **Priority 4c:** Determinands of aesthetic significance not known to occur in the drinking-water supply.

Priority 4 determinands for a specific supply include those health-significant or aesthetic determinands for which sufficient information exists to consider it unlikely they would be present in a particular supply. Some of these are listed in Tables A2.1 and A2.2.

Some determinands, including some pesticides, will be Priority 4 for all New Zealand drinking-water because they are not used in New Zealand. They are included in the tables to ensure MAVs are available should they be used in the future.

Priority 4 determinands may become Priority 2 if the Ministry of Health considers this warranted.

Compliance and Transgressions

4 Bacterial Compliance Criteria

4.1 Introduction

It is impracticable to monitor water supplies for all potential human pathogens, so surrogates are used to indicate the possible contamination of the water supply with human and animal excrement, the most frequent source of health-significant microbial contamination of water supplies. In the DWSNZ, *E. coli* is used as an indicator of contamination of drinking-water by faecal material. The MAV for *E. coli* is less than 1 *E. coli* in 100 mL of sample.

Total or **presumptive coliforms**, or thermotolerant (faecal) coliforms, may be used for drinking-water monitoring to demonstrate compliance with the DWSNZ instead of *E. coli*, but these may lead to false assumptions that faecal contamination has occurred. However, if they are used, a positive result must be treated as though it were a positive *E. coli* result.

If any bacteria have been designated as Priority 2c, they must be monitored at a frequency and for a duration specified by the DWA.

E. coli must not be present in drinking-water leaving the water treatment plant or in the distribution zones. If the *E. coli* MAV is exceeded, the immediate response specified in the following sections must be followed and a record of the remedial actions provided to the DWA.

If more than 0.2 mg/L of free available chlorine (FAC) or chlorine dioxide is maintained in the drinking-water supply **reticulation**, coliform bacteria and *E. coli* are rarely found. For this reason it is permissible to substitute monitoring of FAC for some *E. coli* monitoring in the distribution network. Full substitution is acceptable for water leaving the treatment plant and water in a **bulk distribution zone**.

The efficacy of chlorine dioxide is equivalent to that of chlorine, that is, a concentration of 0.2 mg/L of chlorine dioxide is considered to have a similar disinfecting power as 0.2 mg/L of FACE.

4.2 Content

Separate bacterial compliance criteria have been established for:

- water leaving the treatment plant (section 4.3)
- water in the distribution system (section 4.4)
- secure groundwater (section 4.5).

Section 4.3 deals with water leaving the treatment plant:

- undisinfected (section 4.3.1)
- with a chlorine residual (section 4.3.2) after:
  - continuously monitored chlorination (section 4.3.2.1)
  - non-continuously monitored chlorination (section 4.3.2.2)
  - continuously monitored chlorine dioxide treatment (section 4.3.3)
- with no chlorine residual:
  - ozone disinfected (section 4.3.4)
  - UV disinfected (section 4.3.5).

In addition to these specific compliance criteria, the remedial procedures specified in sections 4.3.9, 4.4.6 and 4.4.11 must be followed if a transgression occurs and the actions taken must be documented. PHRMPs must identify the possible causes of major transgressions (discussed in section 3.1.1), the actions to be taken to reduce their likelihood, and what to do in the event of their happening.

Annual bacterial compliance requires that, depending on the compliance criterion in use, the appropriate requirements of sections 4.3 and 4.4 are met during each compliance monitoring period over 12 consecutive months.

Note: Secure groundwater and water treated only by disinfection are considered to 'leave the treatment plant' at the point where the water enters the distribution system.

4.3 Compliance criteria for drinking-water leaving treatment plant

Sections 4.3.2, 4.3.3, 4.3.4 and 4.3.5 specify the criteria applying to supplies disinfected with chlorine, chlorine dioxide, ozone and UV respectively.

To demonstrate bacterial compliance for water leaving a treatment plant, bacterial compliance criterion 1 (section 4.3.1) or 2 (made up of criteria 2A (section 4.3.2.1) or 2B (section 4.3.2.2), or 3 (section 4.3.3) or 4 (section 4.3.4) or 5 (section 4.3.5) must be met. In all cases, the sampling, analytical and reporting procedures must comply with the DWSNZ.

Criterion 1 is the default criterion used for bacterial compliance. It must be used when there is no disinfection or when the **disinfection residual** cannot be demonstrated to be adequate to disinfect the water (eg, when there is dosing or monitoring equipment failure). Criterion 2A or Criterion 3 may be used when a disinfectant residual is monitored continuously. Criterion 2B is used when non-continuous free available chlorine equivalent (FACE) and *E. coli* monitoring are used. The FACE is the FAC concentration that would have the same disinfecting power as the chlorine solution would have when adjusted to a **pH** of 8.0 (see Appendix A1.5.12, Figure A.1.1). To determine the FACE, it is necessary to measure FAC and pH.

Supplies that usually use criterion 2, 3, 4 or 5 for demonstrating bacterial compliance must use criterion 1 when the requirements of criterion 2, 3, 4 or 5 cannot be met, for example, during periods of instrument servicing or high filtered water turbidity.

Compliance monitoring periods for bacterial compliance are listed in Table 4.1.

Table 4.1: Compliance monitoring periods for bacterial compliance

Determinand or treatment performance parameter	Population served	Compliance monitoring period
Manual monitoring		
E. coli turbidity pH	Up to 5000	One year
	5001 and over	One quarter
free available chlorine chlorine dioxide ozone/C.t	Up to 500	One year
	501–5000	One quarter
	Over 5000	One month
Continuous monitoring		
free available chlorine chlorine dioxide ozone/C.t ultraviolet intensity turbidity pH	All	One day

4.3.1 Compliance criterion 1 for drinking-water leaving treatment plant

This section specifies the criteria that apply to drinking-water leaving the treatment plant when only *E. coli* monitoring is used to demonstrate compliance or when the water has not been disinfected or has no (or inadequate) disinfectant residual. To comply with criterion 1 requirements, the following requirements must be met.

1. The water leaving the treatment plant is monitored for the presence of *E. coli* at a frequency equal to or greater than that specified in section 4.3.8.1, Table 4.2a, for the population band and treatment type to which the water supply belongs. Thus waters disinfected by ozone or UV light are monitored for *E. coli* at the frequency given in the last row of Table 4.2a.
2. The maximum number of 100 mL samples in which *E. coli* is found is equal to or less than the allowable number of exceedences in Appendix A1.8, Table A1.3 over the compliance monitoring period (Table 4.1).
3. The sampling and analytical requirements specified for *E. coli* in sections 4.3.6, 4.3.7.1 and 4.3.8.1 are met.
4. The turbidity and pH requirements in section 4.3.2.1 (for continuously monitored determinands) or 4.3.2.2 for manually monitored determinands with the exception

of water sourced from a secure groundwater. The sampling frequency for turbidity and pH is given in Table 4.2(b).

4.3.2 Compliance criterion 2 for chlorine disinfected drinking-water leaving treatment plant with chlorine residual

For the purpose of criterion 2, chlorination is categorised as one of:

- continuously monitored chlorination (criterion 2A)
- non-continuously monitored chlorination (criterion 2B).

Continuously monitored chlorinated supplies may use FAC monitoring in place of *E. coli* monitoring.

Disinfected supplies that are **non-continuously monitored** for FAC must be monitored for *E. coli* according to Table 4.2.

If the requirements of either section 4.3.2.1 or section 4.3.2.2 are not met, one of section 4.3.1 (Criterion 1), 4.3.3 (Criterion 3), 4.3.4 (Criterion 4) or 4.3.5 (Criterion 5) must be complied with.

4.3.2.1 Compliance criterion 2A for continuously monitored chlorine disinfected water leaving a treatment plant

This section specifies the criteria that apply to drinking-water that receives continuously monitored chlorination before leaving the treatment plant. To comply with criterion 2A requirements, the following requirements must be met.

1. The appropriate sampling requirements in section 4.3.7 are met.
2. The FAC, pH and turbidity must be monitored continuously (refer general requirements of sections 3.2 and 4.3.8.2, 4.3.8.3 and 4.3.8.4 respectively).
3. The FAC in the water leaving the plant does not fall below a FACE of 0.2 mg/L for more than 2 percent of the compliance monitoring period (Table 4.1).
4. The remedial actions described in section 4.3.9 and Figure 4.1 (page 37) are followed if the FACE falls below 0.10 mg/L. Any drop in FACE below 0.2 mg/L is reported to the DWA.
5. The chlorine **contact time** must be more than 30 minutes, taking account of short circuiting in the contact tank.
6. Measurements of the water's turbidity satisfy the following requirements.
   a. The turbidity does not exceed 1.0 NTU[7] for more than 5 percent of the compliance monitoring period (Table 4.1).
   b. The turbidity does not exceed 2.0 NTU for the duration of any three-minute period.

[7] NTU ~ nephelometric turbidity unit.

4.3.2.2 Compliance criterion 2B for non-continuously monitored chlorine disinfected water leaving a treatment plant

This section specifies the criteria that apply to drinking-water that receives 'non-continuously monitored chlorination' before leaving the treatment plant. Plants in which the chlorine is always dosed to achieve a FACE of at least 0.2 mg/L but that do not satisfy all the criteria for continuously monitored chlorination are classed as receiving 'non-continuously monitored chlorination'. To comply with criterion 2B requirements, the following requirements must be met.

1. Section 4.3.1 requirement 1.
2. Section 4.3.1 requirement 2.
3. The appropriate analytical and sampling requirements in sections 4.3.6 and 4.3.7.
4. The FAC, pH and turbidity must be monitored at the frequencies specified in sections 4.3.8.2, 4.3.8.3 and 4.3.8.4 respectively.
5. The FACE in the water leaving the plant must not be less than 0.2 mg/L in any sample.
6. The remedial actions described in section 4.3.9 and Figure 4.1 (page 37) are followed if the FACE falls below 0.10 mg/L. Any drop in FACE below 0.2 mg/L is reported to the DWA.
7. The chlorine contact time must be more than 30 minutes, taking account of short circuiting in the contact tank.
8. Measurements of the water's turbidity must satisfy the following requirements.
    a. The number of samples with turbidity greater than 1.0 NTU does not exceed the number allowed in Appendix A1.8, Table A1.3, over the compliance monitoring period (Table 4.1).
    b. The turbidity of the water after chlorination but before addition of chemicals that affect the turbidity does not exceed 2.0 NTU in any sample.

4.3.3 Compliance criterion 3 for chlorine dioxide disinfected drinking-water leaving a treatment plant

Chlorine dioxide must not be used if the resultant chlorite concentration in the water exceeds the chlorite MAV (0.8 mg/L). Chlorite is potentially a Priority 2a determinand. See also sections 5.14 and 8.3.3.

Chlorine dioxide-disinfected water supplies can achieve bacterial compliance by meeting either of the following requirements.

1. The protozoal compliance requirements for 0.5 log credits in section 5.14.
2. Section 4.3.2.1 or 4.3.2.2 as appropriate, requirements (except FAC monitoring is replaced by FAC and chlorine dioxide monitoring).[8]

[8] Some FAC may appear in the final water so FAC and chlorine dioxide concentrations must be monitored.

4.3.4 Compliance criterion 4 for ozone disinfected drinking-water leaving treatment plant with no chlorine residual after ozone treatment

NB: Ozone must not be used if the resulting concentration of bromate exceeds the bromate MAV (0.01 mg/L). Bromate is potentially a Priority 2a determinand. See also sections 5.15 and 8.3.3.

4.3.4.1 Compliance criteria

1. The requirements of sections 4.3.1, 5.15.1(a) and (b), 5.15.2(b), and 5.15.3, must be met.
2. The ozone C.t value must not be less than the C.t value required to give 0.5 protozoa log credits at the measured water temperature (see section 5.15.1, Table 5.6).
3. For supplies serving 500 or fewer people, the flow through the equipment must be restricted so that the flow rate cannot exceed the flow that gives the contact time required to meet the target C.t value.
4. The compliance monitoring periods are given in section 5.4.2, Table 5.3.

4.3.4.2 Monitoring

1. For supplies serving more than 500 people monitoring must be continuous. The requirements of section 3.2 must be met.
2. For both continuous and manual monitoring:
    a. The ozone concentration and water flow rate must be monitored at frequencies greater than or equal to those specified in section 4.3.8.6.
    b. *E. coli* must be monitored in water leaving the treatment plant, at a frequency equal to or greater than that specified in section 4.3.8.1, Table 4.2a, for the population band and treatment type to which the water supply belongs. Thus waters disinfected by ozone are monitored at the frequency given in the last row of Table 4.2a.
    c. Turbidity must be monitored according to the requirements of section 4.3.8.4.

4.3.4.3 Transgressions and remedial action

1. For continuous monitoring, the **C.t value** determined from the measured ozone residual and flow rate, adjusted to incorporate the effects of ozone decay and reactor hydraulics (see the *Guidelines*), must meet the C.t value for the measured water temperature required to give 0.5 protozoa log credits (section 5.5.1, Table 5.6) for more than 98 percent of the compliance monitoring period given in Table 4.1.
2. For manual monitoring, the number of **C.t values** determined from the measured ozone residual and flow rate, adjusted to incorporate the effects of ozone decay and reactor hydraulics (see the *Guidelines*) that fail to meet the C.t value for the measured water temperature required to give 0.5 protozoa log credits (section 5.5.1, Table 5.6) must not exceed the number allowed in Appendix A1.8, Table A1.3, over the compliance monitoring period (see Table 4.1).

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4.3.5 Compliance criterion 5 for ultraviolet light (UV) disinfected drinking-water leaving treatment plant with no chlorine residual

Water supplies disinfected using UV can achieve bacterial compliance by meeting either of the following requirements.

1. The protozoal compliance requirements of sections 5.16 for 3 protozoa log credits, and 4.3.1

or

2. The requirements of section 4.3.1 and the following requirements.

    a. The equipment validation requirements of section 5.16.2 and monitoring requirements of section 5.16.3 are met.

    b. The UV dose (fluence) must not drop below the **reduction equivalent dose (RED)** target equal to that required for 3 log protozoa credits (ie, 36 mJ/cm^2 for LP or LPHO lamps or 42 mJ/cm^2 for MP lamps – see section 5.16.1) for more than 2 percent of the compliance monitoring period (Tables 4.1 and A1.4) and must not be less than 36 mJ/cm^2 for the duration of any three-minute period.

    c. The water entering the UV reactor(s) has a transmittance (measured in a 10 mm silica cell at 254 nm) of not less than 80 percent cm^{-1} all the time, and, if the reactor was validated at higher transmittances than 80 percent cm^{-1}:

        i. the UV transmittance is not less than 95% of the lowest transmittance for which the reactor has been validated for more than 5% of the time, and

        ii. the UV transmittance is not less than 90% of the lowest transmittance for which the reactor has been validated for more than 1% of the time.

    d. Section 4.3.2.1 requirement 6 is met.

    e. If the appliance has a minimum flow requirement for effective operation, the flow is never less than this.

    f. The maximum flow through the equipment is restricted to less than the manufacturer's design flow.

    g. For continuously monitored parameters the requirements of section 3.2 are met.

4.3.6 Compliance sampling and on-site analytical procedures for water leaving treatment plant: *E. coli* samples

Procedures for sampling, sample preservation, sample transport, storage, test methods and reporting must be agreed beforehand with the Ministry of Health recognised laboratory carrying out the analysis.

E. coli samples must be collected aseptically, in sterile bottles, using sodium thiosulphate to dechlorinate the sample if necessary. Testing should start within six hours of sample collection and should not be delayed more than 24 hours after collection.

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Samples must be transferred to the laboratory in a cool, dark container. It is important the temperature of samples does not increase between the taking and analysing of the samples. To be valid for compliance testing, samples must not be frozen and must arrive at the laboratory at a temperature not higher than 10°C or not higher than the temperature of the water being sampled. If samples cannot be processed immediately on their arrival in the laboratory, they must be stored in a refrigerator.

When special procedures are required, the DWA must authorise them.

4.3.7 Sampling sites for bacterial compliance of water leaving treatment plant

4.3.7.1 *E. coli*

Samples for *E. coli* must be taken from drinking-water leaving the treatment plant at a point after the prescribed disinfection contact time has elapsed but before the first consumer.

For supplies where the treatment plant serves 500 people or less and has only one distribution zone, samples prescribed to be taken from water leaving the treatment plant may be taken from the distribution zone instead if this is more convenient. This is on condition the 'treatment plant' samples are taken from the first available tap after the treatment plant, sampling is at the frequency specified in Table 4.2a and no *E. coli* is found. These samples are additional to those required for monitoring the distribution zone (Table 4.3a) that are to be collected from points closer to the extremities of the distribution zone (see also section 10).

The samples prescribed to be taken from drinking-water leaving the treatment plant may be omitted for supplies to a single building (or a complex of not more than three buildings) that serve a population of less than 150 people and where, because of the short length of the reticulation system, contamination is unlikely to occur in the reticulation.

4.3.7.2 Disinfectants

The FAC (and, if relevant, the chlorine dioxide) sampling site must be where the adequacy of the disinfectant residual, the 30-minute minimum disinfection contact time and the pH can be demonstrated clearly (see the *Guidelines*), but before the first consumer. The disinfectant residual measurement must be made as close as possible to where the *E. coli* samples are taken.

Where lime is used for pH correction, samples for turbidity may be taken before the lime dosing.

Note: If chlorine dioxide is also being used for protozoa **inactivation**, the contact time is likely to be much greater than 30 minutes.

Online process control measurements of FAC or chlorine dioxide concentration made after only a short contact time may be used instead of readings from drinking-water leaving the plant provided:

- a reliable correlation has been established, documented and monitored between the disinfectant concentration after the short contact time and the disinfectant concentration of drinking-water leaving the treatment plant
- the minimum value of the process control FAC or chlorine dioxide concentration that has been established to be necessary to attain a minimum FACE or chlorine dioxide concentration of 0.2 mg/L in drinking-water leaving the treatment plant becomes the value used to demonstrate compliance.

4.3.8 Sampling frequencies for compliance of water leaving treatment plant

4.3.8.1 *E. coli*

The minimum sampling frequencies for *E. coli* for the bacterial compliance criteria are specified in Table 4.2a (column 3). The maximum number of days between samples (Table 4.2a, column 4) must not be exceeded. The number of days of the week used for sampling must not be fewer than the minimum number specified in Table 4.2a (column 5) (ie, different days of the week must be used).

When a supply's population increases temporarily, such as in a holiday period, additional sampling must be performed during that period so the sampling frequency is at least that specified for the population actually present. The increased monitoring programme must be agreed with the DWA.

Water supplies using slow sand filtration and bacterial compliance criterion 1 must monitor *E. coli* at twice the frequency listed in Table 4.2a (column 3) when the water temperature falls below 6°C.

Table 4.2a: Minimum sampling frequency for *E. coli* in drinking-water leaving treatment plant[1]

Supply type	Population served	Minimum sampling frequency	Maximum days between samples[2]	Minimum days of the week used
Secure groundwater supplies	All	Monthly[3]	45 (135)[3]	3 (1)[3]
No or inadequate disinfection[4] (or others using criterion 1)	Up to 500[1]	Weekly	13	5
	501–10,000	Twice a week	5	6
	More than 10,000	Daily	1	7
Chlorinated: non-continuously monitored[5] (criterion 2B)	Up to 500[1]	Fortnightly	22	3
	501–10,000	Weekly	13	5
	More than 10,000	Twice a week	5	6
Ozone disinfected (criterion 4) or UV disinfected (criterion 5)	All	Fortnightly	22	3

Notes

1 Minimum sampling frequencies for *E. coli* in **participating small water supplies** servicing fewer than 500 people are discussed in section 10.

2 'Three days between' means that if a sample is taken on Monday, the next sample must be taken on or before Thursday.

3 Monitoring requirements for secure groundwater supplies may be reduced to one sample per quarter after no *E. coli* has been detected in 12 consecutive months of sampling after the water source has been granted fully secure status.

4 Supplies with no or inadequate disinfection must use Criterion 1. Others types of supply may do so by choice.

5 See sections 4.3.1 and 4.3.2 for explanations of undisinfected drinking-water and continuously and non-continuously monitored chlorination, and for other information on bacterial criterion 1.

Table 4.2b: Minimum sampling frequency for non-continuously monitored free available chlorine, pH and turbidity in drinking-water leaving treatment plant

Population served	Minimum sampling frequency	Maximum days between samples[1]	Minimum days of the week used
Up to 500	13 per quarter (weekly)	11	5
501–5,000	39 per quarter (three times a week)	4	7
5,001–10,000	182 per quarter (twice a day)[2]	1	7

Notes

1 'Three days between' means that if a sample is taken on Monday, the next sample must be taken on Thursday.

2 Until 1 January 2008, after which monitoring must be continuous.

4.3.8.2 Free available chlorine (FAC) disinfection

All plants with chlorination that supply a population greater than 10,000 must monitor FAC continuously. Plants supplying a population of 5,001–10,000 must monitor continuously from 1 January 2008. These requirements do not apply to secure groundwater supplies. Continuous monitors must meet the requirements specified in section 3.2.

The minimum manual sampling frequencies are specified in Table 4.2b (column 2). The maximum number of days between samples (Table 4.2b, column 3) must not be exceeded. The number of days of the week used for sampling must not be fewer than the minimum number specified in Table 4.2b (column 4).

Manual disinfectant residual sampling frequencies must be increased if a flood could have affected the quality of the supply or if there is an emergency operation or an interruption to the supply system, or any other circumstances that may challenge the treatment process and give rise to an increased risk of faecal contamination. The PHRMP must detail the measures to be adopted in these circumstances.

4.3.8.3 pH

The pH must be monitored at the same time and frequency as the disinfectant residual is measured to enable the FACE to be determined.[9] Figure A1.1 (page 127) shows the concentration of FAC necessary to achieve an FACE at a given pH.

Continuous monitors must meet the requirements specified in section 3.2.

4.3.8.4 Turbidity

For plants supplying a population greater than 10,000, the turbidity of the water leaving the treatment plant must be measured continuously. Turbidity must be measured after filtration and disinfection, but may be before addition of lime or other final chemical treatment. Plants supplying a population of 5,001–10,000 must monitor turbidity continuously from 1 January 2008.

For plants that continuously monitor the turbidity of water leaving the filters (for protozoal compliance) (see sections 5.4 and 5.5), it is acceptable to average the turbidity measurements (ie, to measure the combined turbidity of the water leaving the filtration array (see section 5.11) instead of installing a separate turbidimeter.

Where criterion 2B (section 4.3.2.2) is relied on for compliance, the turbidity must be monitored at the frequency specified in Table 4.2b.

[9] Although the efficacy of chlorine dioxide is not affected by pH, because of the possibility of some FAC residual being present in water treated with chlorine dioxide, the pH has to be measured when both disinfectants are used.

For criterion 4 (ozone), turbidity must be monitored at the same frequency as the ozone residual (4.3.8.6), and for criterion 5 (UV), turbidity must be monitored in accordance with Table 5.7b.

Continuous monitors must meet the requirements specified in section 3.2.

4.3.8.5 Chlorine dioxide

All supplies disinfecting with chlorine dioxide must meet the disinfectant requirements of either section 4.3.2.1 or 4.3.2.2 as appropriate measuring chlorine dioxide instead of chlorine.

Continuous monitors must meet the requirements specified in section 3.2.

4.3.8.6 Ozone and flow

Supplies serving a population greater than 500 must continuously monitor the ozone residual and flow rate, and continuously calculate the C.t value (based on the ozone concentration and flow rate).

Continuous monitors must be meet the requirements specified in section 3.2.

Supplies serving a population of 500 or fewer must monitor the ozone residual and calculate the C.t value daily.

4.3.8.7 Ultraviolet light (UV)

The monitoring of all plants with UV treatment must follow the frequency requirements of Table 5.7b.

4.3.9 Response to transgressions in drinking-water leaving treatment plant

This section applies to all drinking-water supplies. Additional responses are required for secure groundwater (see section 4.5.3).

Contaminated drinking-water leaving the treatment plant can affect the whole community, so immediate action is required if a positive *E. coli* presence/absence test result occurs (or a positive total coliform or faecal coliform result if either of these are used for compliance monitoring in place of *E. coli).*

Immediate action must also be taken when the minimum FAC residual of 0.1 mg/L is not reached, the minimum C.t value or UV dose is not achieved, or the turbidity exceeds the maximum specified, thereby compromising the efficacy of the disinfection.

The actions to be taken in these cases (which the PHRMP must document and which are discussed in the *Guidelines*) are summarised in Figure 4.1 (page 37). These requirements may be modified to suit particular circumstances by agreement with the DWA. The actions include:

1. immediately inform the DWA
2. collect follow-up samples for *E. coli* enumeration from the treatment plant and the distribution zone within 12 hours (if possible) of obtaining a positive result. If multiple samples are taken, one of these samples must be from the site that gave the original positive sample. If the plant serves more than one distribution zone, samples must be taken from each distribution zone
3. investigating the cause of the transgression, including inspecting the disinfection equipment, plant records and any other aspects of the plant that could have led to the transgression
4. correcting any faults found
5. inspecting the water supply source if no fault is found at the plant
6. providing customers with an alternative water supply.

The required actions must be applied promptly and reported fully.

Remedial action must be continued until the fault has been identified and remedied, *E. coli* is absent in all samples and the DWA is satisfied that remedial action is complete and no further contaminated water remains in the system. Should the fault not have been positively identified and remedied, sampling must be continued until samples from the treatment plant and the distribution system have tested free of *E. coli* on three successive days. Remedial action may include flushing contaminated water to waste if necessary. Samples collected as a result of a transgression are not counted as part of the routine compliance monitoring programme, unless they are collected on a scheduled sample day, in which case only one sample need be taken on that day and used for both purposes.

If repeat samples continue to be positive, the DWA must be consulted and any action required to reduce the risk of illness, such as the issue of a 'Boil Water' notice, must be carried out if considered necessary. Remedial actions as set out above must be intensified.

When equipment providing continuous disinfectant dosing or monitoring fails, there is no longer confidence that the water supply is safe. The immediate actions specified in 3 and 4 of section 3.2(3) and (4) must be taken.

4.3.10 Compliance for secure groundwater

This section specifies the DWSNZ operational requirements associated with groundwater shown to be secure by meeting the requirements of section 4.5.

1. The groundwater must be monitored at a frequency greater than or equal to that specified in section 4.3.8, Table 4.2a, row 1 (secure groundwater supplies).
2. The sampling frequency must be increased to at least weekly for four weeks when the source water quality may have changed (eg, after a severe earthquake or flood).
3. The source must be reclassified as non-secure if *E. coli* is detected in any sample and the procedures specified in sections 4.3.9 and 4.5.3 must be carried out.

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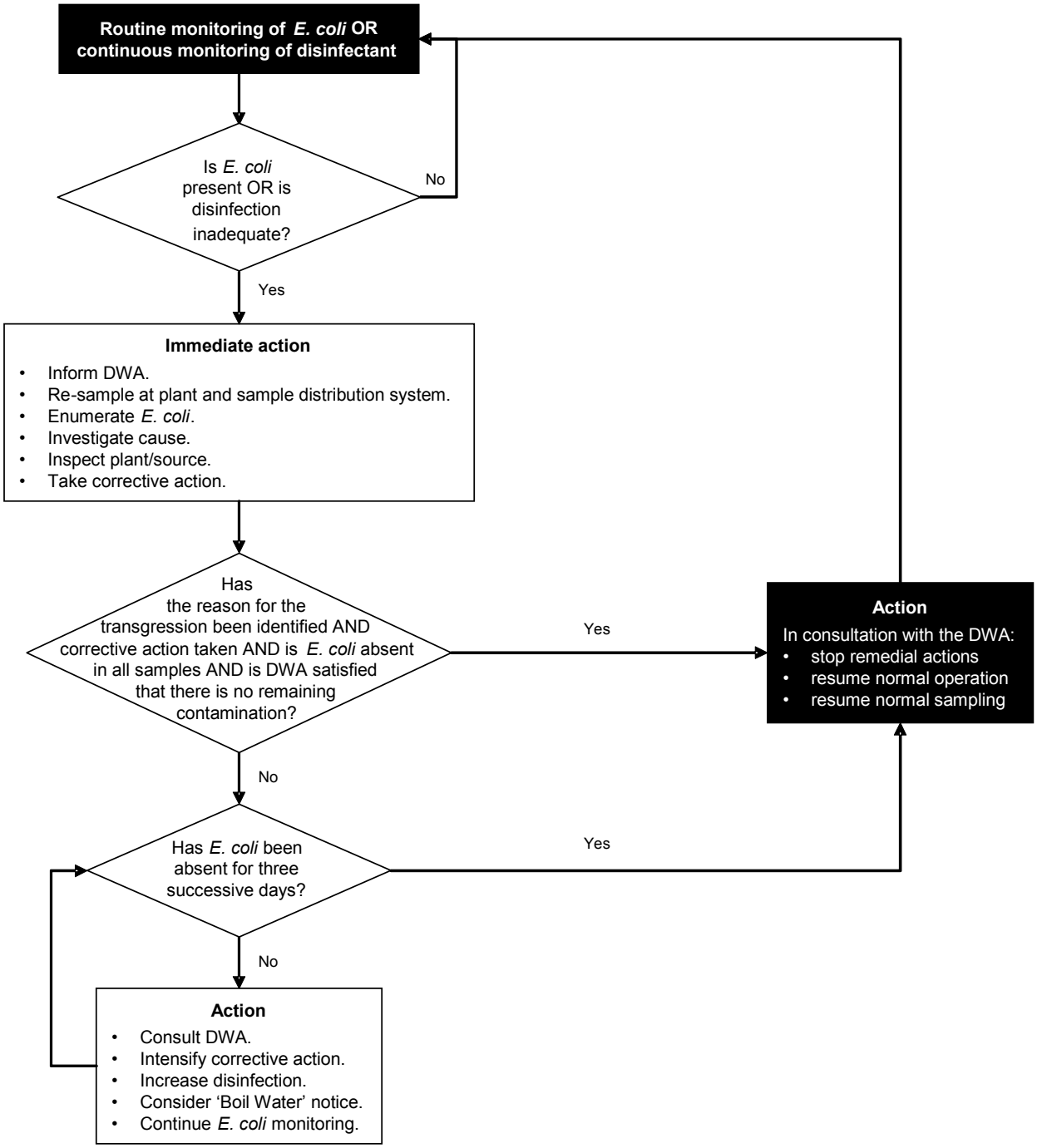
4. Where a treatment plant receives water from secure and non-secure groundwater, the supply must be classified as arising from non-secure groundwater. A PHRMP (prepared for each source) must detail the action to be taken to ensure that the non-secure water does not contaminate the supply with bacteria or protozoa, and the preventive action specified in the PHRMPs must be followed.

Figure 4.1: Response to *E. coli* contamination of drinking-water leaving treatment plant



4.4 Compliance criteria for drinking-water in the distribution system

The compliance monitoring period for bacterial compliance in the distribution system is one year, except for criterion 7B, which is one day.

One of either bacterial compliance criteria 6A or 6B must be used for drinking-water in the distribution system.

Bacterial compliance criterion 6B may be applied to water supplies serving a population greater than 30,000 and where sufficient disinfectant residual exists in the distribution system for FAC or chlorine dioxide determination to be permitted in lieu of some *E. coli* testing. Otherwise, bacterial compliance criterion 6A must be used.

For water in bulk distribution systems, there are corresponding bacterial compliance criteria; criteria 7A and 7B, described in sections 4.4.7 and 4.4.8. For continuously monitored chlorinated bulk distribution systems, compliance may be demonstrated by testing for chlorine and/or chlorine dioxide residual only, that is, chlorine and/or chlorine dioxide residual tests may fully substitute for *E. coli* tests.

Note: In the sections covering distribution systems, the term 'disinfectant residual' means FAC in chlorinated systems and the sum of the FAC and chlorine dioxide concentrations in systems disinfected with chlorine dioxide.

4.4.1 Compliance criterion 6A for drinking-water in a distribution zone

The bacterial compliance criterion 6A for drinking-water in a distribution zone (using *E. coli* monitoring only) must be used:

- in water supply zones serving a population of 30,000 or fewer

or

- when insufficient disinfectant residual exists in the distribution system to achieve compliance with criterion 6B.

To comply with criterion 6A, the following requirements must be met.

1. The water in the distribution system is monitored for the presence of *E. coli*.
2. The sampling sites and frequency and distribution of sampling for *E. coli* meet the requirements of sections 4.4.3 and 4.4.4 respectively.
3. The maximum number of 100 mL samples in which *E. coli* is found is equal to or less than the allowable exceedences listed in Appendix A1.8, Table A1.3.
4. The sampling and analytical procedures comply with the requirements of section 4.3.6.

4.4.2 Compliance criterion 6B for drinking-water in a distribution zone

The bacterial compliance criterion 6B for water in a distribution zone (allowing partial substitution of *E. coli* monitoring by FAC, to establish FACE, or chlorine dioxide monitoring) may be used:

- in water supply zones servicing a population greater than 30,000, and
- when an adequate disinfectant residual is maintained in the distribution system.

To comply with criterion 6B, the requirements of section 4.4.1 must be complied with, together with all of the following requirements.

1. The treatment plant complies with section 4.3.2.1 (criterion 2A) or section 4.3.3 (criterion 3).
2. The disinfectant residual concentration, pH and turbidity are monitored in the distribution zone at the sites, and sampling frequencies and distributions are specified in sections 4.4.3 and 4.4.4.
3. The number of *E. coli* samples substituted by disinfectant residual tests does not exceed 75 percent of the number of *E. coli* samples specified in Table 4.3a (column 2).
4. All samples in the distribution system contain a disinfectant residual concentration of at least 0.2 mg/L, except in occasional areas of low flow where the disinfectant concentration may diminish to 0.1 mg/L. If the disinfectant residual is found to be less than 0.2 mg/L in any particular sample, *E. coli* must be tested for.
5. The monthly median turbidity value of samples taken from the distribution system is not greater than 1.0 NTU, and no sample exceeds 5.0 NTU.

If these requirements are not met, full *E. coli* monitoring must be resumed until compliance with criterion 6A is achieved for a week.

4.4.3 Sampling sites for compliance in the distribution zone

Samples must be taken from sites representative of the water in the distribution zone.

The sampling plan must be approved by the DWA prior to implementation and must take into consideration the following.

1. All samples must be taken from fixed sampling points, such as pumping stations, **service reservoirs** and taps within the distribution zone.
2. Taps installed specifically for sampling purposes, attached directly to a street main and contained in locked cabinets are preferred to consumers' household taps.
3. If multiple samples are taken on a given day, at least one sample must be taken from the same site each day that sampling is undertaken, to monitor parameter trends.
4. The remaining samples must be taken on a rotating basis from the other sites.

Additional sampling requirements in the event of mains construction and maintenance are covered in the code of practice on water supply pipeline construction and maintenance in the *Guidelines*.

4.4.4 Sampling frequencies for compliance in a distribution zone

Compliance criterion 6A

1. The minimum sampling frequencies for *E. coli* in drinking-water in the distribution zones, when *E. coli* monitoring is not partially substituted by disinfectant residual determination, are shown in Table 4.3a (column 2). Monitoring must be carried out on different days throughout the week as shown in Table 4.3b, not exceeding the specified maximum interval.
2. While for communities of up to 500 people the minimum sampling frequency specified is three times each calendar quarter, drinking-water supplies should be monitored at least 10 times each quarter (ie, at least 38 times each year or every 10 days) to provide improved statistical confidence in the annual results. See Appendix A1.8, Table A1.3.

Compliance criterion 6B

1. The minimum sampling frequencies for *E. coli* are determined by the following.
   i. (*E. coli* tests specified in Table 4.3a (column 2) if no substitution with disinfectant residual determination is done) x ([100 – percent of *E. coli* tests replaced]/100).
   ii. Testing must be carried out on different days throughout the week as shown in Table 4.3b, not exceeding the specified maximum interval.
2. The minimum sampling frequencies for the disinfectant residual concentration are determined by the following.
   i. (*E. coli* tests that would be required by Table 4.3a (column 2) if no substitution with disinfectant residual determination is done) x 4 x [percent of *E. coli* tests replaced]/100.
   ii. An additional requirement is that disinfectant residual sampling must be carried out at least daily. (This requirement will mean that for some supplies, substitution of less than 75 percent of *E. coli* samples will require more disinfectant residual samples to be taken than is calculated in the equation above.)
3. pH and turbidity must be measured at the same time as the disinfectant residual.

Table 4.3a: Minimum sampling frequency for *E. coli* in the distribution system[1]

Population served[2]	Minimum number of *E. coli* samples per quarter with no disinfectant residual substitution	Minimum number of samples per quarter where disinfectant residual determination substitutes 75 percent of *E. coli* testing[3]	
		E. coli	Disinfectant residual
Up to 500[4]	3	*Not applicable*	*Not applicable*
501–5,000	13	*Not applicable*	*Not applicable*
5,001–10,000	16	*Not applicable*	*Not applicable*
10,001–15,000	19	*Not applicable*	*Not applicable*
15,001–20,000	22	*Not applicable*	*Not applicable*
20,001–25,000	25	*Not applicable*	*Not applicable*
25,001–30,000	28	*Not applicable*	*Not applicable*
30,001–35,000	31	8	93
35,001–40,000	34	9	102
40,001–45,000	37	10	111
45,001–50,000	40	10	120
50,001–55,000	43	11	129
55,001–60,000	46	12	138
60,001–65,000	49	13	147
65,001–70,000	52	13	156
70,001–75,000	55	14	165
75,001–80,000	58	15	174
80,001–85,000	61	16	183
85,001–90,000	64	16	192
90,001–95,000	67	17	201
95,001–100,000	70	18	210
100,001–110,000	73	19	219
110,001–120,000	76	19	228
120,001–130,000	79	20	237
130,001–140,000	82	21	246
140,001–150,000	85	22	255
150,001–160,000	88	22	264
160,001–170,000	91	23	273
170,001–180,000	94	24	282
180,001–190,000	97	25	291
190,001–200,000	100	25	300
etc			

Notes

1 Any failure to take or deliver samples, or to adhere to the specified sampling frequency requirements, must as soon as possible be re-sampled and the DWA advised. The DWA may grant an exemption if the reasons for the failure are justifiable (see section 3.1).

2 When the population increases, additional sampling must be performed so the sampling frequency is that specified for the population actually present.

3 Testing must be distributed evenly throughout the quarter, be carried out on different days of the week and give a representative geographical coverage of the distribution system (see section 4.4.3). Use calendar quarters (January to March, April to June, July to September, and October to December).

4 For participating small drinking-water supplies, see section 10.

Note: Additional monitoring must be carried out after the installation of new mains or after connections or repairs in the **network reticulation**.[10]

[10] See the code of practice for water supply pipeline construction and maintenance in the *Guidelines*.

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Table 4.3b: Sampling intervals for *E. coli* in the distribution system

Number of *E. coli* samples per quarter	Maximum interval between *E. coli* samples (days)	Minimum number of days of the week used
3–7	45	3
8–12	17	4
13–18	11	5
19–21	8	6
22–30	6	7
31–36	5	7
37–45	4	7
46–60	3	7
61–92	2	7
More than 92	1	7

Notes:

The maximum interval between samples is determined by the number of *E. coli* samples, not by the size of the population. For example, if the zone population is 68,155:

- without replacement, 52 *E. coli* samples are required per quarter (Table 4.4a)
- with 75 percent replacement of *E. coli* by FAC, this requires:
  - 13 *E. coli* samples per quarter (ie, 52 x 25 percent, rounded up if necessary)
  - 156 FAC tests per quarter (ie, 52 x 75 percent x 4).

From Table 4.3b, the 13 *E. coli* samples have a maximum sampling interval of 11 days and are to be sampled over five different days of the week. Similarly, the 156 FAC tests per quarter must be performed every day.

For example, if the maximum interval between samples is three days, this means that if a sample is taken on Monday the next sample must be taken no later than Thursday.

4.4.5 Sampling and on-site analytical procedures for water in a distribution zone

These procedures are the same as detailed in sections 4.3 (Table 4.1), 4.3.6 and 4.4.3.

4.4.6 Response to transgressions involving criteria 6 and 7: *E. coli* present in the distribution zone

When a positive *E. coli* or coliform result has been obtained, or in response to a transgression involving bacterial criteria for water leaving the treatment plant, follow-up sampling must be undertaken within 12 hours (wherever possible) of obtaining that result, as specified in the PHRMP. Figure 4.2 (page 44) summarises the response stages. These requirements may be modified to suit particular circumstances by agreement with the DWA.

The response to the first positive sample (which the PHRMP must specify) must include the following steps.

1. Immediately inform the DWA.
2. Collect follow-up samples for *E. coli* enumeration within 12 hours (if possible) of obtaining a positive result, from original positive sample location and also locations downstream from the first positive site.
3. Start to investigate the possible causes of the positive sample (eg, sampling procedures, treatment plant failure, recent or current maintenance/repair work, fire fighting incident, consumer complaints that could indicate backflow).
4. Correct any faults found during the initial investigation.
5. If no fault is found in the distribution system and no routine *E. coli* sample was taken from water leaving the treatment plant at the time the positive sample was taken from the distribution zone, sample and enumerate *E. coli* in the water leaving the treatment plant.

The required actions must be applied promptly and reported fully.

If any of the results from follow-up sampling are equal to or greater than 10/100 mL, the DWA must be consulted immediately and any action required to reduce the risk of illness, such as the issue of a 'Boil Water' notice and/or increasing the disinfectant dose and/or flushing the system, must be carried out. Investigations into the source and cause of the contamination must be intensified. Reliance only on the level of FACE in the water leaving the treatment plant is not sufficient to eliminate the treatment plant as the source of contamination.

If the results from follow-up sampling are all less than 10/100 mL but any single result is equal to or greater than 1/100 mL, the DWA must be informed and investigations must continue and any faults identified must be corrected. The required actions must be continued until samples from the treatment plant and the distribution system have tested free of *E. coli* on three successive days, the DWA is satisfied that no further contaminated water remains in the system and any remedial action is complete. Remedial action may include flushing contaminated water to waste if necessary.

For a bulk supply, the satellite suppliers must be informed.

When three successive *E. coli*-clear days have occurred and the DWA has approved the remedial actions, these actions can stop and normal operations resume.

Samples collected as a result of a transgression are not counted as part of the routine compliance monitoring programme, unless they are collected on a scheduled sample day, in which case only one sample need be taken on that day and used for both purposes.

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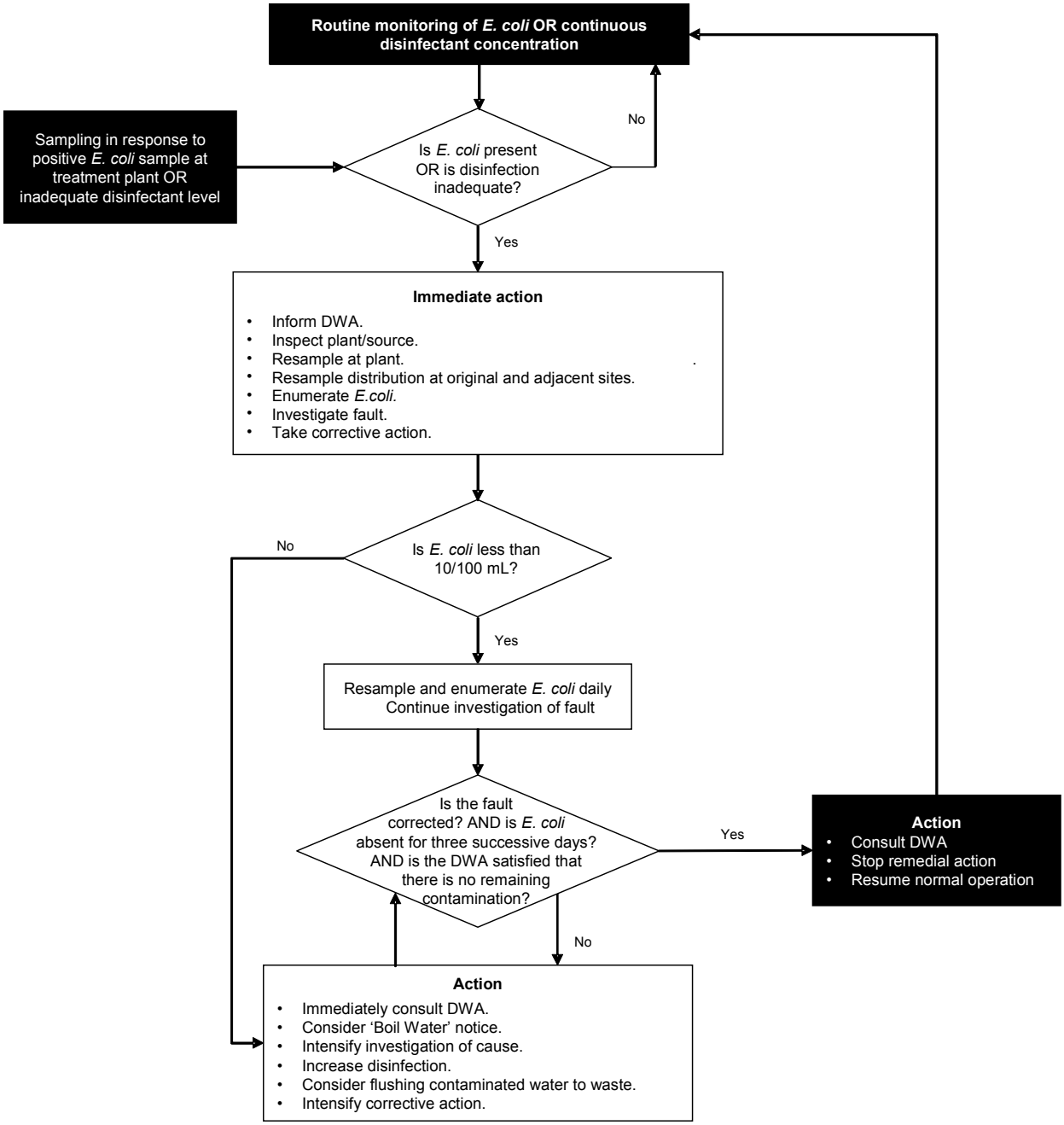
Figure 4.2: Response to *E. coli* contamination of a drinking-water supply distribution zone



4.4.7 Compliance in a bulk distribution zone

Either of the following may be used:

- *E. coli* monitoring for compliance using *E. coli* (criterion 7A, section 4.4.7.1)

or

- full substitution of *E. coli* monitoring with continuous monitoring of FAC, pH and turbidity in supplies continuously disinfected with chlorine or chlorine dioxide (criterion 7B, section 4.4.7.2).

4.4.7.1 Compliance criterion 7A using *E. coli* monitoring only

To comply with criterion 7A monitoring must comply with section 4.4.8 and the following requirements.

1. The water from at least one **bulk water supply point** on each bulk distribution zone (ie, where the water leaves the bulk distribution zone) is monitored for the presence of *E. coli*.
2. *E. coli* is monitored at the bulk water supply point at a frequency equal to or greater than that specified in section 4.4.9.
3. The maximum number of 100 mL samples in which *E. coli* is found is equal to or less than the allowable number of exceedences shown in Appendix A1.8, Table A1.3.
4. The sampling and analytical procedures comply with the requirements of section 4.3.6.

4.4.7.2 Compliance criterion 7B using continuous monitoring of disinfectant residual

To comply with criterion 7B, monitoring must comply with section 4.4.8 and requirement 4 of section 4.4.7.1, together with all of the following requirements.

1. The disinfectant residual, pH and turbidity are monitored in the bulk distribution zone at the frequencies specified in section 4.4.10.
2. The treatment plant complies with criterion 2A (section 4.3.2.1) or criterion 3 (section 4.3.3).
3. The FACE residual in the bulk distribution zone does not fall below 0.2 mg/L for more than 2 percent of the time.
4. The monthly median turbidity value of samples from the bulk distribution system is not greater than 1.0 NTU, and no sample exceeds 5.0 NTU.

If these criteria are not met, full *E. coli* monitoring must be resumed until compliance is achieved for a week.

4.4.8 Sampling sites for bulk water supplies

At least one bulk water supply point (ie, where the water leaves the bulk distribution zone) in each bulk zone must be monitored for the presence of *E. coli* or be continuously monitored for disinfection residual, pH and turbidity. The most distant bulk water supply point should be selected unless consultation with the client and the DWA results in another choice. More than one monitoring point per bulk zone may be necessary where the configuration of the bulk zone (including the treatment plant inputs and the supply points) means that one is not sufficient to represent the quality of water supplied. The additional points should be agreed with the bulk supplier's client and the DWA.

4.4.9 Sampling frequencies for bulk water supplies: criterion 7A

Table 4.4 specifies the minimum sampling frequency for *E. coli* from each bulk water supply point selected from a bulk distribution zone. The frequency depends on the population served by that bulk water supply point.

Table 4.4: Minimum sampling frequency for *E. coli* in a bulk distribution zone

Nominal population served	Minimum sampling frequency	Maximum days between samples	Minimum days of the week used
10,000 or less	13 per quarter (weekly)	13	5
10,001–50,000	26 per quarter (twice a week)	5	6
More than 50,000	39 per quarter (three times a week)	3	7

4.4.10 Sampling frequencies for bulk water supplies: criterion 7B

The disinfectant residual, pH and turbidity must be monitored continuously at the selected bulk water supply point(s).

4.4.11 Response to transgressions against criteria 6B and 7B: free available chlorine or chlorine dioxide too low in the distribution system or bulk distribution zone

If the requirements of section 4.4.2 or 4.4.7.2 are not met, full monitoring of *E. coli* as specified in column 2 of Table 4.3a or Table 4.4 must be carried out in addition to residual disinfectant monitoring. The disinfectant residual determination regime may be reinstated when the disinfectant residual has continuously met the requirements of the DWSNZ for one week.

4.4.12 Response to maximum acceptable value (MAV) exceedence in bulk water supplies

See sections 4.4.6 and 4.4.11.

4.5 Demonstrating security of groundwater

4.5.1 Introduction

Groundwater is considered secure when it can be demonstrated that contamination by pathogenic organisms is unlikely because the groundwater is both:

- not directly affected by surface or climate influences (as demonstrated by compliance with groundwater security criteria 1 (section 4.5.1.1) and 3 (section 4.5.1.3))
- abstracted from a **bore head** that provides satisfactory sanitary protection (groundwater security criterion 2 (section 4.5.1.2)).

Sources from shallow, **unconfined aquifers** will not be given secure status when the **bore** intake depth is:

- less than 10 m below ground surface
- 10–30 m below ground surface, and less than five years of monthly monitoring data showing no *E. coli* contamination exists. If no *E. coli* are detected during five years of monitoring as per line 2 (no or inadequate disinfection) of Table 4.2a for the first three months and then line 1 (secure groundwater supplies) thereafter, and the bore meets groundwater security criteria 1 and 2, the groundwater will be deemed to be secure.

4.5.1.1 Groundwater security criterion 1

Groundwater must not be directly affected by surface or climatic influences

A lack of surface or climate influences must be demonstrated by the residence time in the **aquifer** or by the lack of significant and rapid shifts in chemical determinands that are linked to surface effects as shown by one of the following requirements. Use one of 1, 2 or 3 below.

1. **Residence time determination** carried out by a laboratory recognised by the Ministry of Health for the purpose shows that less than 0.005 percent of the water has been present in the aquifer for less than one year on the basis of reported methods and assumptions.

   Tritium, chlorofluorocabon (CFC) or sulphur hexafluoride (SF6) methods may be used for the residence time determination. The following criteria must be met.

   a. The bore must have been properly purged to ensure samples are representative of the aquifer.
   b. The zero point used for age determination of the water must be the time at which the water leaves the surface.
   c. A full description of the procedure used to determine the residence time must be provided, including the mixing model assumptions, justification and interpretation.
   d. A confirmatory dating must be carried out if the analyst in consultation with the DWA specifies it is necessary.

2. Variations in the concentrations of all of the following determinands do not exceed:
   a. a coefficient of variation of 3 percent in conductivity
   b. a coefficient of variation of 4 percent in **chloride concentration**
   c. a **standardised variance** of 2.5 percent in **nitrate concentration** expressed as milligrams of NO_3-N/L (see the *Guidelines* for calculation examples),

   when measured at least:
   d. monthly for one year, or
   e. two monthly for two years, or
   f. three monthly for three years.

   Should the concentration of any one of these determinands be near the **limit of detection**, so that the coefficient of variation or standardised variance cannot be determined reliably, the results for that determinand may be disregarded at the DWA's discretion.

   Once the bore has been verified as secure, these determinands must be tested annually to check that the results remain within the range of concentrations found originally.

3. If the residence time determination is not possible due to the presence of non-meteoric CFCs, SF_6 or tritium and the water quality variation criteria do not satisfy the requirements for secure groundwater status, the following method may be considered.

   A verified hydrogeological model demonstrating that the bore is extracting from a secure aquifer may be acceptable. The model must be derived from a conservative evaluation of hydrogeologic parameters. Such a model must provide information about potential contaminant pathways and must indicate that contamination by pathogens is very unlikely taking into account predictive uncertainty, to the satisfaction of a person or persons deemed qualified by the Ministry of Health.

For multiple bores and aquifers, the procedures in section 4.5.2 apply.

4.5.1.2 Groundwater security criterion 2

Bore head must be judged to provide satisfactory sanitary protection by person deemed appropriately qualified by the Ministry of Health

The bore head must be sealed at the surface to prevent the ingress of surface water and contaminants. Animals must be excluded from within 5 m of the bore head.

The bore construction must comply with the environmental standard for drilling soil and rock (NZS 4411), including providing an effective backflow prevention mechanism, unless agreed by the DWA (additional advice can be obtained from the *Guidelines*).

The bore head protection must be reviewed every five years, and the water supply owner must report any changes to the DWA.

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The supply's PHRMP must address contaminant sources and contaminant migration pathways. Potential sources of contamination such as septic tanks or other waste discharges must be situated sufficiently far from the bore that contamination of the bore water cannot occur (see *Guidelines*).

4.5.1.3 Groundwater security criterion 3

***E. coli* must be absent from groundwater**

To demonstrate compliance with groundwater security criterion 3, *E. coli* monitoring of the raw water must be carried out as per Table 4.2a row 1 (secure groundwater supplies) prior to any form of treatment, and no *E. coli* must be detected. The sampling and analytical procedures must comply with the requirements of section 4.3.6.

For new bores greater than 30 m deep, a new source for which hydrogeological evidence indicates that the groundwater is likely to be secure may be given interim secure status for the first 12 months of operation, provided that:

- it is monitored for *E. coli* in accordance with Table 4.2a row 2 (no or inadequate disinfection) for the first three months after commissioning. Thereafter it is monitored for the remaining nine months of the 12-month probationary period according to Table 4.2a row 1 (secure groundwater supplies)
- no *E. coli* is detected
- compliance with groundwater security criterion 2 (section 4.5.1.2) is demonstrated.

For bores between 10 and 30 m deep, see section 4.5.1.

If a positive *E. coli* sample is obtained, refer to section 4.5.3.

If the groundwater has not been demonstrated to be secure by the end of the 12-month provisional period, it will revert to the non-secure classification. Full status as a secure groundwater will not be granted until all three groundwater security criteria 1 (section 4.5.1.1), 2 (section 4.5.1.2) and 3 (section 4.5.1.3) have been met.

4.5.2 Multiple bores serving drinking-water supply

Raw water for a drinking-water supply may come from several bores. Separate monitoring of each could require a large number of samples to be collected and analysed for *E. coli*.

Where it can be demonstrated that bores supplying a single pumping station or distribution zone draw from the same aquifer, reduced monitoring may be justified. A verified hydrogeological model demonstrating that the bores all draw from the same secure aquifer may be acceptable to support an application for reduced monitoring. The model must be derived from a conservative evaluation of hydrogeologic parameters and all assumption specified. Such a model must be verified to the satisfaction of a person or persons deemed by the Ministry of Health to be appropriately qualified.

To justify reduced monitoring of several bores in these circumstances, the water supplier must show:

- the bores draw from the same aquifer under similar conditions
- any **aquitard** protecting the source is continuous at the **bore field**
- the chemical character of the water from each bore is similar.

The identified representative bore must be the one that is most vulnerable to contamination of the bores it represents. The sampling of the representative bore must be in accordance with Table 4.3a row 2 (no or inadequate disinfection) for the first three months, with sampling being as per row 1 ('secure groundwater') thereafter.

Provided no *E. coli* are detected, the security of the other bores intercepting that aquifer will be presumed but must first be verified with three sequential samples taken at one month intervals for *E. coli* testing, being collected from each bore with no *E. coli* being found. This verification must be carried out for each aquifer.

The integrity of each bore head must meet groundwater security criterion 2 (section 4.5.1.2).

4.5.3 Response to *E. coli* detection in groundwater classified as secure

If *E. coli* is detected in a groundwater supply that has been classified as secure, that supply must be reassessed before its designation as a secure groundwater can be restored.

If only one (but no more) positive *E. coli* sample is obtained, the supply will be given provisional secure status for the following 12 months of operation, provided that:

- it is monitored for *E. coli* in accordance with Table 4.2a row 2 (no or inadequate disinfection) for the first three months after the positive *E. coli* sample was obtained
- it is monitored at the frequency specified in Table 4.2a row 1 (secure groundwater supplies) for the remaining nine months.
- no *E. coli* is detected in the 12-month trial period
- compliance with criterion 2 (section 4.5.1.2) is confirmed.

If a further positive *E. coli* sample is obtained during the 12-month probationary period, the water must be immediately re-classified as non-secure.

5 Protozoal Compliance Criteria

5.1 Introduction

Protozoa such as *Cryptosporidium* and *Giardia* occur in many New Zealand water sources. Their (oo)cysts are found in the faeces of humans and animals (wild, farm and domestic). Many surface waters and non-secure groundwaters have the potential to be contaminated by protozoa. The protozoal risk associated with secure groundwater is much lower. *Giardia* and *Cryptosporidium* are pathogens that must be eradicated from drinking-water supplies. They are Priority 1 determinands because of their public health significance.

Protozoa can be removed physically by filtration or inactivated by disinfection. Chlorine is effective in inactivating bacteria and viruses but is not effective for inactivating *Cryptosporidium*. The methods available for enumerating pathogenic protozoa and determining their viability (whether they are active or inactive) are becoming less expensive and more reliable, but they are not yet suitable for routine monitoring of treated water quality.

Because of these limitations, the compliance criteria for protozoa are based on the **probability** that the treatment process will have inactivated or removed any protozoa present in the water. PHRMPs must identify the possible causes of major transgressions (discussed in section 3.1), the actions to be taken to reduce their likelihood and what to do in the event of their happening.

Because *Cryptosporidium* is the most infective and the most difficult protozoan to remove or inactivate, the Standards are constructed on the principle that if the treatment process deals successfully with *Cryptosporidium*, it will also deal successfully with other protozoa.

The protozoal compliance criteria in the DWSNZ:

- use risk-based criteria that are more stringent for more contaminated source water than for cleaner source water
- acknowledge any additive effect of successive different treatment processes on protozoa removal where more than one treatment process is used
- use overseas data on the log-removal efficacy (a measure of the percentage of organisms removed) of *Cryptosporidium* for a range of treatment processes
- specify validated treatment processes (where appropriate)
- provide for alternative means of disinfection, including using UV and ozone.

5.2 Cumulative log credit approach

A supply's public health risk of infection from waterborne protozoa is affected by:

- the concentration of *Cryptosporidium* or other protozoal (oo)cysts in the source water
- the extent to which (oo)cysts are inactivated/removed by the treatment processes.

To take account of the additive effect of a series of treatment processes on protozoa removal, 'log credits' are used (see the *Guidelines*), *Cryptosporidium* being used as the reference organism. The log credit for a treatment process is related to the percentage of the protozoa the process can remove, by the expression:

$$\text{Log credit} = \log_{10}[1/\{1-(\text{percentage removal}/100)\}]$$

(See Table A1.2 for the conversion table of percentage removal to logarithms.)

The cumulative effect of successive treatment processes can be calculated by adding the log credits of all the qualifying processes in use. (The cumulative effects cannot be added when the removal is expressed as a percentage.)

> "If a treatment process fails to achieve the log credit allowance specified for it in section 5, no log credits for that process can be counted towards the log credits that the supply requires to meet the *Cryptosporidium* compliance criteria.
>
> A performance transgression does not result in the loss of log credits. Loss of log credits only occurs if the process concerned fails to meet the compliance criteria."

Different rules apply to different combinations of treatment technologies, depending on whether the system includes filtration and the degree of total log removal/inactivation required.

Section 5.2.1 describes the process by which the source water is categorised with respect to the risk of *Cryptosporidium* in it. Sections 5.2.2 and 5.2.3 explain how the source water categorisation is modified if preferential abstraction, multiple sources and/or wastewater recycling are used. The log credits associated with the various treatment processes used to remove or inactivate *Cryptosporidium* are discussed in section 5.2.4.

5.2.1 Procedures for determining raw water risk categories for *Cryptosporidium*

To ascertain the number of log credits required for *Cryptosporidium* compliance, intake waters[11] must be classified according to the risk presented by the concentration of pathogens in the water. The higher the concentration, the higher the level of treatment required. For the management of protozoa, raw waters are classified into four risk categories depending on the measured level of protozoal contamination or, for supplies servicing 10,000 or fewer people, there is the option of using the results of a catchment risk assessment (see Table 5.1).

[11] Intake water is the water that is taken into the treatmant plant for treatment. It includes the raw water from all sources currently in use, together with any recycled water.

Table 5.1: Intake water risk categorisation and the associated *Cryptosporidium* log removal requirements for treatment

Mean number of oocysts/10 L	Log credit requirement	Intake water protozoal risk category
Protozoa monitoring not required	None	Very low[1] (raw water from secure groundwater supplies with no recycle)
Less than 0.01	2	Non-secure groundwater from deeper than 30 m
Less than 0.75	3	Low
0.75–9.99	4	Moderate
10 or more	5	High

Notes

1 Participating small supplies (section 10) serving 500 people or fewer do not have to carry out protozoa monitoring

A default treatment log credit requirement of 4 logs will apply where the intake water protozoal risk category is not determined using the appropriate process (described below) within the specified time.

The following procedures determine the intake water risk category.

Supplies serving more than 10,000 people

For supplies serving more than 10,000people, the minimum protozoa log removal requirement is evaluated by determining the mean oocyst concentration of the intake water.

a. Water quality monitoring

Cryptosporidium and *E. coli* monitoring of the intake water is to be initiated within six months of the DWSNZ 2005 coming into effect. The sampling programme must comprise at least 26 samples collected over a 12-month period at approximately equal time intervals to attempt to ensure representative samples (see *Guidelines*). The samples must tested quantitatively for *E. coli* and *Cryptosporidium* oocysts. Samples must be taken to cover every working day (ie, Monday, Tuesday, Wednesday, Thursday, Friday) at least three times during the sampling programme, which must be agreed beforehand with the DWA. Any changes to the sampling schedule must be made with the prior agreement of the DWA in accordance with the procedures specified in section 3.1.

At the time samples are taken, the information specified in the Guidelines as required for intake water categorisation must also be recorded.

The protozoa monitoring programme must be repeated every fifth year or whenever a catchment risk assessment indicates that the *Cryptosporidium* concentrations is likely to have changed.

The mean oocyst concentration will be used to determine the minimum protozoal log credits the treatment system must provide to achieve compliance as per Table 5.1. Details (including the procedure for handling 'non-detects' and 'below **detection limits**' results when calculating the mean) will be given in the *Guidelines*.

The *E. coli* data are required to help assess the usefulness of *E. coli* as a surrogate for *Cryptosporidium* concentration to reduce the amount of *Cryptosporidium* sampling required in future.

b. Catchment risk assessment

A catchment sanitary inspection must be commenced in accordance with the PHRMP guide for raw water (Ministry of Health 2005(b)) within six months of the DWSNZ 2005 coming into effect. A catchment risk assessment based on the information provided by the sanitary inspection and the risk scores (that are to be established from the integrated national dataset of *Cryptosporidium* and *E. coli* measurements of raw and intake waters) must commence within 18 months of the promulgation of the DWSNZ 2005.

Reassessments must be made every five years thereafter, or after a significant change in activities in the catchment that may change the risk to protozoal water quality. The **catchment assessment** enables changes to the catchment to be recorded.

Supplies serving 10,000 or fewer people

The following options are available to determine their minimum protozoal log removal requirement to supplies serving less than 10,000 people (excluding Participating Small Supplies – see section 10).

a. Catchment risk assessment-based option

A catchment sanitary inspection in accordance with the PHRMP guide for raw water (Ministry of Health 2005(b)) must commence within 18 months of the DWSNZ 2005 coming into effect. A catchment risk assessment must commence within 18 months of the DWSNZ 2005 coming into effect, using the risk scores established in 5.2.1. Reassessments must be made every five years thereafter, or after a significant change in activities in the catchment that may change the risk to protozoal water quality. The log removal requirement is then determined by the intake water protozoal risk category (Table 5.1).

b. Monitoring-based option

The need for monitoring for protozoa must be determined by at least 12 months of weekly *E. coli* monitoring in the intake water, which must start within 18 months of the DWSNZ 2005 coming into effect.

Supplies are exempt from protozoa monitoring if:

- for intake water abstracted from flowing surface waters, the mean *E. coli* concentration over the 12-month monitoring period is less than 50/100 mL[12]
- for intake water abstracted from groundwaters, **springs**, lakes or reservoirs, the mean *E. coli* concentration is less than 10/100 mL.

The *E. coli* monitoring programme must be agreed with the DWA with the days of the week on which sampling must occur being fixed in advance to obtain a good spread of weekly conditions. Changes to the sampling schedule must be made in advance with the DWA's agreement in accordance with the procedures in section 3.1.

Supplies that are not exempt must be sampled and analysed for *Cryptosporidium* at least four times over 12 months during the periods of likely high risk following completion of the 12 months *E. coli* monitoring, that is, twice in spring (the calving/lambing peak) and twice in autumn (the human peak). This sampling must start within six months of a supply's exemption status being determined.

The monitoring programme must be agreed with the DWA, with the sampling dates being fixed in advance to ensure intake water conditions include periods during which the *Cryptosporidium* concentrations are expected to be high. Changes to the sampling schedule may be made in advance with the DWA's agreement and carried out in accordance with the procedures laid out in section 3.1.

Treatment providing at least 3 log credits is required for supplies exempt from protozoal monitoring; all other supplies must achieve the treatment log credits specified in Table 5.1 for the mean oocyst concentrations found during the monitoring programme.

Timeframe for determining log credit requirement

Intake water risk categories must be established within two years of the DWSNZ 2005 coming into effect for supplies serving more than 10,000 people; within three years for supplies serving 10,000 or fewer people that were exempt from protozoa monitoring, or within four years for supplies that were not exempt. In the interim the log credit requirement for the supply will be 3 logs. This will revert to 4 logs if the log credit requirement of the supply has not been established within the two-year period for supplies serving more than 10,000 or more people; within three years for supplies serving 10,000 or fewer people that were exempt from protozoa monitoring, or within four years for supplies that were not exempt.

[12] This is a provisional value that may be adjusted once a national data set has been accumulated from the data obtained from supplies with populations greater than 10,000.

5.2.1.1 Sampling location

The sampling location for collection of samples for *Cryptosporidium* and *E. coli* testing must:

a) be upstream of any pre-treatment process contributing log credits to the overall treatment process – sampling may be from the raw water at the point of abstraction if requirements b) and c) are also met

b) ensure that only water abstracted for treatment is sampled (ie, raw water is not to be sampled if the treatment plant selectively abstracts high quality water only because of variability in the raw water quality, and the combined flow must be sampled if multiple sources are used)

c) be downstream of any return point used to return liquid wastes to the head of the treatment plant.

5.2.1.2 Sampling procedure

Where waste liquid is returned to the head of the treatment plant, samples must be taken during periods when the waste is being returned. (Refer to the *Guidelines*.)

5.2.1.3 Analytical method

Analysis of raw water protozoa must be carried out using the modified EPA1623 method specified in Appendix 3. (For details see *Guidelines.*)

5.2.2 Multiple sources

The management of the risks associated with preferential abstraction or multiple sources must be addressed in the PHRMP.

5.2.3 Information collection for catchment risk assessment

To enable the relationships between catchment activities identified by a catchment sanitary inspection and the concentrations of oocysts in a supply's raw water to be determined, suppliers serving more than 10,000 people will be requested to carry out *Cryptosporidium* monitoring of *raw waters* at the point of abstraction. Sampling should coincide with the untreated water sampling schedule[13] as described in Section 5.2.1a.

a) Samples must be tested quantitatively for *Cryptosporidium*, *E. coli* and turbidity.

b) The samples must be taken from the raw water at the point of abstraction.

c) Where a treatment plant is supplied by more than one source, a sample must be taken from each individual source.

See the *Guidelines* for details of the information collection programme.

[13] In circumstances where the untreated water is not tested according to the pre-determined schedule due to the water not being abstracted at that time, the raw water must still be sampled and the associated information referred to in Section 5.2.1a collected.

5.2.4 Log credits for treatment processes

International studies have measured log removal rates for protozoa for the different steps in **drinking-water treatment processes**. These show how different treatment processes can remove or inactivate protozoa. This is called the *efficacy* of the treatment, and it is measured as percentage removal/inactivation or is converted to *log removal/inactivation* rates (log credits) (see Table A1.2).

Table 5.2 provides a 'toolbox' of different treatment technologies that can be used to achieve protozoa compliance and the log credits that each technology can earn. Each step in the treatment can be added (subject to the rules listed below) to determine the overall efficacy of a treatment process.

The combinations of treatment processes for which the log credits can be added for the purpose of achieving protozoal compliance are given below. All of these processes (1 to 4 below), may be preceded by bank filtration (0.5 or 1.0 log credit).

1a. Coagulation-based processes (using rapid gravity sand filtration):

- coagulation/sedimentation/filtration (3.0 log credit), or
- coagulation/direct sand filtration (2.5 log credit).

Additional log credits may be obtained for:

- enhanced combined filtration (+0.5 log credit), or
- enhanced individual filtration (+1.0 log credit), or
- secondary (sand or carbon) filtration (+0.5 log credit).

And further log credits obtained if the above options are followed by:

- cartridge filtration (0.5 log credit), or
- bag filtration (0.5 log credit).

1b. Coagulation based processes (using membrane filtration):

- coagulation/sedimentation/sand filtration (3.0 log credit), or
- coagulation/direct filtration (2.5 log credit), or
- coagulation/sedimentation (0.5 log credit).

These processes may be followed by membrane filtration (log credit, see Table 5.2).

1c. Any of steps 1a or 1b can be followed or preceded by:

- chlorine dioxide disinfection (dose dependant log credit), or
- ozone disinfection (dose dependant log credit), or
- UV disinfection (dose dependant log credit).

Note that these disinfectants can be used singly or in combination and that using the disinfectants prior to steps 1a or 1b or 1c can give rise to problems with turbidity. Total log credits for disinfection processes cannot exceed 3.

2a. Filtration processes without coagulation (using a single filtration process):

- diatomaceous earth (2.5 log credit), or
- slow sand (2.5 log credit), or
- membrane filtration (log credit, see Table 5.2), or
- cartridge filtration (2.0 log credit), or
- bag filtration (1.0 log credit).

2b. Any option in step 2a can be followed by:

- chlorine dioxide disinfection (dose dependant log credit), or
- ozone disinfection (dose dependant log credit), or
- UV disinfection (dose dependant log credit).

Note that these disinfectants can be used singly or in combination.
Total log credits for disinfection processes cannot exceed 3.

3a. Filtration processes (using two filtration processes):

- diatomaceous earth (2.5 log credit), or
- slow sand (2.5 log credit)

Followed by a filtration process used in a secondary role:

- membrane filtration (log credit, see Table 5.2), or
- cartridge filtration (0.5 log credit), or
- bag filtration (0.5 log credit).

3b. Any option in step 3a can be followed by:

- chlorine dioxide disinfection (dose dependant log credit), or
- ozone disinfection (dose dependant log credit), or
- UV disinfection (dose dependant log credit).

Note that these disinfectants can be used singly or in combination.
Total log credits for disinfection processes cannot exceed 3.

4. Disinfection only:

- chlorine dioxide disinfection (dose dependant log credit), or
- ozone disinfection (dose dependant log credit), or
- UV disinfection (dose dependant log credit).

Note that these disinfectants can be used singly or in combination.
Total log credits for disinfection processes cannot exceed 3.

No other combinations are possible without making special application to the Ministry of Health.

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Table 5.2: Protozoa toolbox: options, credits and criteria

Toolbox option	**Protozoa log credit**[1] (text reference for detailed criteria)
Pre-treatment toolbox components	
Bank filtration of source water	0.5 or 1 log credit (5.3)
Coagulation with Filtration toolbox components	
Coagulation/sedimentation without rapid gravity filtration (Pre-sedimentation in LT2ESWTR terminology)	0.5 log credit (5.4)
Coagulation, sedimentation and filtration	3 log credits[2] (5.4)
Coagulation and direct filtration	2.5 log credits (5.5)
Second stage filtration	0.5 log credit for a second separate filtration stage following filtration with coagulation (5.6)
Enhanced combined filter performance	0.5 log credit (5.7)
Enhanced individual filter performance	1 log credit (5.8)
Filtration without coagulation toolbox components	
Diatomaceous earth filtration	2.5 log credits (5.9)
Slow sand filtration	2.5 log credits; no prior disinfection producing a residual (5.10)
Membrane filtration	Log credit up to the lower value of the removal efficiency demonstrated during the challenge test or verified by the direct integrity test applied to the system (5.11)
Cartridge filtration	2 log credits, with demonstration of at least 3-log-removal efficiency in challenge test (5.12)
Bag filtration	1 log credit, with demonstration of at least 2-log-removal efficiency in challenge test (5.13)
Inactivation toolbox components	
Chlorine dioxide	Up to 3 log credits, based on chlorine dioxide C.t table (5.14)
Ozone	Up to 3 log credits, based on ozone C.t table (5.15)
Ultraviolet light (UV)	Up to 3 log credits, based on UV dose table (5.16)

Notes

1 Some values in this table are derived from the United States Environmental Protection Agency's (USEPA's) *National Primary Drinking Water Regulations: Proposed Long Term 2 Enhanced Surface Water Treatment Rule: Proposed rule* (USEPA 2003c). This rule is subject to confirmation, so this table may need to be revised in the future. Where possible, treatment stages that provide multiple barriers to contamination should be used. (See also the *Guidelines*.)

2 Throughout the DWSNZ, **dissolved air flotation (DAF)** is considered equivalent to sedimentation. Lime-softening plants that include sedimentation and filtration are also considered equivalent.

Protozoal Compliance Criteria

5.3 Bank filtration of source water: treatment compliance criterion

Note the difference between **bank filtration** and an **infiltration gallery** (see also the *Guidelines*).

The use of bank filtration to obtain log credits is possible only when the water supplier can demonstrate good knowledge of the bank filter's performance and that the water abstracted is derived from the river and not groundwater.

To do this, the system must have been in use for at least two years and sufficient data collected over this period for the DWA to be able to assess the system's ability to meet the following requirements.

When there is uncertainty over whether the source of the water abstracted from the bore(s) is the river or groundwater, the required treatment log credits for the water supply (see section 5.2.1) can be determined by monitoring *Cryptosporidium* in the water abstracted from the bore rather than the river. If this is done, no log credits are available from the bank filtration process.

5.3.1 Log credit assessment

Core samples from the **regolith** surrounding the bore must contain at least 10 percent fine-grained material (less than 1.0 mm diameter) in at least 90 percent of their length.

The credits available are based on the **setback distance**.[14] A bore with a setback distance of:

- 7.5 m is eligible for 0.5 log credits
- 15 m is eligible for 1.0 log credits.

To obtain the claimed protozoa log credits for bank filtration, the following requirements must be met during periods when treated water is going to supply.

1. All the water is drawn from bores in an unconsolidated, predominantly sandy aquifer.
2. The monitoring requirements of section 5.3.2 are met.
3. Measurements of the turbidity of the water leaving the bore(s) satisfy all the following requirements.

For continuous monitoring:

- the turbidity does not exceed 1.0 NTU for more than 5 percent of the time over the compliance monitoring period (see section 5.3.2)
- the turbidity does not exceed 5.0 NTU for the duration of any three-minute period.

[14] The setback distance is the distance between the vertical well and the surface water when the river or stream is in a flood with a 1 percent probability of recurrence (sometimes called a 'one in 100 year' flood). For horizontal wells the setback is from the normal flow channel.

For manual sampling:

- the number of samples with turbidity greater than 1.0 NTU does not exceed the number allowed in Appendix A1.8, Table A1.3 over the compliance monitoring period (see section 5.3.2)
- the turbidity does not exceed 5.0 NTU in any sample
- documented evidence shows the turbidity does not exceed 2.0 NTU during the week after a flood that affects the source water (see *Guidelines*).

5.3.2 Monitoring

The protozoal compliance monitoring requirements for water drawn from bank filtration bores are as follows.

1. Turbidity is used as a measure of the efficacy of the bank filtration process in removing particulate matter, including protozoa. The turbidity of the water leaving the bank filtration process must be monitored for a population of:
   - 5000 and greater – continuously
   - fewer than 5000 – at least daily, sampled at evenly spaced times.
2. For continuously monitored parameters the requirements of section 3.2 must be met. The compliance monitoring periods are:
   - for continuous turbidity monitoring – one month
   - for daily turbidity monitoring – one quarter.

5.3.3 Transgressions and remedial action

A transgression occurs if:

- for continuous monitoring the monthly average of daily maximum turbidity values exceeds 1.0 NTU
- for manual monitoring, turbidity exceeds 2.0 NTU in any individual sample.

The PHRMP must document responses to possible transgressions and identify the possible causes of major transgressions (discussed in section 3.1), the actions to be taken to reduce their likelihood and what to do in the event of their happening.

5.3.4 Annual compliance

Annual compliance requires the treatment compliance criterion set out in section 5.3.1 to be met during each compliance monitoring period (see section 5.3.2) over 12 consecutive months.

5.4 Coagulation, sedimentation and filtration processes: treatment compliance criteria

This coagulation, sedimentation and filtration option may include processes where dissolved air flotation is used instead of sedimentation. It also allows single-stage lime softening as an alternative, provided it includes all three processes – **chemical coagulation**, sedimentation and filtration. Recently developed modifications to the sedimentation process such as ballasted sand and buoyant media are also acceptable.

The situation where the coagulation/sedimentation process is not immediately followed by rapid gravity sand filtration is also covered.

5.4.1 Log credit assessment

1. To obtain three protozoa log credits, a coagulation, sedimentation and filtration process must meet the following requirements during periods when treated water is being delivered to the consumer:
   a. filtration is of a rapid gravity granular media design (or pressure equivalent)
   b. all water passes through the full coagulation, **flocculation**, sedimentation and filtration process; all parts of which are continuous, excluding any periods when the filtered water is not going to supply
   c. the monitoring requirements of section 5.4.2 are met
   d. measurements of the turbidity of the water leaving each filter satisfy all the following requirements.
      - For continuous monitoring:
        - the turbidity does not exceed 0.30 NTU for more than 5 percent of the time the filter is online over the compliance monitoring period (Table 5.3)
        - the turbidity does not exceed 0.50 NTU for more than 1 percent of the time the filter is online over the compliance monitoring period (Table 5.3)
        - during a filter run, the turbidity does not exceed 1.0 NTU for the duration of any three-minute period.
      - For manual sampling:
        - the number of samples with turbidity greater than 0.30 NTU does not exceed the number allowed in Table A1.2 over the compliance monitoring period (Table 5.3)
        - not more than one sample exceeds 0.50 NTU over the compliance monitoring period (Table 5.3)
        - during a filter run, turbidity does not exceed 1.0 NTU in any sample.

2. Alternative for when rapid gravity sand filtration does not immediately follow the chemical coagulation/sedimentation (called coagulation-enhanced presedimentation in LT2ESWTR) process.

   To obtain 0.5 log credits for the coagulation/sedimentation process alone, the following conditions must be met:

   - the process must be in continuous operation and all the flow must pass through it
   - coagulant must be added continuously
   - the sedimentation process must achieve at least a 70 percent reduction in turbidity of the water in a least 11 out of the 12 previous consecutive months.

   This monthly demonstration of turbidity reduction must be based on the arithmetic mean of the turbidity of the raw water and the water leaving the sedimentation process measured at the frequency specified in section 5.4.2.

5.4.2 Monitoring

The protozoal compliance monitoring requirements are as follows.

1. Turbidity is used as a measure of the efficacy of the coagulation, sedimentation and filtration process in removing particulate matter, including protozoa.
2. The turbidity must be measured at each filter in the frequencies specified in Table 5.3.[15] Each filter's performance must be reported separately. If there is not one turbidimeter to each filter, each filter must be sampled sequentially (no blending) for five minutes. Sample lines should be short and sample flows high enough to prevent adsorption or precipitation.
3. For continuously monitored parameters, the requirements of section 3.2 must be met.
4. Particle counting may be used as an alternative to turbidimetry to measure the efficacy of the coagulation, sedimentation and filtration process (see *Guidelines*) provided that the relation between particle counts and process performance has been established and documented to the satisfaction of the DWA.
5. Where the coagulation/sedimentation process is not immediately followed by rapid gravity sand filtration, the turbidity of the raw water and the water leaving the sedimentation process must be measured:
   a. continuously for plants serving more than 10,000 people
   b. at least twice a day for plants serving 5,001–10,000 people
   c. at least daily for plants serving 501–5,000 people
   d. twice a week for plants serving 101–500 people.

   In each case, the compliance monitoring period is a month.

[15] For advanced optimisation of the coagulation/sedimentation/filtration process, particle counting may be used (see the *Guidelines*).

Table 5.3: Minimum measurement frequency and compliance monitoring period for turbidity in water leaving each filter for protozoal compliance

Population served	Number of turbidimeters for continuous monitoring	Minimum measurement frequency for each filter (manual measurement)	Compliance monitoring period[1]	
			Continuous	Manual
More than 10,000	One on each filter (or housing)	*Not applicable*	One month	*Not applicable*
5,001–10,000[2]	At least one to every two filters (or housings)	Twice a day	One month	One quarter
501–5,000[3]	At least one to every four filters (or housings)	Daily	One month	One year
500 or fewer[4]	At least one to every four filters (or housings)	Twice a week	One month	One year

Notes

1 The compliance monitoring period is the length of time over which treatment performance is assessed to determine whether the treatment process is complying. Compliance monitoring periods are sequential.

2 Plants supplying baseline permanent populations of 5,001–10,000 must have individual continuous monitoring of each filter from 1 January 2008.

3 Plants supplying baseline permanent populations of 501–5,000 must have individual continuous monitoring of each filter from 1 January 2009.

4 There must be at least one turbidimeter to every two filters from 1 January 2008.

5.4.3 Transgression and remedial action

A performance transgression occurs if:

- for continuous monitoring of water leaving a filter, the turbidity exceeds 0.50 NTU for any period of more than 15 minutes
- or for manual sampling, the turbidity measured in any individual sample exceeds 0.50 NTU.

If a transgression occurs the DWA must be advised and the cause must be investigated and remedied as soon as possible. See the *Guidelines* for guidance on investigating the causes of transgressions and remedial actions.

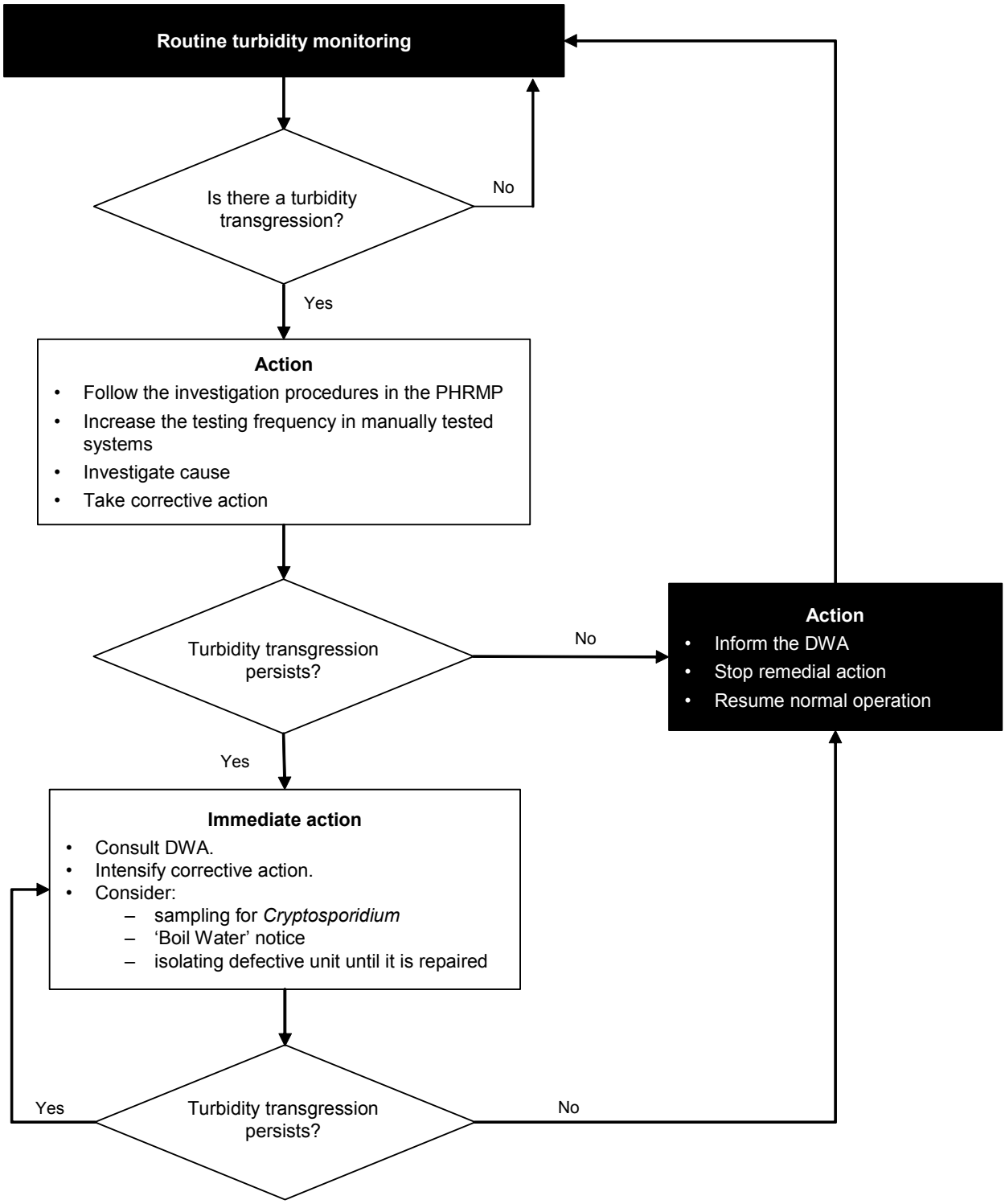
Figure 5.1 (page 65) shows the steps to be followed in response to a turbidity transgression for water leaving a filter. The PHRMP must document responses to possible transgressions and identify the possible causes of major transgressions (discussed in section 3.1), the actions to be taken to reduce their likelihood and what to do in the event of their happening.

For the alternative where rapid gravity sand filtration does not immediately follow the chemical coagulation/sedimentation process:

- failure to achieve the 0.5 log reduction for in any one month is a transgression
- more than one failure per annum constitutes non-compliance.

Protozoal Compliance Criteria

Figure 5.1: Response to turbidity transgression in water after treatment



Note: PHRMP = Public Health Risk Management Plan

5.4.4 Annual compliance

Annual compliance requires that the treatment compliance criteria set out in section 5.4.1 are met during each compliance monitoring period (Table 5.3) over 12 consecutive months.

5.5 Coagulation, direct filtration: treatment compliance criteria

5.5.1 Log credit assessment

To obtain 2.5 protozoa log credits, a coagulation, direct filtration process must meet the following requirements during periods when treated water is being delivered to the consumer.

1. Section 5.4.1 requirement a is met.
2. All water passes through the full chemical coagulation and filtration process, which is continuous.
3. Section 5.4.1 requirement c is met.
4. Section 5.4.1 requirement d is met.

5.5.2 Monitoring

Section 5.4.2 requirements are met.

5.5.3 Transgression and remedial action

Section 5.4.3 requirements are met.

5.5.4 Annual compliance

Annual compliance requires that the treatment compliance criteria set out in section 5.5.1 are met during each compliance monitoring period of one month over 12 consecutive months.

5.6 Second stage filtration: treatment compliance criteria

5.6.1 Log credit assessment

To obtain 0.5 protozoa log credits for second stage filtration, the following requirements must be met during periods when treated water is being delivered to the consumer.

1. A second, separate filtration stage is in operation, which consists of rapid sand, dual media, granular activated carbon (GAC) or other fine grain media in a separate stage after granular media filtration. (A cap, such as GAC, on a single stage of filtration will not qualify for this credit.)
2. The treatment train includes chemical coagulation before the first filters, and both filtration stages treat all of the flow continuously. The first filters may be membrane filters.

3. Measurements of the turbidity of the combined second stage filtrate or effluents satisfy the following requirements.
    a. Turbidity does not exceed 0.15 NTU for more than 5 percent of the time during the compliance monitoring period of one month).
    b. During a filter run, turbidity does not exceed 0.50 NTU for the duration of any three-minute period.
    c. The turbidity does not exceed 0.30 NTU for more than 1 percent of the time the filters are online over the compliance monitoring period of one month).
4. The monitoring requirements of section 5.6.2 are met.

5.6.2 Monitoring

The protozoal compliance monitoring requirements for second stage filtration are as follows.

1. Turbidity is used as a measure of the efficacy of treatment processes in removing particulate matter, including protozoa. The turbidity of the water leaving the filter units that together comprise the second stage filtration process must be measured continuously. (Combined filtrates can be monitored, or a system that calculates the mean turbidity from the readings from online turbidimeters on each filter can be used.)
2. For continuously monitored parameters, the requirements of section 3.2 must be met.

5.6.3 Transgression and remedial action

A performance transgression occurs if the turbidity exceeds 0.30 NTU for more than 15 minutes.

If a transgression occurs the DWA must be advised and the cause must be investigated and remedied as soon as possible. (See the *Guidelines* for guidance on investigating the causes of transgressions and remedial actions.)

Figure 5.1 (page 65) shows the steps to be followed in response to a turbidity transgression for water leaving a filter. The PHRMP must document responses to possible transgressions and identify the possible causes of major transgressions (discussed in section 3.1), the actions to be taken to reduce their likelihood and what to do in the event of their happening.

5.6.4 Annual compliance criteria

Annual compliance requires that the treatment compliance criteria set out in section 5.6.1 are met during each compliance monitoring period of one month over 12 consecutive months.

5.7 Enhanced combined filter performance: treatment compliance criteria

5.7.1 Log credit assessment

To obtain 0.5 protozoa log credits over and above those for coagulation, sedimentation and filtration (or coagulation and direct filtration), the following additional criteria must be met during periods when treated water is being delivered to the consumer.

1. The monitoring requirements of section 5.7.2 are met.
2. Measurements of the turbidity of the filtered water from the combined filters satisfy the following requirements.
    a. The turbidity does not exceed 0.15 NTU for more than 5 percent of the time the filters are online over the compliance monitoring period of one month.
    b. The turbidity does not exceed 0.30 NTU for more than 1 percent of the time the filters are online over the compliance monitoring period of one month.
    c. During a filter run, turbidity does not exceed 0.50 NTU for the duration of any three-minute period.

5.7.2 Monitoring

The protozoal compliance monitoring requirements for enhanced combined filter performance are as follows.

1. Turbidity is used as a measure of the efficacy of the coagulation, sedimentation and filtration process in removing particulate matter, including protozoa. The turbidity of the filtered water from the combined filters must be measured continuously. (Alternatively, a system that calculates the mean turbidity from the readings from online turbidimeters on each filter can be used.)
2. For continuously monitored parameters, the requirements of section 3.2 must be met.

5.7.3 Transgression and remedial action

A performance transgression occurs if the turbidity exceeds 0.30 NTU for more than 15 minutes.

If a transgression occurs and cannot be remedied within one hour the DWA must be advised and the cause must be investigated and remedied as soon as possible. (See the *Guidelines* for guidance on investigating the causes of transgressions and remedial actions.)

Figure 5.1 (page 65) shows the steps to be followed in response to a turbidity transgression for water leaving a filter. The PHRMP must document responses to possible transgressions and identify the possible causes of major transgressions (discussed in section 3.1), the actions to be taken to reduce their likelihood and what to do in the event of their happening.

The PHRMP must document responses to possible transgressions and identify the possible causes of major transgressions (discussed in section 3.1), the actions to be taken to reduce their likelihood and what to do in the event of their happening.

5.7.4 Annual compliance

Annual compliance requires that the treatment compliance criteria set out in section 5.7.1 are met during each compliance monitoring period (Table 5.3) over 12 consecutive months.

5.8 Enhanced individual filter performance: treatment compliance criteria

5.8.1 Log credit assessment

To obtain 1.0 protozoa log credits over and above that for coagulation, sedimentation and filtration (or coagulation and direct filtration), the following additional criteria must be met during periods when filtered water is going to supply.

1. The monitoring requirements of section 5.8.2 are met.
2. Measurements of the turbidity of the filtered water satisfy the following requirements.
    a. The turbidity does not exceed 0.10 NTU for more than 5 percent of the time the filter is online over the compliance monitoring period of one month.
    b. The turbidity does not exceed 0.30 NTU for more than 1 percent of the time the filters are online over the compliance monitoring period of one month.
    c. During a filter run, the turbidity does not exceed 0.50 NTU for the duration of any three-minute period.

Systems that receive the additional 1.0 log credits for individual filter performance cannot also receive the additional 0.5 log credit for enhanced combined filter performance.

5.8.2 Monitoring

The protozoal compliance monitoring requirements for enhanced individual filter performance are as follows.

1. Turbidity is used as a measure of the efficacy of the coagulation, sedimentation and filtration process in removing particulate matter, including protozoa. The turbidity of the water leaving each filter unit is measured continuously.
2. The requirements of section 3.2 must be met.

5.8.3 Transgression and remedial action

A performance transgression occurs if the turbidity exceeds 0.20 NTU for more than 15 minutes.

If a transgression occurs the DWA must be advised as soon as possible and the cause must be investigated and remedied. (See the *Guidelines* for guidance on investigating the causes of transgressions and remedial actions.)

Figure 5.1 (page 65) shows the steps to be followed in response to a turbidity transgression for water leaving a filter. The PHRMP must document responses to possible transgressions and identify the possible causes of major transgressions (discussed in section 3.1), the actions to be taken to reduce their likelihood and what to do in the event of their happening.

The PHRMP must document responses to possible transgressions and identify the possible causes of major transgressions (discussed in section 3.1), the actions to be taken to reduce their likelihood and what to do in the event of their happening.

5.8.4 Annual compliance

Annual compliance requires that the treatment compliance criteria set out in section 5.8.1 are met during each compliance monitoring period (Table 5.3) over 12 consecutive months.

5.9 Diatomaceous earth filtration: treatment compliance criteria

5.9.1 Log credit assessment

To obtain 2.5 protozoa log credits, a diatomaceous earth filtration process, which may be of pressure or vacuum design, must meet the following requirements during periods when treated water is being delivered to the consumer.

1. All water passes through the process, which is continuous while producing treated water.
2. The minimum diatomaceous earth pre-coat thickness that will reliably remove protozoa in different raw water conditions is determined by testing.
3. The monitoring requirements of section 5.9.2 are met.
4. Measurements of the turbidity of the water leaving each filter satisfy the following requirements except in the case of fine colloidal material when the DWA may approve alternative criteria (refer to the *Guidelines*).
    a. For continuous monitoring:
        i. the turbidity does not exceed 0.30 NTU for more than 5 percent of the time the filter is online over the compliance monitoring period (Table 5.3)
        ii. the turbidity does not exceed 0.50 NTU for more than 1 percent of the time the filter is online over the compliance monitoring period (Table 5.3)

iii. during a filter run, the turbidity does not exceed 1.0 NTU for the duration of any three-minute period

iv. during a filter run, filtered water turbidity does not, exceed the raw water turbidity for the duration of any three-minute period, if the raw water turbidity is less than 0.50 NTU.

b. For manual sampling:

i. the number of samples with turbidity greater than 0.30 NTU does not exceed the number allowed in Appendix A1.8, Table A1.3 over the compliance monitoring period (Table 5.3)

ii. not more than one sample exceeds 0.50 NTU over the compliance monitoring period (Table 5.3)

iii. during a filter run, turbidity does not exceed 1.0 NTU in any sample

iv. during a filter run, filtered water turbidity is less than the raw water turbidity in all samples, if the raw water turbidity is less than 0.50 NTU.

5.9.2 Monitoring

The protozoal compliance monitoring requirements for diatomaceous earth filtration are as follows.

1. Turbidity is used as a measure of the efficacy of the diatomaceous earth filtration process in removing particulate matter, including protozoa. The turbidity of the water leaving each filter unit must be measured at the frequencies specified in Table 5.3 as a *minimum*.
2. Each filter's performance must be reported separately. If there is not one turbidimeter to each filter, each filter must be sampled sequentially (no blending) for five minutes. Sample lines should be short and sample flows high enough to prevent adsorption or precipitation.
3. For continuously monitored parameters, the requirements of section 3.2 must be met.

5.9.3 Transgressions and remedial action

A performance transgression occurs if:

- for continuous monitoring the turbidity exceeds 0.50 NTU for more than one hour
- for manual sampling the turbidity measured in any individual sample exceeds 0.50 NTU.

If a transgression occurs, the DWA must be advised and the cause must be investigated and remedied as soon as possible. (See *Guidelines* for guidance on investigating the causes of transgressions and remedial actions.)

Figure 5.1 (page 65) shows the steps to be followed in response to a turbidity transgression for water leaving a filter.

The PHRMP must document responses to possible transgressions and identify the possible causes of major transgressions (discussed in section 3.1), the actions to be taken to reduce their likelihood and what to do in the event of their happening.

5.9.4 Annual compliance

Annual compliance requires that the treatment compliance criteria set out in section 5.9.1 are met during each compliance monitoring period (Table 5.3) over 12 consecutive months.

5.10 Slow sand filtration: treatment compliance criteria

5.10.1 Log credit assessment

To obtain 2.5 protozoa log credits for a slow sand filter used as a primary process, the following requirements must be met during periods when treated water is being delivered to the consumer.

1. All water passes through the process.
2. The filter does not dry out.
3. Disinfecting chemicals leaving a residual disinfectant are not dosed upstream of the filter beds.
4. The filters are operated at a constant flow rate, which is less than 0.35 m/h.
5. The temperature of the water entering the filter does not drop below 6ºC for more than 24 hours.
6. The monitoring requirements of section 5.10.2 are met.
7. For continuous monitoring:
   a. the turbidity does not exceed 0.50 NTU for more than 5 percent of the time the filter is online over the compliance monitoring period (Table 5.3)
   b. during a filter run, the turbidity does not exceed 1.0 NTU for the duration of any three-minute period
   c. during a filter run, if the raw water turbidity is less than 0.50 NTU, the filtered water turbidity does not, exceed the raw water turbidity for the duration of any three-minute period.
8. For manual sampling:
   a. not more than one sample exceeds 0.50 NTU over the compliance monitoring period (Table 5.3)
   b. during a filter run, turbidity does not exceed 1.0 NTU in any sample
   c. during a filter run, if the raw water turbidity is less than 0.50 NTU, the filtered water turbidity is less than the raw water turbidity in all samples.

5.10.2 Monitoring

Turbidity is used as a measure of the efficacy of the slow sand filtration process in removing particulate matter, including protozoa.

The protozoal compliance monitoring requirements for slow sand filtration are as for section 5.9.2 with the following additional requirements.

1. The temperature of the raw water entering the filter is measured daily.
2. The flow rate through the filter is measured at least daily.
3. For continuously monitored parameters, the requirements of section 3.2 must be met.

5.10.3 Transgressions and remedial action

A performance transgression occurs if:

- for continuous monitoring, the turbidity exceeds 0.50 NTU for more than one hour
- for manual sampling, the turbidity measured in any individual sample exceeds 0.50 NTU.

If a transgression occurs, the DWA must be advised and the cause must be investigated and remedied as soon as possible. See the *Guidelines* for guidance on investigating the causes of transgressions and remedial actions.

Figure 5.1 (page 65) shows the steps to be followed in response to a turbidity transgression for water leaving a filter.

The PHRMP must document responses to possible transgressions and identify the possible causes of major transgressions (discussed in section 3.1), the actions to be taken to reduce their likelihood and what to do in the event of their happening.

5.10.4 Annual compliance

Annual compliance requires that the treatment compliance criteria set out in section 5.10.1 are met during each compliance monitoring period (Table 5.3) over 12 consecutive months.

5.11 Membrane filtration: treatment compliance criterion

For the purpose of the DWSNZ, membrane filtration is defined as a pressure- or vacuum-driven separation process in which particulate matter larger than one micrometer is rejected by a non-fibrous, engineered barrier (primarily through a size exclusion mechanism), which has a measurable removal efficiency of a target organism that can be verified using a direct integrity test.

Membrane filtration includes **microfiltration (MF)**, **ultrafiltration (UF)**, **nanofiltration (NF)** and **reverse osmosis (RO)**.

A membrane filter plant may be an assembly of units, trains or modules or even a single membrane (see membrane filter in Definitions).

- A unit is an assembly of modules or trains that can be isolated from the rest of the filter plant for testing or maintenance.
- A train (or bank) is an assembly of modules.
- A module is an assembly of membranes.
- An individual membrane may be one of several different types: 'fibres' (ie, a single filament), tubular, spiral wound, etc.

5.11.1 Log credit assessment

The maximum number of log credits that a membrane filtration process is eligible to receive depends upon the manufacturer's **certification** of the log removal that the filter plant can deliver. The manufacturer's certificate (or verification) must specify the operational and maintenance requirements to ensure that the membrane units will perform to specification and the integrity testing procedure that the water supplier must carry out to demonstrate that the plant is operating at the claimed log credit rating and must document the challenge, or other, tests that were carried out to verify the log credit rating. A suitable verification procedure is outlined in the United States Environmental Protection Agency (USEPA) *Membrane Filter Guidance Manual* (USEPA 2003b).

To obtain the claimed protozoa log credits, the membrane filtration plant must meet the following requirements during periods when the water that is treated is to be delivered to the consumer.

1. All water passes through the filter plant.
2. The monitoring requirements of section 5.11.2 are met.
3. The continuous indirect integrity tests used in section 5.11.2 are carried out on each unit (although these may be replaced by continuous direct integrity tests if they become available and provided they meet the resolution and sensitivity requirements in 4 below).
4. The direct integrity test used in section 5.11.2 meets the following performance requirements.
    a. Resolution: The test is applied in a manner such that a 3-micrometer (µm) hole affects the response from the test.
    b. Sensitivity: The test is capable of verifying the log removal value claimed for the membrane process.
    c. Frequency (see section 5.11.2).
    d. For existing membrane filter plants that do not comply with these resolution and sensitivity requirements, the water supplier must provide documentation of the procedures that have been used to validate the log credit rating claimed.

5. In addition to *routine* direct integrity testing (section 5.11.2), direct integrity testing of each membrane filter unit is carried out as soon as possible if any of the following occur.
    a. The turbidity of the filtered water from the membrane filter unit (the default indirect integrity test) exceeds 0.10 NTU for more than 15 minutes. (If the manufacturer has specified a different maximum turbidity limit as part of the validation requirements, this must be adopted in place of the 0.10 NTU.)
    b. The approved upper control limits of an alternative indirect integrity test specified by the manufacturer (eg, continuous particle counting) are exceeded in the filtrate for more than 15 minutes.
    c. The membrane filter unit has been out of service for maintenance. (The testing must be done before the unit is returned to service.)
6. The filtrate turbidity does not exceed the turbidity of the feedwater for the duration of any three-minute period.
7. No membrane filter unit may be used that has failed its direct integrity test.

5.11.2 Compliance monitoring

The protozoal compliance monitoring requirements for membrane filtration are as follows.

1. Turbidity is used as one measure of the efficacy of the membrane filtration process in removing particulate matter, including protozoa. For membrane filters additional measurement of performance by means of integrity tests specified by the manufacturer are usually used. The turbidity (or other monitoring test specified by the manufacturer) of the membrane filter plant feed water must be monitored continuously.
2. Indirect integrity testing must be undertaken by continuously monitoring the turbidity of the filtrate from each membrane filter unit.[16] Alternatively, continuous indirect integrity monitoring tests specified by the manufacturer may be used.
3. For continuously monitored parameters, the requirements of section 3.2 must be met.
4. Direct integrity tests must be performed on each membrane filter unit at least daily and must follow the manufacturer's test procedure.[17] For the first 10 days of operation of a new filter unit or for a unit that is exceeding the indirect integrity test control limit at daily or more frequent intervals, direct integrity tests must be performed at least every 12 hours.
5. Manufacturers must certify each module's performance specifications and also provide the operational and maintenance requirements for ensuring the module will perform to these specifications.

The compliance monitoring period is one month for direct integrity testing.

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[16] Smaller plants may be able to sample individual modules.

[17] If continuous direct integrity test methods become available that also meet the required sensitivity and resolution, they may be used in lieu of period testing, subject to Ministry of Health approval.

5.11.3 Transgressions and remedial action

A transgression occurs if:

- the turbidity of the filtered water exceeds 0.15 NTU for any period of more than 30 minutes
- the period between an indirect integrity test indicating that a membrane filter unit may require a direct integrity test and the unit being taken out of service or subjected to a direct integrity test exceeds one hour.

An exception report is submitted to the DWA in the event of any transgression that could have resulted in potentially non-compliant water being delivered to consumers. The report must summarise the test results and the remedial action taken in each case.

In this event, the membrane unit or module must be taken off-line for diagnostic testing and repair, and returned to service only after the repair has been completed and confirmed by a direct integrity test.

The PHRMP must document responses to possible transgressions and identify the possible causes of major transgressions (discussed in section 3.1), the actions to be taken to reduce their likelihood and what to do in the event of their happening.

5.11.4 Annual compliance

Annual compliance requires that the treatment compliance criteria set out in section 5.11.1 are met during each compliance monitoring period of one month over 12 consecutive months.

The requirements/criteria for each membrane filter unit for the claimed log credits must not be failed for more than 5 percent of the compliance monitoring period.

5.12 Cartridge filtration: treatment compliance criteria

A cartridge filter plant consists of a set of **housings** each containing between one and 20 cartridge filters.

5.12.1 Log credit assessment

To obtain two protozoa log credits for cartridge filtration, the following requirements must be met during periods when the water that is treated is to be delivered to the consumer.

Note that no combination of bag filters and cartridge filters will qualify for more than 2 log credits.

Also, when a cartridge filter is used for second stage filtration (section 5.2.4, 1(a) and 3(a)) it only attracts 0.5 log credits.

1. Each cartridge has a certified *Cryptosporidium* removal efficiency of 3 log removal or greater. (See the *Guidelines* for certification requirements.)

2. All water passes through the cartridge filter plant.

3. The monitoring requirements of section 5.12.2 are met.

4. For systems required to monitor turbidity (see Table 5.4), measurements of the turbidity of the water leaving each housing satisfy the following requirements, except where the water contains colloidal material that has been shown to be consistently below one micron, when the DWA may approve alternative criteria (refer to the *Guidelines*).

    a. For continuous monitoring:

        i. the turbidity of the water leaving each housing does not exceed 0.5 NTU for more than 5 percent of the time the cartridge filter plant is online over the compliance monitoring period of one month

        ii. the turbidity of the water leaving each housing does not exceed 1.0 NTU for the duration of any three-minute period

        iii. during the period that the housing is online, the filtered water turbidity for the duration of any three-minute period does not exceed the raw water turbidity, if the raw water turbidity is less than 0.50 NTU.

    b. For manual sampling:

        i. the number of samples with turbidity greater than 0.5 NTU does not exceed the number allowed in Appendix A1.8, Table A1.3 over the compliance monitoring period of one month)

        ii. turbidity does not exceed 1.0 NTU in any sample

        iii. filtered water turbidity is less than raw water turbidity in all samples, if the raw water turbidity is less than 0.50 NTU.

5. Individual cartridge filters (or the packaging containing up to 50 individual cartridges) are labelled in accordance with clause 7.3 of NSF/ANSI 53-2002 (plus Addenda 1 and 2), and cartridge filter housings are labelled in accordance with clause 7.2 of NSF/ANSI 53-2002 (plus Addenda 1 and 2), or equivalent.

6. A slow opening/closing valve is fitted ahead of the cartridge filter plant, and the filtrate passes either through a pressure surge valve, or directly to a tank before any subsequent process or pumping. (These steps are to minimise flow surges causing **unloading**.)

7. A flow restrictor that maintains the flow below the certified maximum operating rate is fitted to each housing.

8. Differential pressure measurements to confirm that the minimum filter pressure always exceeds the pressure corresponding to a clean filter that was established during commissioning.

    a. for continuous monitoring:

        i. differential gauges are fitted to each housing

        ii. have a 1.0 kPa accuracy

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b. for manual monitoring (ie, for populations of 500 or fewer):
    i. are located before and after each housing
    ii. have a dial of at least 100 mm diameter
    iii. are a liquid-filled type
    iv. have a range suitable for the process (ie, the system's maximum pressure is about 75 percent of the gauge range).

9. Pressure differences across each housing are kept within the manufacturer's recommendations.

Membrane material configured into a cartridge filtration device that meets the definition of membrane filtration and that can be direct integrity tested according to the criteria specified for membrane filters is eligible for the same removal credit as a membrane filtration process subject to meeting the requirements of section 5.11.

See the *Guidelines* for the required procedures for **commissioning testing**.

5.12.2 Monitoring

The protozoal compliance monitoring requirements for cartridge filtration are as follows.

1. Turbidity is used as a measure of the efficacy of the cartridge filtration process in removing particulate matter, including protozoa. The turbidity of the cartridge filter plant feed water (or other monitoring test specified by the manufacturer) must be monitored as specified below.
2. The flow to each housing, and the differential pressure across each housing, must be measured at the frequencies specified in Table 5.4 as a *minimum*.
3. Turbidity (and/or particle counts if used) must be measured in the water leaving each cartridge filter plant at the frequencies specified in Table 5.4 as a *minimum*.
4. The performance of each filter housing must be reported separately. If there is not one turbidimeter to each filter housing, each housing must be sampled sequentially (no blending) for five minutes. Sample lines should be short and sample flows high enough to prevent adsorption or precipitation
5. Raw water turbidity (and/or particle counts if used) must be monitored at the same frequency as the treated water.
6. Differential pressure measurements must be made immediately after cartridge replacement to ensure proper seating and no damage to the cartridge.
7. If particle count monitoring is used, particles in the 2–5 μm size range must be monitored in the water leaving each cartridge filter plant. The transgression level for the particle count must be set at a level that has been demonstrated to give a performance equivalent to that obtained when the manufacturer's operating specifications (eg, turbidity and differential pressure) are complied with.

8. For continuous pressure measurement, a differential pressure gauge must be fitted across each housing, and the initial pressure drop after every new cartridge set is installed in the housing must be recorded. This must be done at maximum water flow rate (a post-filtration waste valve can be installed to achieve maximum flow).
9. For manual pressure measurements, the pressure readings must be taken at maximum water flow. A valve and drain to waste must be fitted after the filter and flow restrictor and should be open when the pressure reading is taken and recorded.
10. For continuously monitored parameters, the requirements of section 3.2 must be met. The compliance monitoring period is one month.

Table 5.4: Minimum measurement frequencies for differential pressure, flow, turbidity and particle counting for cartridge and bag filtration

Population served	Differential pressure	Flow	Turbidity[1]	Particle counting[1,2] (where used)
More than 10,000	*Not required*	Continuous	See Table 5.3	Continuous
501–10,000	Continuous[1]	Continuous	See Table 5.3	*Not required*
500 or less	Weekly	Daily[3]	*Not required*	*Not required*

Notes

1 Measurement on each housing.

2 Particle counting is optional.

3 Obtained from water meter readings.

5.12.3 Transgressions and remedial action

A performance transgression occurs if:

- for continuous monitoring the turbidity exceeds 0.50 NTU for more than one hour
- for manual sampling the turbidity measured in any individual sample exceeds 0.50 NTU.

The maximum number of allowable transgressions is given in Appendix A1.8, Table A 1.2.

The compliance monitoring period is one month, unless otherwise stated in Table 5.3 for manually monitored systems.

If a transgression occurs, the DWA must be advised and the cause must be investigated and remedied as soon as possible. See the *Guidelines* for guidance on investigating the causes of transgressions and remedial actions.

Figure 5.1 (page 65) shows the steps to be followed in response to a turbidity transgression for water leaving the cartridge filter plant.

The PHRMP must document responses to possible transgressions and identify the possible causes of major transgressions (discussed in section 3.1), the actions to be taken to reduce their likelihood and what to do in the event of their happening.

5.12.4 Annual compliance criteria

Annual compliance requires that the treatment compliance criteria set out in section 5.12.1 be met during each compliance monitoring period of one month over 12 consecutive months.

5.13 Bag filtration: treatment compliance criteria

5.13.1 Log credit assessment

To obtain 1 protozoa log credit for bag filtration, the following requirements must be met during periods when treated water is being delivered to the consumer.

Note that no combination of bag filters and cartridge filters will qualify for more than 2 log credits. Also when a bag filter is used for tertiary filtration (section 5.2.4, 1(a)) it only attracts 0.5 log credits.

1. The bag filter has a certified *Cryptosporidium* removal efficiency of 2 log removal or greater. (See the *Guidelines* for certification requirements.)
2. Section 5.12.1 requirement 2 is met.
3. The monitoring requirements of section 5.13.2 are met.
4. Section 5.12.1 requirement 4 is met.
5. Bag filters are labelled in accordance with clause 7.3 of NSF/ANSI 53-2002 (plus Addenda 1 and 2) or equivalent, and bag filter housings are labelled in accordance with clause 7.2 of NSF/ANSI 53-2002 (plus Addenda 1 and 2) or equivalent.
6. Section 5.12.1 requirements 5–9 are met.

See the *Guidelines* for the required procedures for commissioning testing.

5.13.2 Monitoring

The protozoal compliance monitoring requirements for bag filtration are as follows.

1. Differential pressure (pressure across the bag), flow, turbidity and particle counting must be measured at each filter, or filter unit at the frequencies specified in Table 5.4 as a *minimum*.
2. Turbidity is used as a measure of the efficacy of the bag filtration process in removing particulate matter, including protozoa. Turbidity (and/or particle counts if used) must be measured in the water leaving each bag filter plant at the frequencies specified in Table 5.4 as a *minimum*.
3. Section 5.12.2 requirement 3 is met.

4. Differential pressure measurements must be made immediately after each bag replacement to check the bag is properly seated and no damage to the bag has occurred.
5. Section 5.12.2 requirement 5 is met.
6. For continuous pressure measurement, a differential pressure gauge or transducer must be fitted across the bag filter and the initial pressure drop after every new bag is installed must be recorded. This must be done at maximum water flow rate (a post-filtration waste valve can be installed to achieve maximum flow).
7. Section 5.12.2 requirement 7 is met.
8. For continuously monitored parameters the requirements of section 3.2 must be met.

The compliance monitoring period is one month unless otherwise stated in Table 5.3 for manually monitored systems.

5.13.3 Transgressions and remedial action

A performance transgression occurs if any of the requirements of section 5.13.1 are not met.

If a transgression occurs, the DWA must be advised and the cause must be investigated and remedied as soon as possible. See the *Guidelines* for guidance on investigating the causes of transgressions and remedial actions.

Figure 5.1 (page 65) shows the steps to be followed in response to a turbidity transgression for water leaving the bag filter plant.

The PHRMP must document responses to possible transgressions and identify the possible causes of major transgressions (discussed in section 3.1), the actions to be taken to reduce their likelihood and what to do in the event of their happening.

5.13.4 Annual compliance

Annual compliance requires that the treatment compliance criteria set out in section 5.13.1 are met during each compliance monitoring period of one month over 12 consecutive months.

5.14 Chlorine dioxide: treatment compliance criteria

5.14.1 Log credit assessment

The credits available are based on the demonstration of log inactivation as stated in the chlorine dioxide C.t table (Table 5.5). See the *Guidelines* and USEPA toolbox guidance manual (USEPA 2003a: Part 10) for requirements for determining contact times.

Table 5.5: C.t values (min.mg/L) for *Cryptosporidium* inactivation by chlorine dioxide

Log credit	Water temperature (°C)[1]					
	1	5	10	15	20	25
0.5	305	214	138	89	58	38
1.0	610	429	277	179	116	75
1.5	915	643	415	268	174	113
2.0	1220	858	553	357	232	150
2.5	1525	1072	691	447	289	188
3.0	1830	1286	830	536	347	226

Note

1 C.t values between the indicated temperatures may be determined by interpolation.

To obtain the claimed protozoa log credit for chlorine dioxide treatment, the following requirements must be met when treated water is being delivered to the consumer.

1. All water is treated with chlorine dioxide.
2. The measured C.t value is not less than:
    a. the C.t value given in Table 5.5 for the claimed log credit and measured water temperature for more than 5 percent of the compliance monitoring period (see section 5.14.2)
    b. 80 percent of the C.t value in Table 5.5 for the claimed log credit and measured water temperature for the duration of any three-minute period in the compliance monitoring period.
3. The monitoring requirements of section 5.14.2 are met.
4. Measurements of the turbidity of the water being disinfected satisfy all the following requirements.
    a. For continuous monitoring:
        i. the turbidity does not exceed 1.0 NTU for more than 5 percent of the compliance monitoring period of one month
        ii. the turbidity does not exceed 2.0 NTU for the duration of any three-minute period.

b. For manual sampling:
   i. the number of samples with turbidity greater than 1.0 NTU does not exceed the number allowed in Appendix A1.8, Table A1.3 over the compliance monitoring period for manual sampling (see section 5.14.2)
   ii. the turbidity does not exceed 2.0 NTU in any sample in the compliance monitoring period.

5. The chlorite concentration in the water does not exceed a concentration of 0.8 mg/L (see section 8.3.3).

5.14.2 Monitoring

The protozoal compliance monitoring requirements for chlorine dioxide treatment are as follows.

1. The chlorine dioxide sampling site is at a point where the adequacy of the residual and the minimum disinfection contact time[18] can be demonstrated clearly (see the *Guidelines*) but before the first consumer.
2. The chlorine dioxide residual is monitored continuously.
3. The flow is measured continuously.
4. The water temperature is measured daily, at the same location at which the chlorine dioxide residual is measured or in the raw water.
5. Turbidity is measured at the frequencies specified in Table 5.3 as a *minimum*. For populations of 100 or fewer (not covered by Table 5.3), turbidity must be measured when a sample is collected for *E. coli* testing.
6. For continuously monitored parameters, the requirements of section 3.2 must be met.
7. When the chlorite MAV is likely to be exceeded, a monitoring programme must be established to the DWA's satisfaction.

The compliance monitoring period for:

- C.t values is one month
- turbidity is in Table 5.3.

[18] The contact time is the average time, at peak daily flow, for the water to flow from the chlorine dioxide dose point to the sampling point, after making due allowance for short circuiting and variations in volume (see *Guidelines* section 15.2.9).

5.14.3 Transgressions and remedial action

A performance transgression occurs if any of the requirements of section 5.14.1 are not met.

If a transgression occurs the DWA must be advised, and the cause must be investigated and remedied as soon as possible. See the *Guidelines* for guidance on investigating the causes of transgressions and remedial actions. If the treatment plant has no filters, the frequency of monitoring for the whole flow must be that given in Table 5.3 for each filter.

The steps to be followed in response to a turbidity transgression for treated water or a disinfectant transgression are shown in Figures 5.1 and 5.2 respectively.

The PHRMP must document responses to possible transgressions and identify the possible causes of major transgressions (discussed in section 3.1), the actions to be taken to reduce their likelihood and what to do in the event of their happening.

5.14.4 Annual compliance

Annual compliance requires that the treatment compliance criteria set out in section 5.14.1 are met during each compliance monitoring period over 12 consecutive months.

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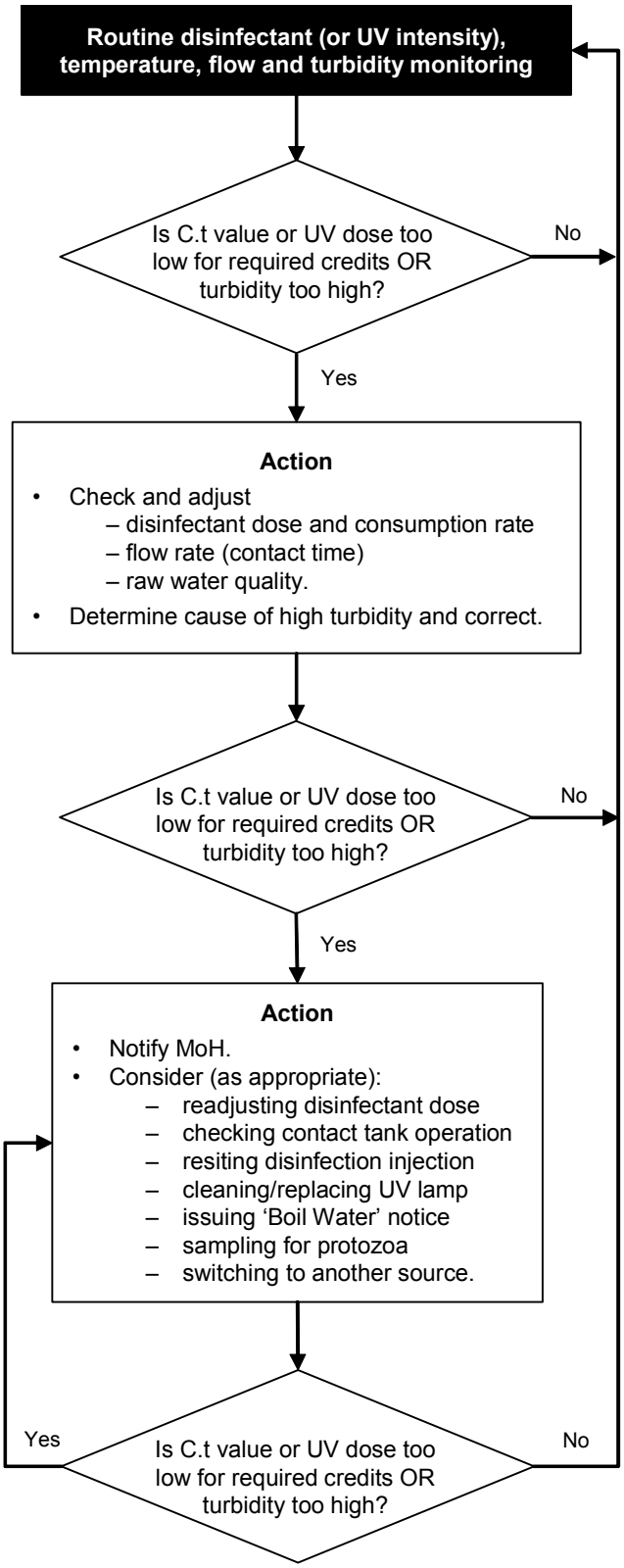
Figure 5.2: Response to disinfectant (chlorine dioxide, ozone, UV) transgression for drinking-water leaving treatment plant



Notes

MoH = DWA.

PHRMP = Public Health Risk Management Plan.

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See sections 5.14 (chlorine dioxide), 5.15 (ozone) and 5.16 (UV).

5.15 Ozone disinfection: treatment compliance criteria

5.15.1 Log credit assessment

The credits available are based on the demonstration of log inactivation as stated in the ozone C.t table (Table 5.6). See the *Guidelines* and USEPA toolbox guidance manual (USEPA 2003a: Part 11) for requirements for determining contact times.

Table 5.6: C.t values[1] (min.mg/L) for *Cryptosporidium* inactivation by ozone

Log credit	Water temperature (°C)[2]					
	1	5	10	15	20	25
0.5	12	7.9	4.9	3.1	2.0	1.2
1.0	23	16	9.9	6.2	3.9	2.5
1.5	35	24	15	9.3	5.9	3.7
2.0	46	32	20	12	7.8	4.9
2.5	58	40	25	16	9.8	6.2
3.0	69	47	30	19	12	7.4

Notes

1 The C.t data in this table are valid for ozone concentrations in the range 0.2–5.0 mg/L. See the *Guidelines* for further information.

2 C.t values between the indicated temperatures may be determined by interpolation.

To obtain the claimed protozoa log credit for ozone treatment, the following requirements must be met during periods when treated water is being delivered to the consumer.

1. All water passes through the ozone contactor.
2. The C.t value determined from the measured ozone residual and flow rate, adjusted to incorporate the effects of ozone decay and reactor hydraulics (see *Guidelines*) meets the following requirements.
    a. For supplies serving more than 500 people:
        i. the C.t value is not less than the C.t value given in Table 5.6 for the claimed log credit and measured water temperature for more than 5 percent of the compliance monitoring period (see section 5.15.2)
        ii. the C.t value is not less than 80 percent of the C.t value in Table 5.6 for the claimed log credit and measured water temperature for the duration of any three-minute period during the compliance monitoring period.
    b. For supplies serving 500 or fewer people:
        i. the number of calculated C.t values failing to attain the C.t value given in Table 5.6 for the claimed log credit and measured water temperature does not exceed the number allowed in Appendix A1.8, Table A1.3 over the compliance monitoring period (see section 5.15.2)

ii. no C.t value during the compliance monitoring period is less than 80 percent of the C.t value in Table 5.6 for the claimed log credit and measured water temperature.

3. The monitoring requirements of section 5.15.2 are met.

4. The bromate concentration in the treated water does not exceed a concentration of 0.01 mg/L. This can be determined by direct measurement of bromate or by showing that the bromide concentration in the water before ozonation does not exceed 0.006 mg/L. Bromate is potentially a Priority 2a determinand (see section 8.3.3).

5. Measurements of the turbidity of the water being disinfected satisfy all the following requirements.

   a. For continuous monitoring:

      i. turbidity does not exceed 1.0 NTU for more than 5 percent of the compliance monitoring period (see section 5.15.2)

      ii. turbidity does not exceed 2.0 NTU for the duration of any three-minute period.

   b. For manual sampling:

      i. the number of samples with turbidity greater than 1.0 NTU does not exceed the number allowed in Appendix A1.8, Table A1.3 over the compliance monitoring period (see section 5.14.2)

      ii. turbidity does not exceed 2.0 NTU in any sample in the compliance monitoring period.

6. Equipment is validated as described in the USEPA toolbox guidance manual (USEPA 2003a: Part 11) or a standard formally recognised by the Ministry of Health as being equivalent.

NB: These turbidity requirements only apply when ozone is used for disinfection. They do not apply to the use of ozone for treatment prior to filtration for the purpose of controlling colour or disinfection by-products, etc.

5.15.2 Monitoring

The protozoal compliance monitoring requirements for ozone treatment are as follows.

1. The ozone residual must be monitored:

   a. continuously for supplies serving more than 500 people

   b. daily for supplies serving 500 or fewer people.

2. The ozone sampling site must be at a point in the contactor where the adequacy of the minimum disinfection contact time[19] can be demonstrated clearly (see the *Guidelines*), but before the first consumer.[20] (The site for the ozone on-line analyser must be established by determining the decay curve of ozone in the contact tank by tracer studies or by computational fluid dynamics, verified by direct measurement. Tests must be carried out at 5°C intervals throughout the whole range of water temperatures occurring in the ozone contact tank, to establish the distance along the contact tank at which the integrated ozone C.t experienced by the water will be 90 percent of the C.t that gives 0.5 protozoa log credits (see section 5.5.1, Table 5.6). The on-line analyser must be placed at the point established to be appropriate for the prevailing water temperature.)
3. C.t calculations for supplies serving:
    a. more than 500 people must be continuous
    b. 500 or fewer people must be daily, using ozone concentration measurements made at peak hourly flow. Contact times do not have to be determined daily, only concentration, but after the initial determination of the contact time it must be re-evaluated if modifications to the process affect its hydraulics.
4. The water temperature must be measured daily if it has been shown to vary by less than 2°C in 24 hours over a month in summer, otherwise measurements must be made at least every four hours. The measurements must be made at the same location at which the ozone residual is measured or in the raw water. For batch process plants the temperature of each batch must be measured.
5. Section 5.14.2 requirement 5 is met.
6. Flow measurements must be made continuously for supplies serving more than 500 people. For supplies serving 500 or fewer people a flow restrictor must be fitted to ensure the flow rate cannot exceed the value determined to give the contact time required for the claimed log credit.
7. For continuously monitored parameters, the requirements of section 3.2 must be met.
8. When the bromate MAV is likely to be exceeded, a monitoring programme must be established to the DWA's satisfaction.

The compliance monitoring period for:

- continuously calculated C.t values is one month
- manually calculated C.t values is two months
- turbidity is in Table 5.3.

[19] The contact time is the average time, at peak flow, for the water to flow from the ozone dose point to the sampling point.

[20] The site may be established by tracer studies or by computational fluid dynamics, verified by direct measurement.

5.15.3 Ozone analyser calibration

The requirements for calibration of the online ozone analyser are described in the *Guidelines*.

Ozone analyser calibration by a Ministry of Health recognised laboratory is preferred, but if the analyser is checked using a field test method, the field test method must be calibrated against the referee method (indigo method, Standard Methods 4500-ozone (APHA 1998)) at least once every six months by a Ministry of Health recognised laboratory. Normally, the indigo method is used for calibration.

5.15.4 Transgressions and remedial action

A performance transgression occurs if any of the requirements of section 5.15.1 are not met.

If a transgression occurs, the DWA must be advised and the cause must be investigated and remedied as soon as possible. See the *Guidelines* for guidance on investigating the causes of transgressions and remedial actions.

The steps to be followed in response to a turbidity transgression for treated water, or a disinfectant transgression are shown in Figures 5.1 and 5.2 respectively.

The PHRMP must document responses to possible transgressions and identify the possible causes of major transgressions (discussed in section 3.1), the actions to be taken to reduce their likelihood and what to do in the event of their happening.

5.15.5 Annual compliance

Annual compliance requires that the treatment compliance criteria set out in section 5.15 are met during each compliance monitoring period over 12 consecutive months.

5.16 Ultraviolet light disinfection: treatment compliance criteria

5.16.1 Log credit assessment

The credits available are based on the UV dose (fluence) delivered by the system's UV reactors. The log credit claimed must be one of the following.

1. 3.0 log for a reactor validated to deliver a reduction equivalent dose (RED) of 40 mJ/cm^2 under DVGW Technical Standard W294 or ōNORM M5873-1

2. That given in Table 5.7a (for the applicable lamp type) corresponding to the UV dose determined using the Tier 1 approach[21] such that the RED measured during the validation of the reactor must be equal to or greater than the RED target.

As an alternative to (b), UV systems serving 5000 or more people may use the Tier 2 approach documented in the *Ultraviolet Disinfection Guidance Manual* (USEPA 2003d) (with the UV doses for *Cryptosporidium* inactivation) to determine the log removal credits that can be claimed for a UV dose from UV light at a wavelength of 254 nm as produced by a low pressure mercury vapour lamp. Systems may apply Table 5.7a to UV reactors with other lamp types through reactor **validation testing** (ie, performance demonstration) as described in section 5.16.3.

Table 5.7a: Tier 1 reduction equivalent dose (RED)[1] targets for *Cryptosporidium* compliance using ultraviolet light (UV)[d]

Log inactivation credits	RED[2] target (mJ/cm^2)[3]	
	LP[4] or LPHO[5]lamps	MP[6] lamps
0.5	6.8	7.7
1.0	11	12
1.5	15	17
2.0	21	24
2.5	28	32
3.0	36	42

Notes

1 RED is the Reduction Equivalent Dose.

2 RED values are taken from the draft *Ultraviolet Disinfection Guidance Manual* (USEPA 2003d: footnote 2). It is possible that different values will be promulgated in the final guidance manual and/or the final ***LT2ESWTR***, and the Ministry of Health may adopt and promulgate such values.

3 The ISO unit for UV dose (fluence) is J/m^2 where 36 mJ/cm^2 = 360 J/m^2.

4 LP is low pressure.

5 LPHO is low pressure/high output.

6 MP is medium pressure.

[21] The USEPA *Ultraviolet Disinfection Guidance Manual* (USEPA 2003d) Tier 1 and Tier 2 approaches differ in the complexity of the method used to determine the log inactivation credit based on the RED measured by bioassay (biodosimetry). The Tier 1 approach provides RED target values to be met during validation that correspond to the log inactivation credit. These RED values incorporate predetermined safety factors based on characteristics of the UV reactor and validation testing. In the Tier 2 approach, the safety factor is calculated using detailed knowledge of the equipment and testing conditions and is then applied to the required dose. The Tier 2 approach is less conservative than Tier 1 and will typically require a lower UV dose for the same log credit.

To obtain the claimed protozoa log credit for UV disinfection, the following requirements must be met when treated water is being delivered to the consumer.

1. All water passes through the UV reactor(s).
2. The UV dose (or fluence) is not less than:
    a. the reduction equivalent dose (RED) target required for the claimed log credit (see Table 5.7a) for more than 5 percent of the compliance monitoring period (see 5.16.3)
    b. 80 percent of the reduction equivalent dose (RED) target required for the claimed log credit for the duration of any three-minute period.
3. The monitoring requirements of section 5.16.3 are met.
4. The water entering the UV reactor has done one of two things.
    a. It has passed through a cartridge filter nominally rated at 5 μm, or smaller, pore size, that has sufficient rigidity to remove contaminants and prevent unloading of these contaminants caused by pressure surges, and the filtered water has a turbidity that never exceeds 2.0 NTU (see Table 5.7b for monitoring frequency) except where the turbidity has been shown to be due to colloidal material that is consistently below 1 micron, when the DWA may approve alternative criteria (see *Guidelines*).
    b. It has met the following turbidity requirements.
    c. For continuous monitoring:
        i. the turbidity does not exceed 1.0 NTU for more than 5 percent of the compliance monitoring period (see section 5.16.3)
        ii. the turbidity does not exceed 2.0 NTU for the duration of any three-minute period.
    d. For manual sampling:
        i. the number of samples with turbidity greater than 1.0 NTU does not exceed the number allowed in Appendix A1.8, Table A1.3 over the compliance monitoring period (see section 5.16.3)
        ii. the turbidity does not exceed 2.0 NTU in any sample.
5. The water entering the UV reactor(s) has a transmittance (measured in a 10 mm silica cell at 254 nm) of not less than 80 percent cm^{-1} all the time and, if the reactor was validated at higher transmittances than 80 percent cm^{-1}:
    i. the UV transmittance is not less than 95% of the lowest transmittance for which the reactor has been validated for more than 5% of the time, and
    ii. the UV transmittance is not less than 90% of the lowest transmittance for which the reactor has been validated for more than 1% of the time.
6. If the appliance has a minimum flow requirement for effective operation, the flow is never less than this.
7. The flow through the equipment is restricted to less than the manufacturer's design flow.

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8. The reactor has undergone validation testing in accordance with requirements (1) and (2) in section 5.16.2, and the *Ultraviolet Disinfection Guidance Manual* (USEPA 2003d) (or DVGW Technical Standard W294 or ōNORM M5873-1).

5.16.2 Validation

The UV equipment manufacturer (or agent) is responsible for obtaining and providing certification of validation. Water suppliers may use the manufacturer's validation certification, provided the equipment is identical (or certified as equivalent) to the equipment tested during the validation process.

The validation testing must demonstrate the operating conditions under which the reactor can deliver the UV dose required in section 5.16.1 requirement 1. The validation testing must have third party verification by an agency accredited to ISO/IEC 17025[22] or by the New Zealand National Metrology Institute (or **accreditation** to an equivalent standard approved by the Ministry of Health).

1. Validation testing of UV reactors must determine a range of operating conditions the system can monitor and under which the reactor delivers the required UV dose. At a minimum, these operating conditions must include:
   - minimum (if appropriate) and maximum flow rates
   - UV intensity (fluence rate) as measured by a UV intensity sensor
   - **UV lamp** status
   - maximum turbidity
   - maximum UV absorbance or transmittance at 254 nm.
2. The validated operating conditions determined by this testing must account for the:
   - UV absorbance or transmittance of the water
   - lamp burn-in fouling and ageing
   - water temperature
   - measurement uncertainty of online sensors
   - UV dose distributions arising from the velocity profiles through the reactor
   - failure of UV lamps or other critical system components
   - inlet and outlet piping or channel configurations of the UV reactor.
3. Validation testing must include the:
   - full-scale testing of a reactor that conforms uniformly to the UV reactors used by the system
   - inactivation of a test micro-organism whose dose response characteristics have been quantified with a low pressure mercury vapour lamp.

[22] *General Requirements for the Competence of Testing and Calibration Laboratories* (IANZ 2000).

5.16.3 Monitoring

For protozoal compliance monitoring of the water leaving the treatment plant:

1. the minimum monitoring requirements stated in Table 5.7b must be met
2. the calibration of the duty UV sensor(s) in the UV reactor must meet the following requirements:
    a. systems serving more than 500 people must:
        i. check the calibration of the sensor, which must be located at the same point in the reactor as that used for the original validation of the appliance's performance, at least monthly against the reference sensor
        ii. ensure the reference sensor is calibrated and third party verification in accordance with the *Ultraviolet Disinfection Guidance Manual* (USEPA 2003d) given by an agency accredited to ISO/IEC 17025 for this type of calibration or by the New Zealand National Metrology Institute (or accreditation to an equivalent standard approved by the Ministry of Health)
    b. systems serving 101–500 people may use a sensor calibrated against a secondary standard instead of primary standard
3. for continuously monitored parameters, the requirements of section 3.2 must be met.

The compliance monitoring period for continuously monitored parameters is one month; for all other measurement frequencies the compliance monitoring period is one year.

Table 5.7b: Minimum monitoring requirements for ultraviolet (UV) disinfection

Population served	Parameter	Minimum monitoring frequency (or control)
More than 10,000	Flow (each reactor)[1] Turbidity[1] UV intensity[1] UV transmittance Lamp outage	Continuous Continuous Continuous Continuous Continuous
501–10,000	Flow (each reactor)[1] Turbidity[1] UV intensity[1] UV transmittance Lamp outage	Continuous Continuous Continuous Twice a week[3] Continuous
101–500	Flow (total)[1] Flow (each reactor) Turbidity UV intensity[1] UV transmittance monitoring[2] Lamp replacement hour meter Lamp outage	Continuous [Flow restrictor] Weekly Continuous Weekly Continuous Continuous
100 or less	Flow (each reactor) Turbidity and UV transmittance Lamp replacement hour meter Lamp outage UV intensity[1]	[Flow restrictor] Monthly Continuous Continuous Continuous

Notes

See Appendix A 1.5.9 for a description of UV transmittance (or absorbance) units and the *Guidelines* for discussion on the measurement of UV transmittance.

1 An alarm must be installed to alert the operator in the event of the parameter being outside the range of its validated limits.

2 Samples must be taken, at least weekly, for 24 months to show the water's UV transmittance is at least 80 percent cm^{-1} and meets the minimum design transmittance level of the installed UV appliance. Once this requirement has been met, monitoring of groundwaters may cease, but surface water sources must incur ongoing monthly sampling.

3 May be reduced to weekly if after 12 months' monitoring, transmittance (in cm^{-1}) is not less than 85 percent.

5.16.4 Transgressions and remedial action

A performance transgression occurs if the UV dose is less than 80 percent of the reduction equivalent dose (RED) target required for the claimed log credit (refer section 5.16.1) for more than 30 minutes.

If a transgression occurs the DWA must be advised, and the cause must be investigated and remedied as soon as possible. See the *Guidelines* for guidance on investigating the causes of transgressions and remedial actions.

Protozoal Compliance Criteria

The steps to be followed if the turbidity of the water leaving a filter fails to comply with the requirements of section 5.16.1 4 (c) or (d) or a disinfectant transgression are shown in Figures 5.1 and 5.2 respectively.

The PHRMP must document responses to possible transgressions and identify the possible causes of major transgressions (discussed in section 3.1), the actions to be taken to reduce their likelihood and what to do in the event of their happening.

5.16.5 Mercury exposure risk

The PHRMP must document a site-specific mercury spill response plan to minimise mercury release in the event of a lamp breakage.

5.16.6 Annual compliance

Annual compliance requires that the treatment compliance criteria set out in section 5.16.1 are met during each compliance monitoring period over 12 consecutive months.

6 Viral Compliance Criteria

Water that is sourced from a catchment in which there is human activity, in particular one with a sewage contamination upstream of the drinking-water **abstraction point**, is likely to contain some human-pathogenic viruses. It is possible some of the present water treatment options may not remove or inactivate all human-pathogenic viruses. However, insufficient information exists regarding the removal or inactivation of viruses through the various processes used in drinking-water treatment. Consequently, while the DWSNZ do not include viral criteria, it is intended they will be included in a future standard when the effectiveness of viral removal or inactivation by water treatment processes is better understood.

It is considered that if no human effluent is in the catchment, viruses will not pose a risk to public health.

Note: Some forms of water treatment are known to be less effective at removing or killing viruses than others. For example, filtration without coagulation is not as effective at removing viruses as coagulation and filtration, and UV treatment is less effective at killing viruses than the other disinfectants recognised in the DWSNZ. The UV disinfection criteria given in section 5.15 may not provide adequate protection against viruses.

When the source is a low risk surface water and the overall treatment process does not include filtration, at least two disinfectants, one of which may be chlorine, should be used to provide adequate protection against viruses as well as protozoa.

7 Cyanotoxin Compliance Criteria

7.1 Introduction

Cyanotoxins are the toxins produced by cyanobacteria (previously known as blue-green algae). Cyanotoxins may or may not be present when cyanobacteria are present.

Cyanotoxins are not found in groundwater, so this section does not apply to groundwaters.

Although cyanotoxins are chemical determinands, several factors mean their monitoring requirements are different from other chemical determinands.

- Cyanobacteria may appear irregularly or seasonally.
- Cyanotoxins may be present at potentially health-significant concentrations for only short periods, so monitoring throughout the whole year is unnecessary.
- Unlike most chemical determinands, the health effects of cyanotoxins are acute at low concentrations and potentially fatal. Even if there are no acute effects, long-term effects may result.
- Cyanobacteria numbers, and, hence, cyanotoxin concentrations, can increase rapidly and unpredictably. Therefore, in view of their toxicity, higher monitoring frequencies are required for cyanotoxins than for other Priority 2 chemical determinands.

Cyanotoxins, when present at concentrations more than 50 percent of their MAV in a distribution zone, are assigned as Priority 2 (cyanotoxin) to that zone.

The DWA, on the basis of data collected by the water supplier, has responsibility for determining when cyanotoxins should be assigned to Priority 2 status for a water supply. See section 7.3.1.

Section 7.3 specifies the Priority 2 (cyanotoxin) monitoring requirements.

For further information, especially on the assessment of risk from cyanotoxins, see the *Guidelines*.

7.2 Management protocols

When the raw water for a drinking-water supply comes from a surface source that has previously experienced algal blooms or the DWA judges the source water to be at risk of bloom development, the water supplier must adhere to the following procedures.

1. Collect information about the source that will assist in determining:
   a. whether cyanobacteria are present in the source water
   b. when cyanotoxin concentrations reach or exceed potentially health-significant concentrations (greater than 50 percent of the MAV).

2. The raw water sample must be treated to lyse (rupture) any whole cells present prior to analysis for the cyanotoxin. The cyanotoxin concentration measured in this sample is an estimate of the total toxin concentration that may appear in the treated water should cells be ruptured during treatment and other removal processes fail to reduce the dissolved toxin concentration.

3. Develop a protocol, approved by the DWA, that:
   a. identifies which determinands or observations are to be monitored for assessing the development of cyanobacteria
   b. specifies the actions that will be taken in the event of a cyanotoxin reaching a potentially heath-significant concentration
   c. initiates a cyanotoxin monitoring programme in the source water when the protocol indicates that the risk of cyanotoxins being present has reached a predetermined level based on evidence from 7.2 1(b).

4. Notify the DWA when the protocol shows the development of cyanobacteria and cyanotoxins in the source water has reached a stage where source water cyanotoxins are approaching 50 percent of the MAV.

Lists of the laboratories that undertake cyanobacteria cell counts and cyanotoxin analysis are available at the Ministry of Health website, www.moh.govt.nz/water *Register of Recognised Laboratories: Drinking water supplies*, and www.drinkingwater.org.nz. (This identifies which laboratories are recognised and which have still to obtain accreditation.)

7.3 Priority 2 determinands

The requirements of sections 7.2 1(b), 7.2 2, 7.2 3(b) and (e) and 7.2 4 and 7.3 need be met only when the Ministry of Health has determined adequate analytical services for monitoring cyanotoxin concentrations are available and the Ministry has notified water suppliers of the need to meet the requirements for compliance with the DWSNZ.

The requirements of section 7.3 must be met in addition to those of 7.2.

7.3.1 Identification of Priority 2 determinands

A cyanotoxin will be assigned as a Priority 2 (cyanotoxin) determinand to water leaving a treatment plant or in the distribution zone when:

- any sample of the treated water leaving the plant or water in the distribution zone shows the toxin level to have exceeded 50 percent of the determinand's MAV
- the zone serves more than 500 people.

The DWA decides to assign a cyanotoxin to the Priority 2 level based on the outcome of the investigations carried in section 7.2.

Cyanotoxins may be reassigned as Priority 3 determinands, after three successive samples from the supply show the toxin levels to be less than 50 percent of the MAV and show a trend of decreasing toxin concentration. Compliance requirements then return to following the protocol developed in section 7.2.

7.3.2 Compliance requirements for Priority 2 determinands

Once a cyanotoxin is assigned as a Priority 2 (cyanotoxin) determinand to a supply, the requirements in this section must be met.

7.3.2.1 Monitoring

Monitoring of cyanotoxins in raw water samples must be carried out as specified in section 7.2.

When the cyanotoxin concentration approaches 50 percent of the MAV:

1. advise the DWA
2. commence monitoring cyanotoxins in the treated water.

7.3.2.2 Sampling frequency

Water from the treatment plant or from the distribution zone must be sampled twice weekly for cyanotoxin analysis, until the cyanotoxin is reclassified as a Priority 3 determinand.

7.3.2.3 Sampling location

Sampling of raw water must be carried out where cell population densities are likely to be highest. In lakes and reservoirs, this is often at, or near, the down-wind or down-stream end of the water body (see the *Guidelines*).

Samples for cyanotoxin analysis of treated water must be taken from water leaving the treatment plant or from the distribution zone if cyanotoxin breakthrough is suspected.

7.3.2.4 Analytical requirements

Only laboratories recognised by the Ministry of Health for the purpose may be used for the chemical analysis of cyanotoxins.

Analytical techniques for cyanotoxins are specified in the tables in the referee methods section in Appendix 3.

7.3.3 Transgressions and remedial action

A transgression occurs if a cyanotoxin MAV is exceeded in the drinking-water.

When a transgression occurs, the cause must be investigated as soon as possible. See the *Guidelines* for guidance on investigating the causes of transgressions.

Cyanotoxin Compliance Criteria

In the event of a cyanotoxin MAV being exceeded, the water supplier must:

- inform the DWA
- provide consumers with an alternative source of water until four weeks after toxin analysis of the water in the distribution system shows the cyanotoxin concentration to have diminished to below 50 percent of the MAV
- continue to work on reducing the levels of cyanobacteria in the source water
- assess why high toxin levels are being found and what actions can be taken to improve treatment effectiveness, when a treatment system is in place that should be capable of removing cyanotoxins.

8 Chemical Compliance Criteria

8.1 Introduction

The purpose of the chemical compliance criteria is to avoid concentrations of determinands of public health significance being present in drinking-water at levels that present a significant health risk.

Chemical constituents of drinking-waters may come from the:

- source water
- treatment process
- distribution system
- consumer's plumbing.

Sections 8.2 to 8.5 detail the monitoring requirements necessary to demonstrate compliance for those determinands that have been designated as Priority 2 for a particular supply.

8.2 Compliance criteria

Two types of Priority 2 chemical determinands exist.

- **Priority 2a:** Chemical determinands that could be introduced into the drinking-water supply by the treatment chemicals at levels potentially significant to public health (usually greater than 50 percent of the MAV). Priority 2a does not include disinfection by-products or determinands introduced into the drinking-water from piping or other construction materials.
- **Priority 2b:** Chemical determinands, other than those introduced by the treatment chemicals, that have been demonstrated to be in the drinking-water supply at levels potentially significant to public health (usually greater than 50 percent of the MAV). Priority 2b includes determinands present in the raw water (some or all of which pass through the treatment process), disinfection by-products and cyanotoxins (section 7) and determinands introduced into the drinking-water from the water supplier's piping or other construction materials.

Determinands specified by the Ministry of Health as Priority 2 must be monitored to establish compliance with the DWSNZ. Priority 2 determinands may be specific to individual distribution zones or to the treatment plant if the determinand applies to more than one zone. Appropriate sampling sites are indicated in the tables in the referee methods section of the *Guidelines.*

A further category is plumbosolvent water. Strictly, plumbosolvency is a property of water, but it is listed here and in Appendix 3 Table A3.1 for convenience. Many of New Zealand's waters are soft, with moderate to low levels of **alkalinity** and pH. These properties can give the water a high solvation potential, so that the water may dissolve metals from plumbing fittings if it lies for too long in the plumbing, for example, overnight. Hard waters with a high CO_2 content can also be plumbosolvent.

Although not all New Zealand's drinking-waters are plumbosolvent, they are assumed to have this property unless the water supplier can prove otherwise. Unless the water has been shown not to be plumbosolvent, advice must be given to consumers to help them reduce their exposure to any metals of health significance dissolved from the plumbing (see section 8.2.3).

Metals that are present in the water supplied to consumers at concentrations greater than 50 percent of their MAV and that have not arisen from corrosion of the consumer's plumbing are designated as Priority 2 determinands.

8.2.1 Compliance criteria for Priority 2 determinands

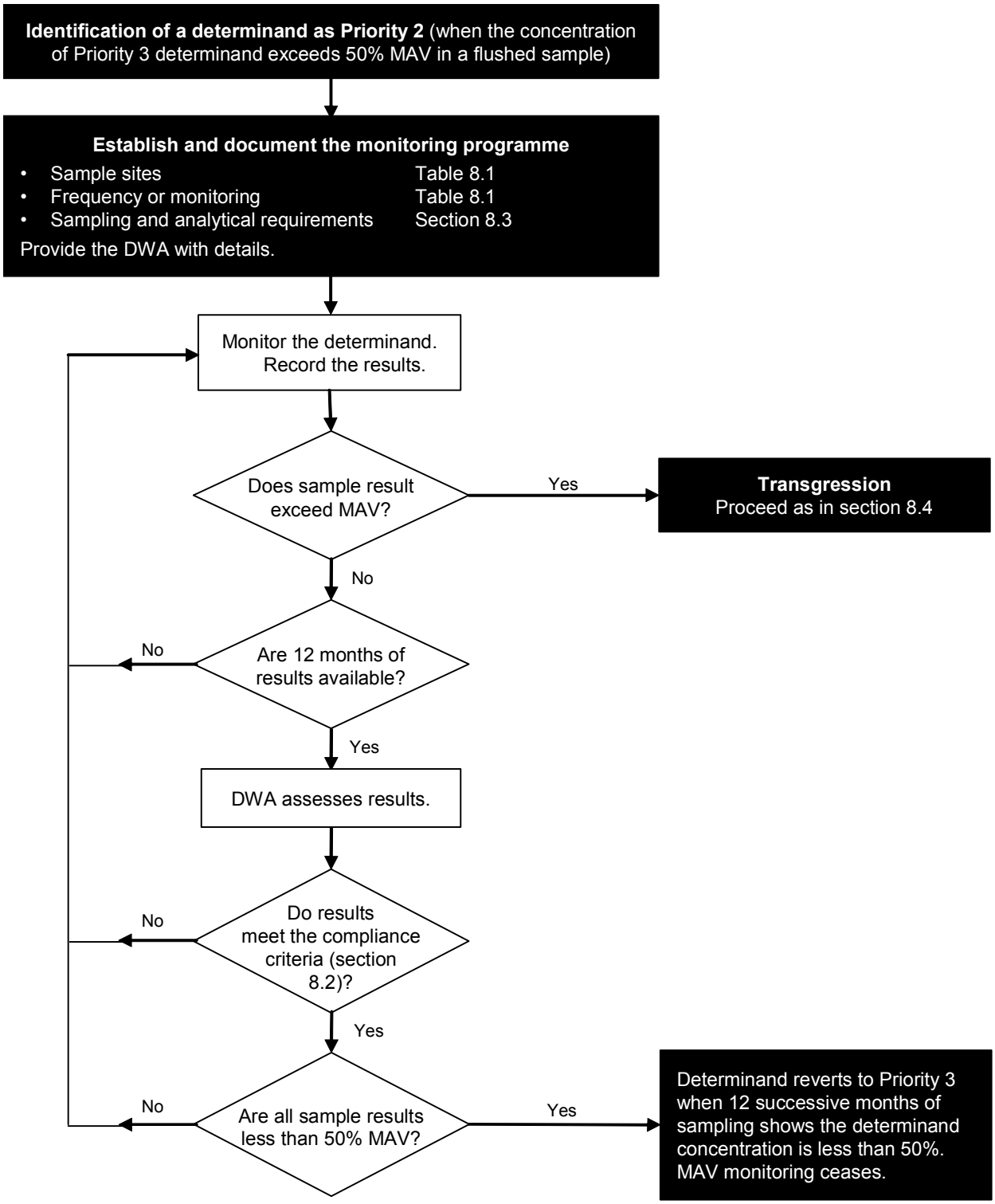
Chemical compliance is assessed from the results of sampling carried out over 12 consecutive months. The compliance criteria are as follows.

1. Samples are taken at the required sites and in the frequency for the determinand in question.
2. Sampling and analytical techniques comply with the requirements of the DWSNZ.
3. When more than one determinand that causes similar toxicological effects is present, the sum of the ratios of the concentration of each determinand to its respective MAV does not exceed one for compliance with the DWSNZ. In the DWSNZ, this applies to nitrate/nitrite, trihalomethanes (THMs), the haloacetic acids and haloacetonitriles.
4. The maximum number of transgressions found, when sampling is carried out at the frequency specified, does not exceed the allowable number of transgressions in Appendix A1.8, Table A1.3. (Note: This table refers to the number of samples taken at equal intervals over the compliance period. For P2 determinands, the compliance monitoring period is one year.)

   For larger sets of samples, consult the Extended Table of Allowable Exceedences in the statistical considerations section in the *Guidelines*.
5. The procedure outlined in section 8.4 is followed when determinands exceed the MAV and results and actions are documented.

Figure 8.1 (page 103) illustrates how to establish compliance of Priority 2 chemical determinands with the DWSNZ.

Figure 8.1: Establishing compliance of Priority 2 determinands with DWSNZ



8.2.2 Compliance criteria for Priority 3 and 4 determinands

Priority 3 and 4 chemicals do not have to be monitored.

A Priority 2 determinand may be relegated to Priority 3 when 12 successive monthly samples show concentrations below 50 percent of the MAV. When no obvious reason exists for the concentration decrease that led to the reversion of the determinand to Priority 3, monitoring should continue at once a quarter until the DWA is satisfied the change is permanent. The Ministry of Health will adjudicate if there is any disagreement about the need to continue monitoring.

8.2.3 Compliance criteria for plumbosolvent water

Because the softness of most New Zealand waters is associated with the leaching of metals such as lead from plumbing fittings, all waters are assumed to be plumbosolvent unless they have been demonstrated not to be, using the procedure in section 8.5. In addition, where there is no evidence that the water is not plumbosolvent, the water supply owner must:

1. publish twice a year, for supplies servicing more than 1000 people, a public notice provided by the Ministry of Health that states:
   a. the water in the supply is mildly corrosive to plumbing fittings and may accumulate metals of health concern (eg, lead, nickel, cadmium or antimony) if it lies for too long in the plumbing

      and

   b. before using the water for drinking, especially after the water has been sitting overnight, at least 500 mL of water should be flushed from the tap and discarded to flush away these corrosion products
2. provide this public warning to consumers at least twice a year (about every six months), for example, with each water supply bill or water rate demand.

See the *Guidelines*, for general advice about plumbosolvent waters and flushing away metals of health concern.

8.3 Monitoring requirements

8.3.1 Sampling sites for Priority 2a determinands

Sampling of Priority 2a determinands that are introduced with water treatment chemicals may be carried out in the drinking-water leaving the treatment plant, or from the distribution zone if the determinand concentration is unlikely to change during distribution. Alternatively, compliance can be demonstrated by certified analysis of the chemicals used in water treatment and demonstration that the treatment process cannot introduce a sufficient amount of contaminant to cause the determinand to become Priority 2.

8.3.2 Sampling sites for Priority 2b determinands

Priority 2b determinands are of two main types:

- **Type 1**: Substances whose concentration is unlikely to vary in the distribution system
- **Type 2**: Substances whose concentration may vary in the distribution system.

Priority 2b Type 1 determinands may be monitored in the drinking-water leaving the treatment plant or in the distribution zone if this is more convenient.

Priority 2b Type 2 determinands, which have a source in the distribution system or which react in or with it, must be sampled from only the distribution zone.

The referee methods tables in Appendix 3 indicate which sampling site(s) are appropriate for each determinand. A tick in the DZ column indicates the sample must be taken from only the distribution zone. Ticks in both the TW and DZ columns indicate the determinands may be sampled from the drinking-water at the treatment plant or in the distribution zone. The sampling location (distribution zone or treatment plant) will be identified when the Priority 2 assignation is made.

Distribution zone sampling sites must be selected to be representative of the water quality in the distribution zone or appropriate for the determinand in question, unless the DWA specifies otherwise. For example, samples for monitoring disinfection by-products (Priority 2b Type 2 determinands) should be collected from sampling sites near the ends of the distribution system, but samples should be collected only if the disinfection process has been operating normally for several days beforehand.

Once the appropriate sampling area of the distribution zone has been identified for the particular determinand, some sampling should be carried out at fixed sites so water quality trends can be followed.

Further sampling at random sites may be useful to investigate the:

- effects of different reticulation materials on water quality
- spatial and temporal effects on drinking-water quality
- how representative the selected fixed sites are.

8.3.3 Monitoring frequencies for Priority 2a determinands

Sampling frequencies are summarised in Table 8.1.

The DWA must approve the monitoring programme, including the sampling dates, which must include sufficient additional samples to meet any deficiencies that arise from a failure to comply with the programme prescribed in the DWSNZ (see section 3.1). Fluoridated drinking-water supplies must be monitored for fluoride at least 13 times each calendar quarter (ie, at least weekly).

The FAC content of the drinking-water leaving the treatment plant must be monitored at least weekly (see Table 8.1, note 1).

Well-managed drinking-water supplies will undergo process monitoring of these determinands more frequently than is specified above. These process monitoring results can be used to demonstrate compliance provided the sampling and analytical procedures are in accordance with the requirements of the DWSNZ for the determinand concerned see section 3.2(b) and *Guidelines.*

For Priority 2a determinands, other than FAC and fluoride, the minimum monitoring frequency is three times each quarter (ie, monthly). Analysis is not required if the water supply owner can demonstrate to the DWA by calculation that impurities from the treatment chemicals will be less than 50 percent of the MAV using data from their maximum dose rates and verified certified analyses covering each batch from each source of the chemical used.

Additional sampling and analysis may be necessary when a change in operating conditions could affect the concentrations of determinands of health significance introduced by the treatment process, for example:

- the chemicals used in treatment do not have a validated certificate of quality
- a chemical of health significance is dosed into the water upstream of the treatment process to control water quality problems (the DWA must also be advised)
- after process changes that could affect the concentration of the determinand in the drinking-water.

8.3.4 Monitoring frequencies for Priority 2b determinands

Sampling frequencies are summarised in Table 8.1.

The DWA must approve the monitoring programme, which must include sufficient additional samples to meet any deficiencies that arise from a failure to comply with the programme prescribed in the DWSNZ (see section 3.1).

Priority 2b Type 1 determinands, which may be sampled at the point where the drinking-water leaves the treatment plant or in the distribution system, must be monitored at least monthly. Priority 2b Type 2 determinands, whose concentration may change in the distribution system, must be monitored at selected fixed site(s) at least monthly and sufficient extra random samples should be collected throughout the year to detect any spatial variability and effects from the distribution system. See Table 8.1. Random and fixed sites have been discussed in section 8.3.2.

Table 8.1: Monitoring requirements for Priority 2a and 2b determinands

Priority	Sampling site locations	Number of sampling sites	Minimum sampling frequency	Maximum days between samples
2a	Drinking-water leaving the treatment plant	1	fluoride: weekly chlorine: weekly[1] all others: monthly	13 13 45
2b, Type 1	Drinking-water leaving the treatment plant[2]	1	monthly	45
2b, Type 2	Distribution zone	Sufficient sites chosen to reflect the problems associated with the determinand in relation to the materials used and reaction time for disinfection by-products and corrosion products	At least three samples taken monthly from the selected sampling locations, except where a water supplier wishes to demonstrate the water is notplumbosolvent and the requirements of section 8.5 are to be followed	45

Notes

1 The weekly FAC samples are to demonstrate the MAV (6 mg/L) is not exceeded. This is not to be confused with the requirements of bacterial compliance criteria.

2 May also be monitored in the distribution zone if this is more convenient.

8.3.5 Monitoring procedures

Procedures for sampling, sample preservation, storage and sample transport must be confirmed with the Ministry of Health recognised laboratory carrying out the analysis.

If the results of chemical analysis of water leaving the treatment plant will be affected by temporal changes in the condition of the raw water (eg, for disinfection by-products) the sampling schedule for the year's monitoring programme must be provided to the DWA before the programme starts.

Samples for Priority 2 determinands, obtained from the treatment plant or the distribution zone, must be collected after flushing the tap long enough to ensure the sample is representative of water from the distribution zone. Adequate flushing is especially important when monitoring heavy metals to avoid metals arising from the corrosion of plumbing contributing to the measurements. A flush volume of at least 20 L should be used. See the *Guidelines* for further discussion on sampling techniques.

8.3.6 Analytical requirements

Only laboratories recognised for the purpose by the Ministry of Health may be used for analyses to check compliance with the DWSNZ.

The laboratory's statistically determined detection limits (**method detection limit**) for each determinand ideally should be one fifth, or less, of the MAV for that determinand. This may not be possible for all determinands. The limit of detection, **precision** and uncertainty of test methods must be included on all analytical reports. See Part 1000 of Standard Methods for the specification for IANZ accreditation (APHA 1998). See the *Guidelines* for further discussion on testing.

Analytical requirements for chemicals are specified in the tables in Appendix 3.

8.4 Transgressions and remedial action

A chemical MAV transgression occurs when the measured value of a determinand in a sample exceeds the MAV.

A single sample exceeding the MAV will not necessarily result in non-compliance with the DWSNZ, provided the requirements of section 3.1 are met and the number of exceedences is not more than as detailed in section 8.2.1 requirement 4.

To minimise any risks to public health, however, appropriate action must be taken. After an exceedence has occurred, the water supplier must advise the DWA immediately of the cause of the exceedence, investigate and take appropriate action.

All incidents of exceedence must be recorded, including monitoring results, actions taken and outcomes.

8.5 Assessment of plumbosolvency

When a water supplier wishes to demonstrate that the water from its supply is not plumbosolvent the procedures detailed in the *Guidelines* may be used (ie, determine lead in the "first flush" water sample from a high-lead brass fitting, eg, the C38500 alloy (designation used in AS1657)).

9 Radiological Compliance Criteria

9.1 Introduction

The purpose of the radiological compliance criteria is to avoid concentrations of determinands of public health significance being present in drinking-water at levels that present a significant health risk.

9.2 Rationale for radiological maximum acceptable value (MAV)

All living organisms are exposed to radiation from natural sources including:

- cosmic radiation from outer space
- external radiation from natural **radionuclides** (uranium and thorium and their decay products, and potassium-40) present in soils, rocks and building materials
- internal radiation due to potassium-40 and inhaled radionuclides, particularly radon decay products.

Radon is a noble gas, which emanates from rocks and soil and can concentrate in buildings. Use of water can increase the indoor radon concentration, if radon is present in the water supply. Natural radiation exposure varies regionally as the compositions of soils and rocks change, and increases with altitude as cosmic radiation intensity increases, and nothing can be done to prevent exposure. Radionuclides in drinking-water contribute less than 5 percent to the exposure from natural sources.

Different radionuclides have a different radio-toxicity, and for an accurate determination of the exposure, a detailed radioanalytical assessment is required. However, a quick and cost-effective screening can be performed by testing for total concentration of **alpha-emitting radionuclides** and **beta-emitting radionuclides** and for the concentration of radon-222. The first two tests allow setting an upper limit for exposure from ingestion and the latter for exposure from ingestion and inhalation of radon decay products.

The DWSNZ adopt MAVs for total concentrations of alpha-emitting and beta-emitting radionuclides, excluding radon-222 and potassium-40, which would limit the annual radiation dose resulting from the consumption of two litres of water per day to less than 5 percent of the average annual radiation dose due to all natural sources. The MAV for radon-222 limits the exposure from radon in water to half the average exposure from radon in air.

9.3 Compliance criteria

The MAVs given in Table 2.4 for radiological determinands must not be exceeded.

9.4 Monitoring requirements

The monitoring frequency for radiological determinands is 10 years for groundwater supplies.

Water from new underground sources must be tested before it is connected to a reticulated drinking-water supply.

If radiological sampling of water is contemplated, the National Radiation Laboratory (NRL) should be consulted.

If the radioactivity of a drinking-water supply exceeds 50 percent of the MAV, the determinand must be assigned as a Priority 2 determinand and the sampling frequency increased to once per year. Every three years, the data must be examined and the monitoring requirements re-evaluated by the DWA in consultation with the NRL. When sufficient evidence exists that 50 percent of the MAV is no longer being exceeded, the radiological determinand will be reclassified as a Priority 3 determinand.

9.5 Exceedence of radiological maximum acceptable value (MAV)

The NRL provides analytical and radiological advisory services appropriate for drinking-water testing. If the total alpha-concentration exceeds the MAV, the water should be analysed for uranium-238, uranium-234 and radium-226 and a **radiological assessment** should be undertaken. If the total beta-concentration exceeds the MAV, the water should be analysed for radium-228 and any other beta-emitting radionuclides that may be present and a radiological assessment should be undertaken.

If one of the radiological MAVs is exceeded, the NRL will advise the DWA and the water supplier of the remedial action to be taken.

10 Small Water Supply Compliance Criteria

A small water supply is a supply that serves fewer than 500 people. Most small water supplies are privately owned, but a significant number are publicly owned (ie, owned by a local authority).

All occupied buildings[23] [24]must have a potable water supply for human consumption, utensil washing, food preparation and oral hygiene.

All reticulated water supplies must have potable water.

Individual dwellings and reticulated community supplies providing drinking-water for less than 1500 person days each year (eg, 25 persons for 60 days) are exempt from having to demonstrate ongoing compliance with the *Drinking-water Standards for New Zealand* (DWSNZ). (A self-supplied building that provides water to another building that is not on the same title is classed as a reticulated community supplier.)

For short duration events (eg, a 'Woodstock' or school camp), advice from a drinking-water assessor (DWA) or the local authority Environmental Health Officer on the provision of a potable water supply must be obtained. Small water supplies that are subject to the health legislation can demonstrate compliance with the DWSNZ in two ways.

- **Participating supplies** may opt to use a Public Health Risk Management Plan (PHRMP)-based compliance system that a DWA has assessed to be satisfactory. A participating supply must be able to demonstrate that risks to public health are adequately managed through the preparation and implementation of the approved PHRMP and that the maximum acceptable values MAVs in the DWSNZ are not exceeded.
- **Standard supplies** are ones that have not opted into the participatory scheme so must meet the requirements for the appropriate population band given in the DWSNZ to demonstrate compliance.

Both participating and standard supplies must provide potable water (ie, water in which no determinand exceeds its maximum acceptable value (MAV)).

In all cases, before a new water source is used for a drinking-water supply, the DWA must approve the source.

[23] Building Act 2004

[24] Health Act 1956

10.1 Participating supplies

10.1.1 Ongoing compliance requirements for participating supplies

The MAVs for determinands of public health significance for small supplies are the same as those for all drinking-water supplies. The MAVs are listed in section 2.

The following compliance requirements have to be met to show that the supply is complying with the DWSNZ.

- A sanitary inspection must have been carried out.
- A current PHRMP must be in existence, and being implemented.
- Water quality must be being monitored and meet the requirements of section 10.1.3.
- The responses that have been specified in the PHRMP must be made when a MAV is exceeded.

Further information on these is given in the *Guidelines.*

Provided the supplier can show these requirements have been met, the supply will be deemed to comply with the DWSNZ and to meet the requirements for being a participating small water supply. However, if compliance with these requirements cannot be demonstrated, the compliance requirements for the supply revert to those for a standard supply of less than 500 people given in sections 4, 5 and 7, 8, 9. Where water quality monitoring data from a participating small water supply show that water quality is unsatisfactory, but the DWA considers the correct steps to improving the water quality are being taken, reversion to the requirements of sections 4, 5 and 7, 8, 9 may be delayed to provide time to establish the effectiveness of the remedial actions.

10.1.2 Demonstrating that the PHRMP is current and implemented

Sanitary inspections of the supply must be carried out annually to the DWA's satisfaction and must cover the elements of the PHRMP, including confirmation that:

- the sanitary inspection of the water source is current (see section 10.1.2.1)
- any treatment processes use an 'acceptable treatment system' (see the *Guidelines* effective for the minimum and maximum intended volumes of water production and the expected worst raw water quality
- the reticulation and storage facilities are secure
- the operator's skills and knowledge are adequate for the supply and a supply management plan exists and is followed
- water quality monitoring meets the requirements of section 10.1.3.

If the supply does not produce potable water (ie, the MAVs in the DWSNZ are exceeded), the PHRMP must document the reason for the failure and the steps needed to remedy it.

10.1.2.1 Sanitary inspection

A regular sanitary inspection of the source water catchment or recharge zone must be carried out at the frequency specified in Table 10.1. In addition to these routine inspections, prompt inspection is necessary after any change in the catchment that might lead to changes in the likelihood of contaminants entering the source water, such as a new contaminating activity, major erosion, etc. The inspection identifies what could happen to cause the water quality to deteriorate so that the water becomes unsafe to drink.

The sanitary inspection must identify actual or potential sources of contaminants in the catchment or recharge zone and ways to reduce the likelihood of these contaminants entering the source water included in the supply's PHRMP.

A groundwater source must be assumed non-secure until it has been shown to meet the criteria of section 4.5.

Table 10.1: Sanitary inspection frequency

Population type supplied	Raw water source		
	Secure[4] groundwater	**Rainwater**	**Surface-influenced water**
Residential/community[1]	Three-yearly	Three-yearly	Every second year
Commercial gain/tourism/[2] vulnerable population[3]	Annually	Annually	Annually

Notes

1 Residential or community supplies are ones that are not operated for tourism or commercial purposes. They include residential subdivisions, community halls, sporting facilities and marae. Individual dwellings are exempt.

2 Commercial gain/tourism supplies are ones that supply facilities used for commercial gain or tourism, including accommodation facilities, food-processing facilities (excluding ready-to-eat places) and places of employment. Also included (although not for reasons of commercial gain) are educational facilities (unless identified in the **vulnerable population** category).

3 Vulnerable population groups include preschool facilities, primary schools, medical care facilities, aged care facilities and such other at-risk categories as the Ministry of Health may define. Supplies used to prepare ready-to-eat food are also included here for convenience.

4 Secure groundwater is defined in section 4.5.

10.1.3 Water quality monitoring

Water quality monitoring is required for all participating small water supplies at the frequency described in sections 10.1.3.1 and 10.1.3.2.

Analyses must be carried out by a laboratory recognised by the Ministry of Health as competent to carry out drinking-water analysis except where special procedures or analyses in the field are authorised by a DWA.

Procedures for sampling, preserving, storing and transporting samples must be agreed beforehand with the laboratory carrying out the analysis, except where special procedures are authorised for isolated drinking-water supplies or for analyses in the field.

Presence/absence tests or other rapid-test methods for *E. coli* that are acceptable to the Ministry of Health may be used for routine monitoring.

The supplier must consult the local DWA as to the appropriate steps for providing assurance of satisfactory drinking-water quality management when a microbial sample cannot be sent to a recognised laboratory within the required period at the frequency described in section 10.1.3.1, because the supply is:

- isolated from courier routes
- temporarily inaccessible (eg, due to severe weather conditions)
- no person certified by a DWA as competent to undertake compliance monitoring is available.

Testing of samples should start within six hours of sample collection and must not be delayed more than 24 hours after collection. Samples must be transferred to the laboratory in a cool, dark container. It is important the temperature of samples does not increase between the samples being taken and analysed. To be valid for compliance testing, samples must not be frozen and must arrive at the laboratory at a temperature not greater than 10°C or not higher than the temperature of the water being sampled. If samples cannot be processed immediately on arrival in the laboratory, they must be stored in a refrigerator.

Samples must be taken from randomly selected locations throughout the water distribution system. If the presence of disinfection by-products is suspected, samples must be taken as far from the point of disinfection as possible.

10.1.3.1 Monitoring frequency for *E. coli*

How often samples are to be collected to monitor *E. coli* depends on supply characteristics, which will be reflected in the supply PHRMP. The minimum sampling frequencies for small supplies of varying characteristics are listed in Table 10.2. The PHRMP may require more frequent monitoring, but it would rarely be more than monthly.

Table 10.2: Monitoring frequencies for *E. coli*, according to supply characteristics

Population type supplied	Secure groundwater	Rain or surface-influenced water
Residential/community[1]	Annually[2]	Six-monthly[3]
Commercial gain/tourism/[4] vulnerable population[5]	Three-monthly[6]	Three-monthly

Notes

1 Residential or community supplies are ones that are not operated for tourism or commercial purposes. They include residential subdivisions, community halls, sporting facilities and marae. Individual dwellings are exempt.

2 Maximum interval between samples is 480 days.

3 Maximum interval between samples is 240 days.

4 Commercial gain/tourism supplies are ones that supply facilities used for commercial gain or tourism, including accommodation facilities, food-processing facilities (excluding ready-to-eat places) and places of employment. Also included (although not for reasons of commercial gain) are educational facilities (unless identified in the vulnerable population category).

5 Vulnerable population groups include preschool facilities, primary schools, medical care facilities, aged care facilities and such other at-risk categories as the Ministry of Health may define. Supplies used to prepare ready-to-eat food are also included here for convenience.

6 Maximum interval between samples is 120 days.

10.1.3.2 Chemical monitoring

Any potential sources of chemical contamination of the source waters that have been identified during the sanitary inspection must be identified in the supply PHRMP. The DWA should be consulted as to likely chemical hazards and the monitoring that must be done.

The water from this source must be monitored annually for likely chemical determinands of public health significance until three consecutive samples have shown they are present at less than 50 percent of their MAV.

Where the possibility of cyanotoxins entering the water exists because a supply's source water is found to contain cyanobacteria at certain times of the year, the water supplier must consult the DWA to find a way to identify when potential problems with these organisms might arise and display notices not to use the water for any purpose at all taps.

In many places in New Zealand, the water is plumbosolvent (ie, it corrodes metal plumbing fittings and may give rise to undesirable concentrations of lead, zinc, copper or other metals in the supply). It is not necessary to test for this, but consumers should be warned annually that New Zealand drinking-waters are often plumbosolvent so they should flush about 500 mL of water (two standard glasses) from the tap before drawing water for drinking.

10.1.4 Responses to be made when the maximum acceptable value (MAV) is exceeded

A sampling plan must be operated to determine whether the MAV or the operational requirements:

1. are exceeded continually
2. are exceeded seasonally or intermittently
3. have exceeded the transgression limits as the result of a once-only event.

The DWA will then determine what action needs to be taken.

In circumstance 1:

- the supplier must consult the DWA to decide whether a permanent 'Boil Water' notice needs to be issued in the case of bacterial or protozoal contamination[25]
- if a permanent 'Boil Water' notice is issued, an approved sign must be displayed next to all taps connected to this supply
- permanent consumers must be told about the presence of any chemical determinands found in the water at concentrations that could affect their health and whether they should treat their water.[26]

10.1.4.1 *E. coli*

When *E. coli* is detected in a sample, there must be an immediate response to discover the reason for the transgression and minimise the likelihood of a transgression recurring. Figure 4.1 (page 37) shows the actions that must be taken.

When a positive result has been obtained from a presence/absence or equivalent test carried out in the field by the operator, a second sample must be collected within 12 hours of the water supplier being informed of that result and the number of *E. coli* present must be determined by a Ministry of Health recognised laboratory.

10.1.4.2 Protozoa (*Cryptosporidium* and *Giardia*)

When a treatment process fails to perform within the operational requirements that protect against protozoal contamination, the DWA must be advised and an appropriate course of action decided.

[25] Boiling water is likely to increase the danger of drinking-water containing cyanotoxins (toxins, or poisons, from blue-green algae).

[26] Some isolated supplies may be used intermittently by most consumers, although a few consumers may rely on them permanently.

10.1.4.3 Chemical

When any chemical determinand is found to be present in the treated water at more than 50 percent of its MAV, it should be noted in the PHRMP and monitored annually until its concentration has been found to be less than 50 percent of its MAV in three consecutive samples *and* a reason for the drop in its concentration has been identified. If the determinand concentration exceeds the MAV, remedial action must be agreed with the DWA and carried out.

10.2 Standard supplies

See sections 4, 5 and 7, 8, 9.

11 Tankered Drinking-water Compliance Criteria

11.1 Registration of water carriers

All water carriers who provide drinking-water to customers must be registered on the Ministry of Health Register of Community Drinking-water Supplies and Suppliers.

11.2 Sources and classes of water

Tankered drinking-water is water delivered by tanker and not through a water network reticulation. It is preferably sourced from water provided by a registered drinking-water supplier whose supply complies with the DWSNZ. It may be delivered by road or rail to the consumer's storage facility on a commercial or voluntary basis.

Every carrier of drinking-water anywhere in New Zealand must ensure any water sold or supplied for potable purposes – drinking, food preparation or personal hygiene – meets the requirements of this section and the water quality is protected from contamination at all times during its loading, transit and delivery.

When water is to be taken from a reticulated water supplier, the supplier's requirements in respect of back-flow prevention, metering, access points and the use of the supplier's equipment must be complied with at all times.

Tankered water carriers may also carry water from a source that is not a registered water supplier whose supply complies with the DWSNZ and is in accordance with the requirements of Class 2 water, when such a class of water is specified by the customer. When practicable, only the highest quality of water should be used.

Water delivered by tanker is categorised into two classes. These classes represent the expected risk/quality of water being delivered to the consumer and define the actions the tanker operator must take during the supply operation.

Class 1 drinking-water is divided into two subclasses.

- Class 1(a) is water taken from a reticulated supply that complies with the DWSNZ and is listed in the Register of Community Drinking-water Supplies and Suppliers in New Zealand.
- Class 1(b) is water taken from an independent 'participating small water supply' that meets the compliance criteria for such systems.

Class 2 drinking-water is water intended for drinking purposes after appropriate treatment that does not meet Class 1(a) or Class 1(b) criteria. Class 2 water may be taken only from water sources approved by a DWA.

11.3 Operation

Every tanker must maintain and carry a logbook that contains the details of each load transported and each cleaning schedule. Such a log book must be kept for at least 10 years.

The operator of any vehicle used to transport water must ensure all tanks and the systems used for loading or unloading water:

- have not been used previously for transporting any noxious, toxic or hazardous matter, non-food liquids or human or animal wastes unless a DWA has certified them to be clean
- are protected from contamination during loading, transportation and delivery
- are kept clean and clear of any possible contaminants before sourcing the water to be delivered, with all openings and connections sealed to protect them from possible contamination. (If unused for the transport of drinking-water for a period of 30 days, the tank and fittings must be disinfected by filling with potable water containing at least 5.0 mg/L chlorine or other disinfectant approved by a DWA for not less than 30 minutes before discharging to waste.)

Following transport of non-potable water, or r any other consumable liquid such as milk or beer, the tanker must be subjected to a cleaning and disinfection process approved by a DWA before being used to transport potable water.

11.4 Monitoring

Samples must be collected for *E. coli* testing at a Ministry of Health recognised laboratory as follows:

- every third month, if the water being carried is always from a supply containing at least 0.2 mg/L FAC at the filling point
- monthly, if the water being carried is always from a supply that satisfies the requirements of the DWSNZ for that supply
- as specified by the DWA, if the water carried is from any other source.

Procedures for sampling are given in the *Guidelines*.

Whenever non-potable water has been transported, the tank must be washed, cleaned and refilled with potable water and a sample collected during the refilling or during the next delivery for *E. coli* testing.

All samples must be collected during the unloading or discharge process.

All positive *E. coli* tests must be immediately reported to the DWA who may require no further water to be transported from that source or in that tanker until the reason for the positive test has been identified and dealt with to the DWA's satisfaction.

11.5 Delivery

When water is delivered, a written statement must be supplied to the consumer stating the:

- delivery date and volume of water delivered
- source and class of water delivered and, where applicable, the grading of the treatment plant and distribution system, including the meaning of such grading, from where the water was taken.

If the water is supplied to non-residential premises, the statement must be displayed in a prominent location that allows all potential consumers to read it.

If the water is Class 2, the statement must also contain information from the DWA, who may require the statement to include a 'Boil Water' notice.

11.6 Documentation and records

All documentation and logbook records must be in accordance with the Ministry of Health recognised code of practice used by all registered tankered water carriers (see *Guidelines*).

A log must be kept of the:

- nature of any cargo tankered
- cleaning carried out before drinking-water is tankered after any cargo other than drinking-water has been tankered.

12 Compliance Criteria: Records

Records must be kept of the results of monitoring drinking-water determinands. The records are necessary to demonstrate the DWSNZ are being complied with. They are an essential requirement for the public health grading of drinking-water supplies.

The records must include the following information.

- The name of the supply, treatment plant(s) and distribution zone(s) to which the information relates and the unique supply component code listed in the *Register of Community Drinking-water Supplies and Suppliers in New Zealand* (Ministry of Health 2002). If the water supply has not been registered, this should be undertaken with the Ministry of Health.
- Up-to-date records of the resident population in the district served by the supply.
- The treatment processes in operation at the beginning of the year being reported and any modifications that changed the process during the previous year.
- Unless analysing for Priority 2a determinands, the concentration of any impurities in the chemicals being dosed. This should include the calculations used that proved analysis of the impurities was not needed.
- Anything that could significantly affect water quality that has occurred in the drinking-water supply system or catchment.
- A log of observations made of the appearance of the source water where regular source inspections are required.
- The determinands monitored during the year. If any Priority 1 or Priority 2 determinands have not been monitored, or monitored at less than the required frequency, the reasons must be recorded, with corroborating data where appropriate.
- All monitoring results of the raw water or water entering the treatment plant that are required for raw water classification.
- The sampling frequency for each determinand, the dates and times on which the measurements were made (for samples before and after flushing where this is necessary), the sampling site location, the supply component code, the name of the sampler(s) and the analytical results.
- Any remedial action taken as a result of the level of a determinand exceeding the MAV or because the water supplier considered it necessary.
- The analytical method used, the limit of detection, precision and uncertainty for each of their test methods.
- The name of the laboratory used for the analyses, as listed in the Ministry of Health's Register of Recognised Laboratories.
- Any re-evaluation of the operational programme undertaken, and the reasons for this. Notes concerning treatment modification are included above, but changes in the operation or the materials used in the reticulation should also be noted where appropriate.
- Operational records, including process changes and operational monitoring.

- Copies of all equipment validations or certifications.
- The names of staff supervisors and operators and their relevant qualifications and experience.

All records must be stored safely for a minimum period of 10 years (as required under the Health (Retention of Health Information) Regulations 1996), and all records must be made available to Ministry of Health designated officers as required.

Proper internal documentation of the monitoring programme, as detailed in the *Guidelines* will enable water suppliers to collate this information easily. Using the Water Information New Zealand (WINZ) database system (available through the Ministry of Health) will assist in calculating compliance and maintaining the necessary records in the correct format.

Compliance Criteria: Records

Appendix 1: Units, Conversions and Exceedences

A1.1 Basis for units

The DWSNZ uses the International System of Units (SI) (Système Internationale d'Unités of the Comité International des Poids et Mesures (CIPM)), consistent with the units used by the USEPA and in the Australian drinking-water standards.

The internationally recognised (CIPM) unit of volume is the litre (L).

The SI unit of weight is the kilogram (kg).

The SI unit of length is the metre (m).

The decimal prefixes may be used to form names and symbols of multiples of the **SI units**. The choice of appropriate multiple is governed by convenience to result in a numerical value within a practical range.

A1.2 Comparing a test result against a MAV or operational requirement

The MAVs given for chemical determinands in Tables 2.2 and 2.3 are mostly stated to one significant figure. This reflects the uncertainty associated with the toxicological data used to establish the MAV.

Despite the uncertainties and factors built into their derivation, MAVs and operational requirements must be treated as exact numbers for the purpose of determining compliance by means of comparison of a test (eg, an analytical) result against them.

To establish compliance, the test result (measurement) must be compared with the MAV or operational requirement without being rounded off (ie, a result of 0.014 mg/L lead must not be rounded to 0.01 mg/L).

However, before comparing the test result with the MAV, allowance must be made for the uncertainty of the accuracy of the test result. To correct for this uncertainty the figure that must be used for the comparison, is the "**adjusted result**", which is the sum of the test result and its uncertainty. (The statistical name of the uncertainty is the "one sided confidence limit".)

In line with current practice whether or no a transgression has occurred will continue to be determined by comparing the test result (ie, the actual analytical result) with the MAV until 31 December 2007. From 1 January 2008 the adjusted result will be used. Laboratories must report the:

- test result the actual result of the analysis)
- uncertainty of the determination (single sided confidence limit)

- adjusted result
- limit of detection

for each chemical determinand from 1 January 2006.

The analyst (or person responsible for calibrating a continuous monitoring instrument) is responsible for calculating the "adjusted result" and documenting the method used for calculating the uncertainty.

The method of determining the uncertainty of an analytical result is described in the *Guidelines*. It is related to the detection limit of the test method used for measurement, which must have a detection limit less than the operational requirement or 50% of the MAV (to allow Priority 2 status to be assessed). That is, reporting a lead analysis as <0.1 mg/L, for example is unsatisfactory because the result could be 0.09 mg/L which is nine times the MAV of lead, which is 0.01 mg/L.

As far as possible, the method detection limit for tests should be at least a fifth of the MAV or operational requirement (ie, at least as low as 0.002 mg/L for lead, 0.06 NTU for a turbidity operational requirement of 0.30 NTU, or 0.02 NTU for an operational requirement of 0.10 NTU).

It is normal for regulatory bodies to adopt a precautionary approach in compliance matters. This has always been the case for *E. coli* (or faecal coliforms in earlier editions of the DWSNZ). For example, a sample containing 1 *E. coli* per 100 mL is a transgression, ignoring confidence limits.

A test result plus its uncertainty therefore must not exceed the MAV or operational requirement. For example, if the uncertainty in lead analysis at the 0.01 mg/L level is 0.003 mg/L, to give confidence of compliance the test result cannot exceed 0.007 mg/L.

A1.3 Units and conversion tables

Table A1.1: Units of concentration

Standard unit	Standard symbol	Other units	Unit symbol	Equivalent units	Equivalent units
milligrams per litre	mg/L or mgL^{-1}			parts per million, ppm	grams per cubic metre, g/m^3 or gm^{-3}
		micrograms per litre	$\mu g/L$ or μgL^{-1}	parts per billion, ppb = 10^{-3} ppm	milligrams per cubic metre, mg/m^{-3} or mgm^{-3}
		nanograms per litre	ng/L or ngL^{-1}	parts per trillion, ppt = 10^{-3} ppb	

Notes:

1 mg/L = 1000 or 10^3 μg/L = 1,000,000 or 10^6 ng/L

1 ng/L = 0.001 or 10^{-3} μg/L = 0.000001 or 10^{-6} mg/L

One billion is one thousand million or 10^9.

A1.4 Microbial

Colony forming units per millilitre (cfu/mL).

Most probable number per 100 millilitres (MPN/100 mL).

1 µm = 1 micrometre = 1 micron = 0.001 mm or 10^{-3} millimetres.

A1.5 Physical and other

A1.5.1 Plumbosolvency

The **Langelier Saturation Index (LSI)** has been used to quantify plumbosolvency. However, in some waters the correlation between the index and the plumbosolvency of the water has been found to be poor, so the index is not used for this purpose in the DWSNZ.

The index is defined as the pH of the water minus the pH at which the water will be in equilibrium with solid calcium carbonate, that is:

SI = pHac – pHs

Where:

SI = Langelier Saturation Index

pHac = the actual pH

pHs = the pH of the water in equilibrium with calcium carbonate.

Therefore, the units of the Langelier Saturation Index are pH units, which are dimensionless.

A1.5.2 Contact time (C.t)

C.t is the concentration of the disinfectant in mg/L multiplied by exposure or contact time in minutes.

A1.5.3 Colour

The Hazen Colour Unit (HU) is sometimes referred to as the True Colour Unit (TCU). Strictly speaking, true colour is the colour of a filtered sample. The colour of an unfiltered sample is called ‘apparent colour’.

1 HU = 1 mg platinum/L in the form of the chloroplatinate ion.

A1.5.4 Conductivity

millisiemens per metre (mS/m or $mS.m^{-1}$)

1 mS/m = 10 µmhos/cm

1 µS/cm = 1 µmhos/cm

Note: Conductivity is strongly influenced by the temperature of the sample being tested. Normal practice is to measure the conductivity at 25°C or to convert it to this temperature, including the temperature in the report.

A1.5.5 Log removal

A method for expressing the removal of particles or the removal or inactivation of organisms.

Table A1.2: Relationship between log removal and percentage removal

Log removal	Expressed as percent removal
1	90
2	99
2.5	99.7
3	99.9
3.5	99.97
4	99.99
5	99.999

A1.5.6 pH

pH is the negative log of the hydrogen ion activity = – log aH^+
Approximated to indicate – log (hydrogen ion concentration) = – log $[H^+]$.

A1.5.7 Temperature

degrees Celsius (°C) or centigrade

A1.5.8 Turbidity

Nephelometric turbidity unit (NTU).

The turbidity of a specified concentration of formazin suspension (1.000 g of hydrazine sulphate/100 mL of water) is defined as 40 NTU. Alternative (working) standards are defined relative to this standard.

A1.5.9 UV absorbance and transmittance[27]

Note: 'The spectral attenuation (absorbance) of the water must be lower' is synonymous with 'the transmittance (UVT) of the water must be higher'.

Absorbance (A) = – $\log_{10}$(transmittance), or A = – logT.

[27] Sometimes colloquially called absorbance and transmission.

Measurements of transmittance or absorbance are made in a spectrophotometer at 253.7 nm (rounded to 254 nm). The sample is placed in a silica cell; these have different path lengths, so the path length must be quoted. A transmittance of 94 percent measured in a 10 mm cell is equivalent to 78 percent measured in a 40 mm cell.

A1.5.10 Ultraviolet disinfection

Irradiance is the power per unit area incident from all upward directions on an infinitesimally small element of surface area dA, divided by dA; whereas fluence rate (intensity) is the power incident from all directions on to an infinitesimally small sphere of cross-section dA, divided by dA. Both have the SI unit of W/m^2.

The fluence (UV dose) and radiant exposure (both J/m^2 or mJ/cm^2 or $mW.s/cm^2$) are the counterparts of irradiance and fluence rate respectively, where power is replaced by energy. UV dose is the product of the average fluence rate acting on a micro-organism from all directions and the exposure time.

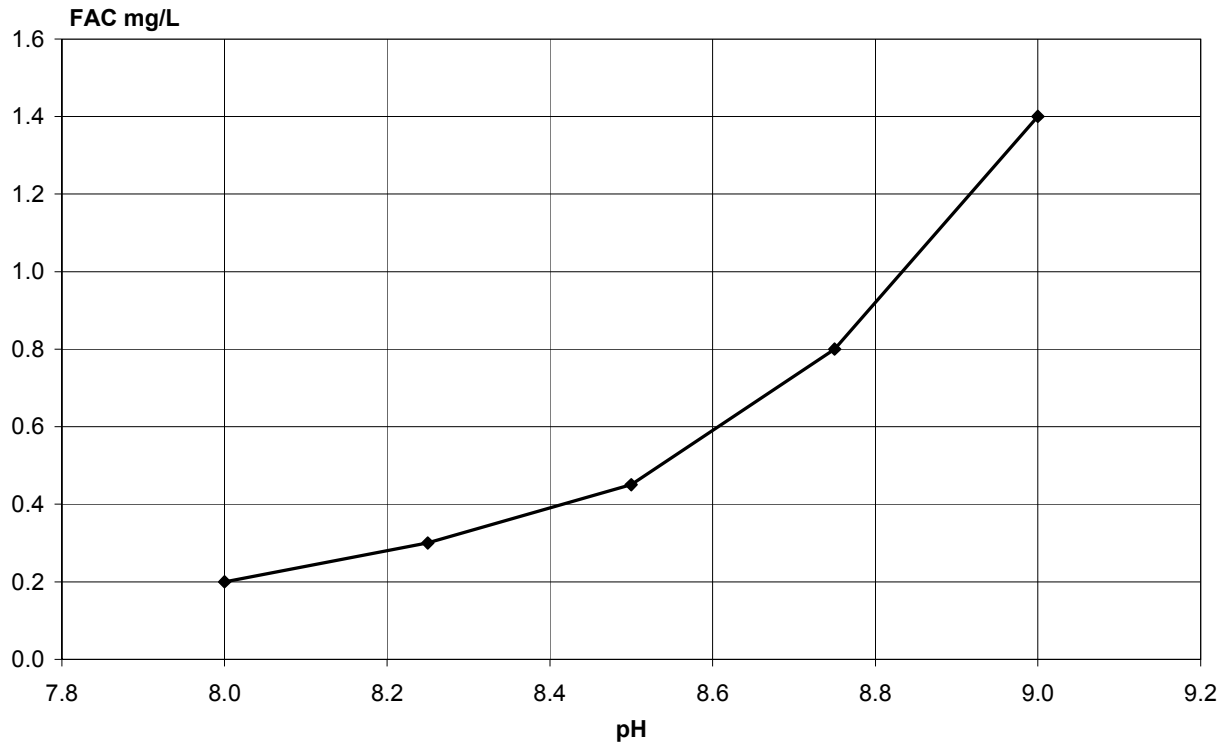
A1.5.11 Volume

1 cubic metre equals 1000 litres

1 litre equals 1000 mL

A1.5.12 FAC disinfection equivalents (FACE) at different pH values

Figure A1.1: Free available chlorine (FAC) concentration at different pH values to provide disinfection equivalent of 0.2 mg FAC/L at pH 8.0



A1.6 Chemical

The concentration of some determinands can be expressed using different units.

A1.6.1 Aluminium

A dose of 11 ppm alum is equivalent to approximately 1 mg/L aluminium.

A1.6.2 Asbestos

Million fibres per litre (MF/L)

A1.6.3 Ammonium

Ammonium nitrogen x 18/14 = ammonium ion
NH_4-N x 18/14 = NH_4^+

A1.6.4 Hardness

Total hardness = calcium hardness + magnesium hardness, expressed as mg/L $CaCO_3$
Ca as $CaCO_3$ = Ca as Ca x 100/40
Mg as $CaCO_3$ = Mg as Mg x 100/24.3

A1.6.5 Nitrate

Nitrate nitrogen x 62/14 = nitrate
NO_3–N x 62/14 = NO_3

A1.6.6 Nitrite

Nitrite nitrogen x 46/14 = nitrite
NO_2–N x 46/14 = NO_2

A1.7 Radioactivity

Activity of radionuclide:
Becquerel per litre (Bq/L)

A1.8 Permitted exceedences

Appendix A1.8, Table A1.3 lists the number of exceedences that can be tolerated for 95 percent confidence that a benchmark is not being exceeded more than 5 percent of the time.

Appendix A1.8, Table A1.3 refers to the number of samples, irrespective of the frequency of sampling. Thus the number of permissible transgressions in 250 samples is the same (7) whether all 250 samples were collected in one day or taken over the course of a year.

Table A1.3: Allowable exceedances (for 95% confidence that the MAV is exceeded for no more than 5% of the time)

Exceedences	Number of samples
0	38–76
1	77–108
2	109–138
3	139–166
4	167–193
5	194–220
6	221–246
7	247–272
8	273–298
9	299–323
10	324–348

Table A1.4: Allowable exceedances (for 95% confidence that the MAV is exceeded for no more than 2% of the time)

Exceedences	Number of samples
0	95–193
1	194–274
2	275–349
3	350–420
4	421–489
5	490–556
6	557–621
7	622–686
8	687–750
9	751–813
10	814–875

Appendix 2: Guideline Values and Other Chemicals

Table A2.1: Guideline values (GVs) for aesthetic determinands

Determinand	GV	Units	Comments
aluminium	0.10	mg/L	Above this, complaints may arise due to depositions or discoloration.
ammonia	1.5 0.3	mg/L	Odour threshold in alkaline conditions. For control of chloramine formation in chlorinated water.
calcium			See hardness.
chloride	250	mg/L	Taste, corrosion.
chlorine	0.6–1.0	mg/L	Taste and odour threshold (MAV 5 mg/L)
2-chlorophenol	0.0001 0.01	mg/L	Taste threshold. Odour threshold.
colour	10	TCU	Appearance.
copper	1	mg/L	Staining of laundry and sanitary ware (PMAV 2 mg/L)
1,2-dichlorobenzene	0.001 0.002	mg/L	Taste threshold. Odour threshold (MAV 1.0 mg/L)
1,4-dichlorobenzene	0.0003 0.006	mg/L	Odour threshold. Taste threshold (MAV 0.4 mg/L)
2,4-dichlorophenol	0.0003 0.04	mg/L	Taste threshold. Odour threshold.
ethylbenzene	0.002 0.08	mg/L	Odour threshold. Taste threshold (MAV 0.3 mg/L)
hardness (total) (Ca + Mg) as $CaCO_3$	200 100–300	mg/L	High hardness causes scale deposition, scum formation. Low hardness (<100) may be more corrosive. Taste threshold.
hydrogen sulphide	0.05	mg/L	Taste and odour threshold.
iron	0.2	mg/L	Staining of laundry and sanitary ware.
magnesium			See hardness.
manganese	0.04 0.10	mg/L	Staining of laundry. Taste threshold (MAV 0.4 mg/L)
monochlorobenzene	0.01	mg/L	Taste and odour threshold (MAV 0.3 mg/L)
odour (threshold odour number)	3		Odour should be acceptable.

Determinand	GV	Units	Comments
pH	7.0–8.5		Should be between 7.0 and 8.0. Most waters with a low pH have a high plumbosolvency. Waters with a high pH: have a soapy taste and feel. Preferably pH <8 for effective disinfection with chlorine.
sodium	200	mg/L	Taste threshold.
styrene	0.004	mg/L	Odour threshold (MAV 0.03 mg/L)
sulphate	250	mg/L	Taste threshold.
taste			Should be acceptable to most consumers.
temperature			Should be acceptable to most consumers, preferably cool.
toluene	0.03 0.04	mg/L	Odour. Taste threshold (MAV 0.8 mg/L)
total dissolved solids	1000	mg/L	Taste may become unacceptable from 600–1200 mg/L.
trichlorobenzenes (total)	see below		(MAV 0.03 mg/L)
1,2,3-trichlorobenzene	0.01	mg/L	Odour threshold.
1,2,4-trichlorobenzene	0.005	mg/L	Odour threshold.
1,3,5-trichlorobenzene	0.05	mg/L	Odour threshold.
2,4,6-trichlorophenol	0.002 0.3	mg/L	Taste threshold. Odour threshold (MAV 0.2 mg/L)
turbidity	2.5	NTU	Appearance. For effective terminal disinfection, median turbidity <1 NTU, single sample <5 NTU.
xylene	0.02	mg/L	Odour threshold (MAV 0.6 mg/L)
zinc	1.5	mg/L	Taste threshold. May affect appearance from 3 mg/L.

Table A2.2: Determinands for which health concerns have been raised but for which no maximum acceptable value (MAV) has been set*

Name	Remarks
asbestos	Toxicological information suggests that oral ingestion (unlike inhalation) is unlikely to be a health risk.
brodifacoum	
bromochloroacetic acid	DBP[1]
bromochloroacetonitrile	DBP[1]
chloroacetones	DBP (chlorination)[1]
2-chlorophenol	Aesthetic GV of 0.0001 mg/L (taste)[1]. DBP (chlorination).
chloropicrin	DBP (chlorination)[1]
chlorothalonil	Pesticide[2]
dialkyltins	[1]
dibromoacetic acid	DBP (ozone)[1]
dichloramine	DBP (chlorination)[1]
3,4-dichloroaniline	Degradation product of propanil[1]
1,3-dichlorobenzene	[1]
1,1-dichloroethane	[1]
2,4-dichlorophenol	Aesthetic GV of 0.0003 mg/L.[1] DBP (chlorination).
1,3-dichloropropane	[1]
dioxins	Many congeners. Very low water solubility. Not in WHO list of determinands of health concern.
fenitrothion	Pesticide[3]
glyphosate	Pesticide[3]
iodine	[1]
methamidophos	Pesticide[2]
methomyl	Pesticide[2]
monobromoacetic acid	DBP (ozone)[1]
MX	DBP (chlorination)[3]
phorate	Pesticide[2]
propoxur	Pesticide[2]
quintozene	Pesticide[2]
3,3´,4,4´-tetrachloroazobenzene	Degradation product of propanil[1]
trichloroacetonitrile	
trichloramine	DBP (chlorination)[1]

Notes

* DBP indicates a disinfection by-product. Any difficulty in meeting a MAV must never be a reason to compromise adequate disinfection. Trihalomethanes are DBPs. Some DBPs may also have other sources.

1 WHO (2004) states that data are not adequate to permit recommendation of health-based MAV.

2 WHO (2004) states that unlikely to occur in drinking-water.

3 WHO (2004) states that this determinand occurs in drinking-water at concentrations well below those at which toxic effects are observed.

Appendix 3: Sampling Requirements, Referee Method and Alternative Analytical Methods for Determinands

A3.1 *E. coli*, faecal coliforms, presumptive coliforms

The *E. coli* referee method is:

APHA 9223 B – Enzyme Substrate Coliform Test
Presence / Absence
Multi-Well MPN (Quantitray)
MPN (multiple tube technique).

Faecal coliforms

APHA 9221 E – Multiple Tube Fermentation (MPN) Technique (EC Medium)
Total or Presumptive Coliforms
APHA 9221 B – Multiple Tube Fermentation (MPN) Technique (Lauryl Tryptose Broth)

A3.2 *Cryptosporidium*

The *Cryptosporidium* enumeration procedure that is to be used for assessing the protozoal risk category of a raw water for the purposes of section 5.2.1 is a modified EPA 1623. Protozoal recovery must be assessed by the addition of colour seed to every sample. Both *Cryptosporidium* and *Giardia* are to be recorded.

The sample size shall be a minimum of 10L and the entire pellet must be analysed.

The full method description is given in the *Guidelines*.

A3.3 Turbidimeters

Turbidimeters used for compliance monitoring must comply with:

- ISO 7027, or USEPA Method 180.1, or USEPA Method 10133, or GLI Method 2: and/or
- be approved by the USEPA for drinking-water monitoring.
- The separation between data records is not to be more than one minute for measurements.
- The signal averaging time is to be one minute or less.

Primary calibration must be undertaken by personnel approved to do so by the DWA, and in accordance with the manufacturer's recommended procedures and frequency or three-monthly whichever is the most frequent. Primary calibration must be performed using StablCal (Hach) or PrimeTime (HF Scientific) (or other MoH-approved stabilised formazin preparation); or AMCO-AEPA-1 styrene divinylbenzene microsphere suspensions (Advanced Polymer Systems), except in the following circumstances under which user-diluted formazin preparations may be used.

1. The calibration point is 20 NTU or greater.
2. The 4000 NTU formazin preparation is obtained from a quality certified manufacturer.
3. The dilution is done immediately prior to use for calibration.
4. The **quality assurance** procedures are approved by the DWA.

Verification of online turbidimeters must be carried out weekly using the manufacturer's secondary standard. If the instrument reading is outside the limits specified for the secondary standard, then that instrument must be recalibrated using the primary calibration method.

A3.4 pH

The pH referee method is APHA 4500-H^+B/electrometric method. The pH electrode must be calibrated before each set of measurements is made, and the manufacturer's instructions must be followed for the storage of the electrode when not in use. Calibration solutions used must be prepared by an analytical laboratory using the formulations given in the above method, or purchased from a chemical manufacturing company as a certified solution.

Two buffers (about 7 then 4) must be used to calibrate and set the slope of the pH meter. Finally a pH 9 buffer must be used to check that the calibration holds over the whole range.

For potable waters (which are often only weakly buffered in New Zealand waters), the laboratory must note the time taken for the pH to return from measuring the 9 buffer to reading the pH of an unbuffered potable water. If this has become slow, then the electrode needs attention or is unsuitable.

Meters being used for potable water require special thin glass electrodes to work properly on unbuffered waters. "Robust" electrodes are not suitable.

A3.5 Temperature

A thermometer that has been calibrated according to TELARC technical guide no 3 *Working Thermometers Calibration Procedures* August 1986 must be used. Checks against another similarly calibrated thermometer must be made at least once every six months. If the readings diverge by more than 0.5^{o}C both thermometers must be recalibrated.

A3.6 Continuous monitoring analysers

For validation of on line continuous monitoring analyser records used to demonstrate compliance with these Standards, the value of the determinand recorded at a specified time must be checked to be the same as that obtained by from a grab sample that has been taken at the same time from the designated sampling point for that determinand and that has been analysed by the referee method [or a subordinate method that has been verified against the referee method]. If the monitor is checked using a subordinate method, the subordinate method must be validated against the referee method at least once every six months by a Ministry of Health approved laboratory.

The result, together with any adjustments that are made to the instrument and the identity of the operator(s), mustl be recorded. The frequency of checking for each class of instrument must be at least the greater of that specified below or that recommended by the manufacturer, and must be increased if this is found necessary to ensure that the rate of “drift” of the instrument reading is insignificant.

Table A3.1: Sampling requirements, referee method and alternative analytical methods for water properties and inorganic determinands listed in Table 2.2

Name	Sampling location		Container	Referee method	Alternative methods
	TW	DZ			
high plumbosolvency		✓	P(A)	*[Determine Pb on first flush sample]*	See *Guidelines*
antimony		✓	P(A), G(A)	GFAA (APHA 3113) (pre-concentration may be necessary)	ICP-MS (EPA 200.8)
arsenic	✓	✓	P(A), G(A)	GFAA (APHA 3113)	HGAA (APHA 3114) ICP-MS (EPA 200.8)
barium	✓	✓	P(A), G(A)	GFAA (APHA 3113)	FAA (APHA 3111) ICP (APHA 3120) ICP-MS (EPA 200.8)
beryllium	✓	✓	P(A)	ICP-MS (EPA 200.8)	
boron	✓	✓	P	Colorimetric method (Department of Environment 1980, 1981)	Colorimetric method (APHA 4500-B B) ICP-MS (EPA 200.8) ICP (APHA 3120)
bromate		✓	P	IC (EPA 300.0)	IC (JAWWA (1992), 84(11): 88)
cadmium		✓	P(A), G(A)	GFAA (APHA 3113)	ICP (APHA 3120) ICP-MS (EPA 200.8)
chloramines (mono-chloramine, dichloramine, trichloramine)		✓	G	TITR (APHA 4500-Cl F) DPD	TITR (APHA 4500-Cl D) Amperometric Colorimetric DPD (APHA 4500-Cl G)
chlorate	✓	✓	P	IC (EPA 300.0)	IC (JAWWA (1992), 84(11): 88)
chlorine		✓	G	TITR (APHA 4500Cl F)	TITR (APHA 4500Cl D)
chlorite		✓	P	IC (EPA 300.0)	IC (JAWWA (1992), 84(11): 88)
chromium		✓	P(A), G(A)	GFAA (APHA 3113)	FAA (APHA 3111) ICP (APHA 3120) ICP-MS (EPA 200.8)
copper		✓	P(A), G(A)	GFAA (APHA 3113)	FAA (APHA 3111) ICP (APHA 3120) ICP-MS (EPA 200.8)
cyanide (total)	✓	✓	P	Total cyanide (APHA 4500-CN C)	
cyanogen chloride		✓	G(S)	(APHA 4500-CN J)	[Hydrolyses rapidly, testing must be done on-site. If no cyanide pre-chlorination then no cyanogenchloride possible]
fluoride	✓	✓	P	Ion selective electrode (APHA 4500-F C)	IC (APHA 4110) Colorimetric method, SPADNS (APHA 4500-F D)
lead		✓	P(A), G(A)	GFAA (APHA 3113)	ICP (APHA 3120) (pre-concentration may be needed) ICP-MS (EPA 200.8)
lithium	✓	✓	G(A)	Flame emission (APHA 3500-Li B)	ICP-MS (EPA 200.8)
manganese		✓	P(A), G(A)	GFAA (APHA 3113)	FAA (APHA 3111) ICP (APHA 3120) ICP-MS (EPA 200.8)

Name	Sampling location		Container	Referee method	Alternative methods
	TW	DZ			
mercury	✓	✓	G(A)	CVGAA (3112 B)	ICP-MS (EPA 200.8)
molybdenum	✓	✓	P(A), G(A)	GFAA (APHA 3113)	ICP (APHA 3120) ICP-MS (EPA 200.8)
nickel		✓	P(A), G(A)	GFAA (APHA 3113)	ICP (APHA 3120) ICP-MS (EPA 200.8)
nitrate		✓	P, G	Cadmium reduction (APHA 4500-NO_3-E)	IC (APHA 4110) Ion selective electrode (APHA 4500-NO_3-D)
nitrite		✓	P, G	Colorimetric method (APHA 4500-NO_2-B)	IC (APHA 4110)
selenium	✓	✓	P(A), G(A)	GFAA (APHA 3113)	HGAA (APHA 3114) ICP (APHA 3120) ICP-MS (EPA 200.8)
silver	✓	✓	P(A)	GFAA (APHA 3113)	ICP-MS (EPA 200.8)
tin		✓	P(A)	GFAA (APHA 3113)	ICP-MS (EPA 200.8)
uranium	✓	✓	P(A)	ICP-MS (EPA 200.8)	

Table A3.2a: Sampling requirements, preferred method and alternative analytical methods for cyanotoxins of health significance listed in Table 2.3

Name	Sampling location		Container	Referee method	Alternative methods
	TW	DZ			
anatoxin-a	✓	✓	G(S) P(S)	LC-MS (Namikoshi *et al.* 2003; Dell'Aversano *et al.* 2004; Furey *et al.* 2003)	HPLC-FLD (James *et al.* 1998) HPLC–UV (Wong and Hindin 1982)
anatoxin-a(S)	✓	✓	G(S) P(S)	ChE Inhibition Assay (Mahmood and Carmichael 1987; Barros *et al*. 2004.)	Mouse Bioassay (Falconer 1993)
cylindrospermopsin	✓	✓	G(S) P(S)	LC-MS (Eaglesham *et al.* 1999; Dell'Aversano *et al.* 2004)	HPLC-PDA (Harada *et al.* 1994; Torokne *et al.* 2004)
homoanatoxin-a	✓	✓	G(S) P(S)	LC-MS (Namikoshi *et al.* 2003; Dell'Aversano *et al.* 2004; Furey *et al.* 2003)	HPLC-FLD (James *et al.* 1998) HPLC-UV (Wong and Hindin 1982)
microcystins (expressed as MC-LR toxicity equivalents)	✓	✓	G(S) P(S)	HPLC-UV/PDA (Lawton *et al.* 1994; Meriluoto 1997)	LC-MS (Zweigenbaum *et al.* 2000; Barco *et al.* 2002; Spoof *et al.* 2003) ADDA-ELISA (Fisher *et al.* 2001) PP2A (An and Carmichael 1994; Meriluoto 1997; Ward *et al.* 1997)
nodularin	✓	✓	G(S) P(S)	HPLC-UV/PDA (Lawton *et al.* 1994; Meriluoto 1997)	LC-MS (Zweigenbaum *et al.* 2000; Barco *et al.* 2002; Spoof *et al*. 2003) ADDA-ELISA (Fisher *et al.* 2001) PP2A (An and Carmichael 1994; Meriluoto 1997; Ward *et al.* 1997)
saxitoxins (as STX-eq)	✓	✓	G(S) P(S	HPLC-FLD (Lawrence and Niedzwiadek 2001; Oshima *et al.* 1989; Thomas *et al.* 2004)	LC-MS (Quilliam *et al.* 2001; Dell'Aversano *et al.* 2004) Mouse Bioassay (Falconer 1993; AOAC 1996) Receptor Binding Assay (Powell and Doucette 1999; Doucette *et al.* 1997; Ruberu *et al.* 2003)

Table A3.2b: Sampling requirements, referee method and alternative analytical methods for organic determinands of health significance listed in Table 2.3

Name	Sampling location		Container	Referee method	Alternative methods
	TW	DZ			
acrylamide	✓	✓	G(S)	LLE/GC-ECD (EPA 8032)	HPLC/UVD (Department of Environment 1988) LSE/HPLC-UV (EPA 8316)
benzene	✓	✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall & PID (APHA 6230D, EPA 502.2)
benzo[a]pyrene		✓	G(S)	LSE/GC-MS (EPA 525)	LLE/HPLC (EPA 550) LSE/HPLC (EPA 550.1)
bromodichloromethane		✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall & PID (APHA 6230D, EPA 502.2) LLE/GC-ECD (EPA 551)
bromoform		✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall & PID (APHA 6230D, EPA 502.2) LLE/GC-ECD (EPA 551)
carbon tetrachloride		✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall & PID (APHA 6230D, EPA 502.2) LLE/GC-ECD (EPA 551)
chloroform		✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall & PID (APHA 6230D, EPA 502.2) LLE/GC-ECD (EPA 551)
di(2-ethylhexyl)adipate		✓	G(S)	LSE/GC-MS (EPA 525.2)	LLE or LSE/GC-PID (EPA 506)
di(2-ethylhexyl)phthalate		✓	G(S)	LSE/GC-MS (EPA 525.2)	LLE or LSE/GC-PID (EPA 506)
dibromoacetonitrile		✓	G(S)	LLE/GC-ECD (EPA 551)	
dibromochloromethane		✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC (APHA 6230D, EPA 502.2) LLE/GC-ECD (EPA 551)
dichloroacetic acid		✓	G(S)	LSE/GC-ECD (EPA 552.1)	LLE/GC-ECD (APHA 6251)
dichloroacetonitrile		✓	G(S)	LLE/GC-ECD (EPA 551)	
1,2-dichlorobenzene		✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall & PID (APHA 6230D, EPA 502.2) LLE/GC-MS (APHA 6410B)
1,4-dichlorobenzene	✓	✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall & PID (APHA 6230D, EPA 502.2) LLE/GC-MS (APHA 6410B)
1,2-dichloroethane		✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall & PID (APHA 6230D, EPA 502.2)
1,1-dichloroethene	✓	✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall & PID (APHA 6230D, EPA 502.2)
1,2-dichloroethene (cis/trans)	✓	✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall & PID (APHA 6230D, EPA 502.2)
dichloromethane		✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall & PID (APHA 6230D, EPA 502.2)
2,4-dichlorophenol		✓	G(S)	LLE/GC-MS (APHA 6410B)	
EDTA	✓	✓	G(S) P(S)	Reverse phase ion pair liquid chromatography (Bergers and De Groot 1994)	
epichlorohydrin	✓	✓	G(S)	P&T/GC-MS (EPA 8260)	GC/ECD (Pesselman and Feit 1988)

Name	Sampling location		Container	Referee method	Alternative methods
	TW	DZ			
ethylbenzene	✓	✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall & PID (APHA 6230D, EPA 502.2)
fluoranthene		✓	G(S)	LSE/GC-MS (EPA 525)	LLE/HPLC (EPA 550) LSE/HPLC (EPA 550.1)
formaldehyde		✓		LSE/HPLC (EPA 554)	LLE/HPLC-UV (EPA 8315)
hexachlorobutadiene	✓	✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall & PID (APHA 6230D, EPA 502.2)
monochloroacetic acid		✓	G(S) P(S)	LSE/GC-ECD (EPA552.1)	
monochlorobenzene	✓	✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall & PID (APHA 6230D, EPA 502.2)
nitrilotriacetic acid	✓	✓	G(S)	GC-MSD (Malaiyandi et al 1979; Aue et al 1972)	
styrene	✓	✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall & PID (APHA 6230D, EPA 502.2)
tetrachloroethene		✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall & PID (APHA 6230D, EPA 502.2) LLE/GC-ECD (EPA 551)
toluene		✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall & PID (APHA 6230D, EPA 502.2)
tributyltin oxide	✓	✓	G(S)	LLE/GC-FPD (Greaves and Unger 1988)	
trichloroacetaldehyde/ chloral hydrate		✓	G(S)	LLE/GC-ECD (EPA 551)	
trichloroacetic acid		✓	G(S)	LSE/GC-ECD (EPA 552.1)	LLE/GC-ECD (APHA 6251)
trichloroacetonitrile		✓	G(S)	LLE/GC-ECD (EPA 551)	
trichlorobenzenes	✓	✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall & PID (APHA 6230D, EPA 502.2)
1,1,1-trichloroethane	✓	✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall & PID (APHA 6230D, EPA 502.2) LLE/GC-ECD (EPA 551)
trichloroethene		✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall & PID (APHA 6230D, EPA 502.2) LLE/GC-ECD (EPA 551)
2,4,6-trichlorophenol		✓	G(S)	LLE/GC-ECD (APHA 6251)	LLE/GC-ECD & FID (APHA 6420) LLE/GC-MS (APHA 6410B) Acetylation/LLE/GC-MS (EPA 1653)
vinyl chloride		✓	G(S)	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall & PID (APHA 6230D, EPA 502.2)
xylenes		✓	G(S)	P&T/GC-MSD (APHA 6210D, EPA 524.2)	P&T/GC-Hall & PID (APHA 6230D, EPA 502.2)

Table A3.3: Sampling requirements, referee method and alternative analytical methods for pesticides listed in Table 2.3

Name	Sampling location		Container	Referee method	Alternative methods
	TW	DZ			
alachlor	✓	✓	G	LSE/GC-MS (EPA 525.2)	LLE/GC-NPD (EPA 507) LLE/GC-ECD (EPA 505)
aldicarb	✓	✓	G	RP HPLC (EPA 531.1)	HPLC/FLD (APHA 6610)
aldrin/dieldrin	✓	✓	G	LLE/GC-MS (APHA 6410B)	LLE/GC-ECD (EPA 505)
atrazine	✓	✓	G	LSE/GC-MS (EPA 525.2)	LLE/GC-NPD (EPA 507)
azinphos-methyl			G	LLE/GC-ECD (EPA 8141[a])	
bentazone	✓	✓	G	LSE/GC-ECD (EPA 515.2)	LLE/GC-ECD (APHA 6640B) HPLC/UVD (EPA 555)
bromacil			G	LLE/GC-NPD (EPA 507)	
carbofuran	✓	✓	G	RP HPLC (EPA 531.1)	HPLC-FLD (APHA 6610)
chlordane	✓	✓	G	LLE/GC-MS (APHA 6630C)	LLE/GC-ECD (EPA 508)
chlorpyriphos	✓	✓	G	LSE/GC-MS (EPA 525.2)	LLE/GC-MS (EPA 8270) LLE/GC-NPD or FPD (EPA 8140)
chlortoluron	✓	✓	G	LLE/LSE/HPLC (EPA 553)	LLE/LSE/HPLC-UV or HPLC-MS (EPA 8321B)
cyanazine			G	LLE/GC-ECD (EPA 551.2)	
2,4-D	✓	✓	G	LSE/GC-ECD (EPA 515.2)	LLE/GC-ECD (APHA 6640B) HPLC/UVD (EPA 555)
2,4-DB	✓	✓	G	LSE/GC-ECD (EPA 515.2)	LLE/GC-ECD (APHA 6640B) HPLC/UVD (EPA 555)
DDT + isomers	✓	✓	G	LLE/GC-MS (APHA 6410B)	LLE/GC-ECD (APHA 6630B) LLE/GC-ECD (EPA 508)
diazinon	✓	✓	G	LSE/GC-MS (EPA 525.2)	LLE/GC-NPD (EPA 507) LLE/GC-NPD or FPD
1,2-dibromo-3-chloropropane	✓	✓	G	P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall&PID (APHA 6230D) LLE/GC-ECD (APHA 6231B) LLE/GC-ECD (EPA 551)
1,2 dibromoethane	✓	✓	G	P&T/GC-MS (APHA 6210D, EPA524.2)	P&T/GC-Hall&PID (EPA 502.2, APHA 6230D)
1,2-dichloropropane	✓	✓	G	P&T/GC-MS (APHA 6210D, EPA524.2)	P&T/GC-Hall&PID (EPA 502.2, APHA 6230D)
1,3-dichloropropene	✓	✓	G	P&T/GC-MS (APHA 6210D, EPA524.2)	P&T/GC-Hall&PID (EPA 502.2, APHA 6230D)
dichlorprop	✓	✓	G	LSE/GC-ECD (EPA 515.2)	LLE/GC-ECD (APHA 6640B) HPLC/UVD (EPA 555)
dimethoate	✓	✓	G		
diquat	✓	✓	G	LSE/HPLC-UV (EPA 549.2)	

Name	Sampling location		Container	Referee method	Alternative methods
	TW	DZ			
diuron	✓	✓	G	LLE/LSE/HPLC (EPA 553)	LLE/LSE/HPLC-UV or HPLC-MS (EPA 8321B)
endrin	✓	✓	G	LLE/GC-MS (APHA 6410B)	LLE/GC-ECD (EPA 505)
ethylene dibromide	✓	✓	G	LLE/GC-ECD (EPA 551.2)	
fenoprop	✓	✓	G	LLE/GC-ECD (EPA 515.2)	LLE/GC-ECD (APHA 6640B)
heptachlor and epoxide	✓	✓	G	LLE/GC-ECD (EPA 505)	LLE/GC-ECD (EPA 508)
hexachlorobenzene	✓	✓	G	LSE/GC-MS (EPA 525.2)	LLE/GC-ECD (EPA 505) LLE/GC-ECD (EPA 508)
hexazinone	✓	✓	G	LLE/GC-NPD (EPA 507)	
isoproturon	✓	✓	G	LSE/GC-MS (EPA 525.2)	RPHPLC/ED (electrochemical) LLE, HPLC-UV
lindane	✓	✓	G	LSE/GC-MS (EPA 525.2)	LLE/GC-ECD (EPA 508) LLE/GC-ECD (EPA 505) LLE/GC (APHA 6630B)
malathion	✓	✓	G	LSE/GC-MS (EPA 525.2)	LLE/GC-NPD (EPA 507)
MCPA	✓	✓	G	HPLC/UVD (EPA 555)	LLE/GC-ECD (APHA 6640B)
mecoprop	✓	✓	G	LSE/GC-ECD (EPA 515.2)	LLE/GC-ECD (APHA 6640B) HPLC/UVD (EPA 555)
methyl parathion	✓	✓	G	LSE/GC-MS (EPA 525.2)	LLE/GC-NPD (EPA 507)
metalaxyl			G	LLE/GC-NPD (EPA 507)	LSE/GC-MS (EPA 525.2) LSE/GC-MS (EPA 508.1)
methoxychlor	✓	✓	G	LSE/GC-MS (EPA 525.2)	LLE/GC (APHA 6630B) LLE/GC-ECD (EPA 508) LLE/GC-ECD (EPA 505)
metolachlor	✓	✓	G	LLE/GC-NPD (EPA 507)	LSE/GC-MS (EPA 525.2) LSE/GC-MS (EPA 508.1)
metribuzin	✓	✓	G	LLE/GC-NPD (EPA 507)	LSE/GC-MS (EPA 525.2) LSE/GC-MS (EPA 508.1)
molinate	✓	✓	G	LLE/GC-NPD (EPA 507)	LSE/GC-MS (EPA 525.2) LSE/GC-MS (EPA 508.1)
oryxalin	✓	✓	G	LLE/LSE/HPLC (EPA 553)	LLE/LSE/HPLC-UV or HPLC-MS (EPA 8321B)
oxadiazon	✓	✓	G	LLE/GC-NPD (EPA 507)	LSE/GC-MS (EPA 525.2) LSE/GC-MS (EPA 508.1)
pendimethalin	✓	✓	G	LLE/GC-ECD/NPD (EPA 8091)	
pentachlorophenol	✓	✓	G	LSE/GC-MS (EPA 525.2)	LSE/GC-ECD (EPA 515.2) Acetylation/LLE/GC-MS (EPA 1653)

Sampling Requirements, Referee Method and Alternative Analytical Methods for Determinands

Name	Sampling location		Container	Referee method	Alternative methods
	TW	DZ			
permethrin	✓	✓	G	LLE/GC-ECD (EPA 508)	LLE/GC-ECD (EPA 8081)
picloram	✓	✓	G	LLE/GC-ECD (EPA 515.2)	HPLC/PDAUV (EPA 555)
pirimiphos methyl	✓	✓	G	LSE/GC-MS (EPA 525.2)	
pirimisulphuron	✓	✓	G	[No New Zealand lab does this, cannot find a method]	
procymidone	✓	✓	G	LLE/GC-NPD (EPA 507)	LSE/GC-MS (EPA 525.2) LSE/GC-MS (EPA 508.1)
propanil	✓	✓	G	LLE/HPLC/UV (EPA 632.1)	
propazine				LLE/GC-NPD (EPA 507)	
pyridate	✓	✓	G		LLE/HPLC UV
pyriproxifen	✓	✓	G		
simazine	✓	✓	G	LSE/GC-MS (EPA 525.2)	LLE/GC-NPD (EPA 507)
2,4,5-T	✓	✓	G	LSE/GC-ECD (EPA 515.2)	LLE/GC-ECD (APHA 6640B) HPLC/UVD (EPA 555)
terbuthylazine	✓	✓	G	LLE/GC-ECD (EPA 1656)	LLE/GC-NPD (Department of Environment 1986)
thiabendazole	✓	✓	G	HPLC – Fluorescence (EPA 641)	
triclopyr	✓	✓	G	LSE/CD-ECD (EPA 515.2)	LLE/GC-ECD (APHA 6640B) HPLC/UVD (EPA 555)
trifluralin	✓	✓	G	LLE/GC-ECD (EPA 508)	LLE/GC-MS (EPA 8270)
1080	✓	✓	G	LSE/GC-ECD Ozawa and Tsukioka (1987) (proposed)	

Note: In the analysis of the organic determinands, it is the extraction method that is important. The choice of the final method of detection, for example, MSD or ECD affects the sensitivity and selectivity of the analysis.

Table A3.4: Sampling requirements, referee method and alternative analytical methods for radiological determinands listed in Table 2.4

Name	Sampling location		Container	Referee method	Alternative methods
	TW	DZ			
total alpha activity			[Kit supplied by NRL[1]]	EPA 520/5-84-006 method 00-02	
total beta activity			[Kit supplied by NRL[1]]	EPA Method 900.0 August 1980	
radon			[Kit supplied by NRL[1]]	Gregory (1976)	

Notes

(S) NRL = National Radiation Laboratory, PO Box 25 099, Christchurch, phone 03 366 5059, fax 03 366 1156, www.nrl.moh.govt.nz

Table A3.5: Sampling requirements, referee method and alternative analytical methods for aesthetic determinands listed in Table A2.1

Name	Sampling location		Container	Referee method	Alternative methods
	TW	DZ			
aluminium		✓		GFAA (APHA 3113)	ICP (APHA 3120) ICP-MS (EPA 200.8) Colorimetric method (APHA 3500-Al B)
ammonium		✓		Colorimetric – phenate (APHA 4500-NH3 F)	ISE (APHA 4500-NH3 D, E)
calcium	✓	✓		Flame AA (APHA 3111B)	ICP (APHA 3120) ICP-MS (EPA 200.8)
chloride	✓	✓		IC (APHA 4110)	
chlorine		✓		DPD FAS titrimetric (APHA 4500-Cl F))	DPD FAS colorimetric (APHA 4500-Cl G))
2-chlorophenol		✓		LLE/GC-MS (APHA 6410B)	
colour		✓		Nessleriser (APHA 2120B)	Spectrophotometric (APHA 2120C)
copper		✓		Flame AA (APHA 3111B)	ICP (APHA 3120) ICP-MS (EPA 200.8)
1,2-dichlorobenzene		✓		P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall & PID (APHA 6230D, EPA 502.2) LLE/GC-MS (APHA 6410B)
1,4-dichlorobenzene		✓		P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall & PID (APHA 6230D, EPA 502.2) LLE/GC-MS (APHA 6410B)
2,4-dichlorophenol		✓		P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall & PID (APHA 6230D, EPA 502.2) LLE/GC-MS (APHA 6410B)
ethylbenzene		✓		P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall & PID (APHA 6230D, EPA 502.2) LLE/GC-MS (APHA 6410B)
hardness (total) (Ca + Mg) as $CaCO_3$		✓		Calculation from Ca, Mg (APHA 2340B)	EDTA Titrimetric (APHA 2340 C)
hydrogen sulphide		✓		Calculation (APHA 4500-S^{2-}H)	
iron		✓		Flame AA (APHA 3111B)	ICP (APHA 3120) ICP-MS (EPA 200.8)
magnesium	✓	✓		Flame AA (APHA 3111B)	ICP (APHA 3120) ICP-MS (EPA 200.8)
manganese		✓		Flame AA (APHA 3111B)	ICP (APHA 3120) ICP-MS (EPA 200.8)
monochlorobenzene		✓		P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall & PID (APHA 6230D, EPA 502.2) LLE/GC-MS (APHA 6410B)

Name	Sampling location		Container	Referee method	Alternative methods
	TW	DZ			
odour		✓		'Acceptable to most consumers'	Threshold Odor Test (APHA 2150B)
pH		✓		Electrometric (APHA 4500-H^+ B)	
sodium	✓	✓		Flame AA (APHA 3111B)	ICP (APHA 3120) ICP-MS (EPA 200.8)
styrene		✓		P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall & PID (APHA 6230D, EPA 502.2) LLE/GC-MS (APHA 6410B)
sulphate	✓	✓		IC (APHA 4110)	
taste		✓		'Acceptable to most consumers'	APHA 2160 B, C
temperature		✓		Field measurement (APHA 2550B)	
toluene		✓		P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall & PID (APHA 6230D, EPA 502.2) LLE/GC-MS (APHA 6410B)
total dissolved solids	✓	✓		Gravimetric (APHA 2540C)	
trichlorobenzenes (total)		✓		P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall & PID (APHA 6230D, EPA 502.2) LLE/GC-MS (APHA 6410B)
1,2,3-trichlorobenzene		✓		P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall & PID (APHA 6230D, EPA 502.2) LLE/GC-MS (APHA 6410B)
1,2,4-trichlorobenzene		✓		P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall & PID (APHA 6230D, EPA 502.2) LLE/GC-MS (APHA 6410B)
1,3,5-trichlorobenzene		✓		P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall & PID (APHA 6230D, EPA 502.2) LLE/GC-MS (APHA 6410B)
2,4,6-trichlorophenol		✓		LLE/GC-MS (APHA 6410B)	
turbidity		✓		Nephelometric (APHA 2130B)	
xylene		✓		P&T/GC-MS (APHA 6210D, EPA 524.2)	P&T/GC-Hall & PID (APHA 6230D, EPA 502.2) LLE/GC-MS (APHA 6410B)
zinc		✓		Flame AA (APHA 3111B)	ICP (APHA 3120) ICP-MS (EPA 200.8)

Sampling Requirements, Referee Method and Alternative Analytical Methods for Determinands

Notes to tables

Abbreviations

DZ	distribution zone
TW	water leaving the treatment plant

Container

(S)	acid washed
G	glass
P	plastic
(S)	solvent washed

Analytical method

BA	bioassay
ELISA	Enzyme linked immunosorbent assay
CVGA	cold vapour atomic absorption method
ECD	electron capture detector
FAA	flame atomic absorption
FID	flame ionisation detector
FLD	fluorescence detector
FPD	flame photometric detector
GC	gas chromatography
GFAA	graphite furnace atomic absorption
HGAA	hydride generation atomic absorption
HPLC	high pressure liquid chromatography
IC	ion chromatography
LC	Liquid chromatography
LSE	liquid/solid extraction
MS	mass spectrometer
ND	nitrogen specific detector
NPD	nitrogen/phosphorus detector
P&T	purge and trap
PDA	Photo-diode array
PID	photoionisation detector
RPHPLC	reversed-phase HPLC
TITR	titrimetric method
UVD	ultraviolet detection

Source: APHA refers to APHA (1998) and EPA refers to USEPA (2003c).

Sampling Requirements, Referee Method and Alternative Analytical Methods for Determinands

Definitions

Note: Words appearing in bold type in the body text are defined in this section.

Abstraction point	The point at which water that is intended for drinking comes under the control of the drinking-**water supplier**.
Accreditation	Accreditation provides formal recognition that an organisation is meeting internationally accepted standards of quality, performance, technical expertise and competence. Accreditation is an independent endorsement of a commitment to these standards. (See IANZ 1998.)
accuracy	Combination of **bias** and **precision** of an analytical procedure that reflects the closeness of a measured value to a true value.
ADDA	3-amino-9-methoxy-2,6,8-trimethyl-10-phenyldeca-4,6-dienoic acid
adjusted result	The **adjusted result** of a determinand concentration is the sum of the **test result** for the determinand concentration and the **uncertainty** in the determination of that concentration.
aesthetic determinand	A constituent or property of the water that can adversely affect the water's taste, odour, colour, clarity or general appearance, including substances such as manganese and iron compounds that can stain washing and utensils.
alarm	A device that alerts the duty treatment plant operator in such a way that they can make an immediate response to address the problem that caused the alarm.
algae	Algae are unicellular to multicellular plants that occur in fresh water, marine water and damp terrestrial environments. All algae possess chlorophyll. They may contribute to taste and odour problems in water.
alkalinity	Alkalinity is a measure of buffering capacity. A buffer limits the change in **pH** that occurs when water comes in contact with acidic or alkaline substances. The principle cause of alkalinity in most drinking-waters includes at least one of bicarbonate, carbonate or hydroxide. Alkalinity is measured by titrating with a standard acid to a designated pH.
alpha-emitting radionuclide	A **radionuclide** that undergoes a nuclear transformation by emitting a helium-4 nucleus (alpha particle).
annual compliance	Compliance of a drinking-water supply with the **DWSNZ** is assessed over 12 consecutive calendar months and reported to the Government and public annually.

aquifer A water-saturated zone of the ground that will yield water to **bores** or **springs** at a sufficient rate to serve as an adequate source of water. An aquifer contains pores or open spaces filled with water.

aquitard A low-permeability layer that restricts the flow of **groundwater** from one **aquifer** to another, for example, sandy silt. The rate at which water can be abstracted from these layers is usually too low for the formation to be used as a source.

bacteria The simplest form of life that can be unicellular or multicellular. Bacteria possess a simple nucleus, can reproduce rapidly and lack chlorophyll. Some members of the group are disease-causing.

bag filter A pressure-driven separation process that removes particulate matter larger than 1 µm, using an engineered porous filtration media by surface filtration. A bag filter is typically constructed of a non-rigid, fabric **filtration** medium housed in a pressure vessel (**housing**) in which the direction of flow is from the inside of the bag to the outside.

bank filtration A **surface water** pre-treatment process using the bed and bank of the river and the adjacent **aquifer** as a natural filter and relying solely on the natural properties of the **surface water** bed and aquifer, unmodified by engineering works or activity, except for the recovery of ground water via a pumping **bore** (USEPA 2003d).

The requirements for bank filtration are specific, so many existing infiltration galleries will not qualify.

The mechanisms active in this type of system are believed to be similar to **slow sand filtration**, so provide a more reliable removal of **protozoa** than the mechanisms active in infiltration galleries.

becquerel Radioactive activity of one nuclear transformation per second.

beta-emitting radionuclide A **radionuclide** that disintegrates by emitting a negative (or positive) electron (beta particle).

bias Consistent deviation of measured values from the true value caused by systematic errors in a procedure. See **accuracy** and **precision**.

bore Any hole constructed to access **groundwater** for supply purposes.

bore field More than one **bore** connected to a single water supply.

bore (intake) depth Depth to the bottom of the casing or top of the uppermost screen.

bore head The physical structure, facility or device at the land surface from which **groundwater** is abstracted from sub**surface water**-bearing formations.

bulk distribution zone The part of the distribution network which delivers water from the treatment plant(s) to one or more distribution zones. Usually, but not necessarily, owned and operated by a different water supplier, may or may not include service storage, and services only a nominal number of consumers directly. A bulk distribution zone may be identified due to its operational characteristics, or the characteristics of the water it supplies, by agreement between the water supplier(s) and the DWA. Each bulk distribution zone will be separately graded.

bulk water supply point The point at which the water's ownership changes from the bulk **water supplier** to the satellite supplier.

carcinogen A substance that induces cancer.

cartridge filtration A pressure-driven separation process that removes particulate matter larger than 1 μm, using an engineered porous filtration media through surface or depth **filtration**. A cartridge **filter** is typically constructed as rigid or semi-rigid, self-supporting filter elements placed in a **housing**. The flow is from the outside of the cartridge to the inside.

catchment assessment A survey of the area from which raw water for a **drinking-water** supply is obtained to allow potential contaminant sources to be identified, and the risk they present to the **raw water** quality evaluated. Water quality data (eg, ***E. coli*** results) are not part of the assessment, but in combination with the catchment assessment, they are used to establish the source risk category.

certification The issuing of a certificate of satisfactory performance (for a treatment installation).

Certification may be done by the manufacturer, vendor or installer. It should be drafted in such a way that the manufacturer, vendor or installer's certificate guarantees that the treatment process will meet the specified performance standards provided the process is operated according to the procedures specified by the manufacturer, vendor or installer as being necessary to achieve the specified performance rating.

Another form of certification can be provided by a certifying body accredited by International Accreditation New Zealand (or JASANZ) as competent to certify that an operator is capable of performing a function satisfactorily. For example IANZ will accredit the **drinking-water assessors (DWAs)** as competent to certify that drinking-water plant staff are competent to carry out **FAC** or *E. coli* presence/absence testing.

challenge test A test of a treatment process (usually by the manufacturer or vendor of the process) to establish the performance parameters of that treatment process; that is, the degree of treatment it can achieve (eg, the log credit rating) and the operational requirements to ensure the specified performance rating can be sustainably achieved. This may be done in the factory.

chemical coagulation The use of metallic salts (eg, aluminium or iron) or organic polyelectrolytes (polyamines or polydadmacs) to aggregate fine suspended or colloidal particles, causing them to clump together into larger particles.

chloramines Compounds that may form through the reaction of **free available chlorine (FAC)** with nitrogen compounds. Chloramines formed from the reaction of FAC with ammonia are monochloramine, dichloramine or trichloramine.

chlorinated supply See **chlorination**.

chlorination

chlorinated supply

Supplies that are chlorinated but have not been demonstrated consistently to have a **FAC** concentration equivalent to at least 0.2 mg/L of FAC at **pH** 8.0.

continuously monitored chlorination

Requires the use of an online continuous **FAC** monitor, calibrated at least as frequently as recommended by the equipment suppliers, with an alarm system (FAC monitor or dosage monitor) that can prompt a site visit, without delay, to service the fault or condition.

non-continuously monitored chlorination

Chlorination in which the **FAC** (equivalent at **pH** 8) is always at least 0.2 mg/L but that do not satisfy all the criteria for **continuously monitored chlorination**.

chronic level The dose of a **determinand** that causes an effect after long-term exposure.

coagulation See **chemical coagulation**.

coefficient of variation The **standard deviation (s)** divided by the estimate of the mean ($\bar{x}$); often expressed as a percentage. This statistic normalises the **standard deviation** and can help when comparing analyses that cover a wide range of concentrations. Also called **relative standard deviation**. See the example in the *Guidelines*.

coliform organisms The **bacteria** used as indicators that organic, possibly faecal, contamination of the water may have occurred. Sometimes referred to as total or **presumptive coliforms** and includes ***E. coli***.

commissioning test	**Validation testing** of a treatment process in situ (ie, when it has been installed at the treatment plant), performed at the time of commissioning (see **validation test**). This may be by using a **challenge test** or by demonstrating that the operating parameters necessary to achieve the specified performance rating, which have been previously established by challenge testing, are being achieved on site.
community drinking-water supply	A reticulated publicly or privately owned drinking-water supply connecting at least two buildings on separate titles and serving at least 1500 person days a year (eg, 25 people at least 60 days per year).
compliance	A drinking-water supply is said to be in compliance with the **Drinking-water Standards for New Zealand (DWSNZ)** when the results of the **monitoring** of Priority 1 and 2 **determinands** show that the water supply satisfies the requirements of the DWSNZ.
compliance criteria	Requirements that must be satisfied to achieve **compliance**.
compliance monitoring	**Monitoring** conducted to test whether a drinking-water supply complies with the **DWSNZ**.
compliance monitoring period	The time over which treatment performance is assessed to determine whether a **transgression** has occurred and whether the number of permissible **transgressions** has been exceeded. Compliance **monitoring** periods are sequential.
compliant	A drinking-water supply is said to be **compliant** if it complies with the DWSNZ.
contact time	The hydraulic residence time, determined by a tracer test or by a USEPA recognised calculation procedure, from the point of entry to the disinfectant contact device (normally a tank) to the point of exit. The contact time should ideally be within the confines of the treatment plant site, although 'contact mains' disinfection may be practised as long as the required contact time is met prior to the first consumer.
contaminant	A substance or organism in the water that can cause undesirable public health or aesthetic effects.

continuous compliance monitoring

The process of measuring and recording a defined chemical or physical property by taking frequent measurements, using an electronic **monitoring** device specifically designed for the purpose, to prove the values of the measured property meet the requirements of the **DWSNZ**.

The frequency of readings is provided in sections 4 and 5. Records from continuous **monitoring** instrumentation should report the duration of **exceedences** and their extent.

See **monitoring**.

continuously monitored chlorination

See **chlorination**.

control limit

A value set by the **water supplier** for each compliance criterion, with the aim of triggering some action to prevent the value reaching the **transgression** level. The control limit is recorded in the **PHRMP** along with the preventive actions considered to be necessary when the control limit is reached.

conventional treatment

Is a series of processes including **coagulation, flocculation, sedimentation,** and **filtration,** with **sedimentation** defined as a process for removal of solids before filtration by gravity or separation. **Dissolved Air Flotation, (DAF),** may be regarded as conventional treatment for purposes of awarding treatment log credits.

Cryptosporidium

A member of the **protozoa** family. During its complex life cycle, thick-walled oocysts are formed that are 4–6 μm in diameter. The oocysts are excreted in faeces and are the infective form of the organism. *C. parvum* is the species responsible for most human infection. *Cryptosporidium* generally causes self-limiting diarrhoea, which may include nausea, vomiting and fever. In immunocompromised people, infection can be life-threatening.

C.t value

The product of the concentration (C mg/L) of the disinfectant and the **contact time** (t minutes) required to cause a specified level of inactivation in a **micro-organism**. C.t is a measure of the exposure to the disinfectant. It has the unit min.mg/L.

cyanobacteria

A major group of **bacteria** (often with the ability to carry out photosynthesis) previously known as 'blue-green **algae**'. Cyanobacteria occur throughout the world in fresh and salt waters. Some species produce toxins.

cyanotoxin

A toxin secreted by certain cyanobacteria.

DAF

See **dissolved air flotation (DAF)**.

data sheets	The section in the *Guidelines* that lists the sources, occurrence, removal process, analysis, health effects and derivation of the MAVs of **determinands**.
DBP	See **disinfection by-product (DBP)**.
designated officer	A **health protection officer** or **DWA** designated by the Director-General of Health under section 7A(4) of the Health Act 1956.
detection limit	See **method detection limit**.
determinand	A constituent or property of the water that is determined, or estimated, in a sample, for example: microbial determinand: total coliforms; chemical determinand: chloride; physical determinand: turbidity; and radiological determinand: radon.
diatomaceous earth filtration	Filtration that uses diatomaceous earth as the medium usually 0.01–0.2 mm in size in a process in which a precoat cake of filter media is deposited on a support membrane and additional filter media is continuously added to the feed water to maintain the permeability of the filter cake.
direct filtration	A **water treatment process** using **chemical coagulation** without a clarification step upstream of the filter(s).
direct integrity test	See **integrity test**.
disinfectant C.t value	See **C.t value**.
disinfection	The process used to inactivate **micro-organisms** in a drinking-water supply. Common methods of disinfection include **chlorination**, **ozonation**, **ultraviolet light (UV)** irradiation and boiling.
disinfection by-product (DBP)	A **contaminant** produced in the **drinking-water** supply as a by-product of the **disinfection** process.
disinfection residual	The amount of disinfectant still present in the water at any time.
dissolved air flotation (DAF)	A clarification process in which the flocs formed during **coagulation** and **flocculation** are floated to the surface for removal by air bubbles. This is in contrast to conventional clarification in which the flocs are removed by settling.
distribution system	All the trunk main, storage and distribution system components that follow a treatment plant and any post-treatment storage facility at the treatment plant. See **network reticulation**.

distribution zone	The part of the drinking-water supply network within which all consumers receive **drinking-water** of identical quality, from the same or similar sources, with the same treatment and usually at the same pressure. It is part of the supply network that is clearly separated from other parts of the network, generally by location but in some cases by the layout of the pipe network. For example, in a large city, the central city area may form one zone, with outlying suburbs forming separate zones; in a small town, the system may be divided into two distinct areas. The main purpose of assigning zones is to separately grade parts of the system with distinctly different characteristics.
drinking-water	Water intended to be used for human consumption, food preparation, utensil washing, oral hygiene or personal hygiene.
Drinking-water Assessor (DWA)	Currently refers to an officer appointed for a health district under the Health Act 1956. Includes any Deputy DWA and, for the purposes of Part IV of the Act, any medical practitioner acting under the DWA's direction. Used to describe the **designated officer** who will be so appointed under the proposed Public Health Bill (which is yet to be enacted). A DWA will have to be qualified as specified in the Bill.
Drinking-water Standards for New Zealand (DWSNZ)	A yardstick to assess the quality of drinking-water. The DWSNZ define the **maximum acceptable values (MAVs)** of health significant determinands and specify methods for determining whether a drinking-water supply complies with the DWSNZ.
DWA	See **Drinking-water Assessor (DWA)**.
DWSNZ	See **Drinking-water Standards for New Zealand (DWSNZ)**.
enhanced combined filter performance	Performance measured on the **combined filter effluent, conventional** and **direct filtration plants** that demonstrates a turbidity level in the **combined filter effluent (CFE)** less than or equal to 0.15 NTU in at least 95 percent of the measurements taken each month. (**LT2ESWTR** definition)
enhanced individual filtration performance	**Individual filter** performance demonstrates ongoing compliance with the following turbidity criteria, based on continuous monitoring of turbidity for **each individual filter**. (1) Filtered water turbidity less than 0.1 NTU in at least 95% of the maximum daily values recorded at each filter in each month, excluding the 15-minute period following backwashes, and (2) No individual filter with a measured turbidity level of greater than 0.3 NTU in two consecutive measurements taken 15 minutes apart. (**LT2ESWTR** definition**)**

E. coli	A bacterium used as an indicator that faecal contamination of the water has almost certainly occurred, so **pathogens** may be present in the water.
Escherichia coli	See ***E. coli***.
exceedence	The occurrence of a **determinand** in a sample at a concentration greater than the **maximum acceptable value (MAV)**.
FAC	See **free available chlorine (FAC)**.
FACE	See **free available chlorine equivalent (FACE)**.
faecal coliform (thermotolerant coliforms)	See also **thermotolerant coliform**, ***E. coli***, **presumptive coliform** and **total coliform**.
filter (granular media)	A single or multiple containment of granular media, the outflow from which is controlled as a single unit that can be independently isolated from service.
filtrate	Water leaving a filter.
filtration	A treatment process that removes suspended particles from water by passing the water through a medium such as sand or other suitable material.
flocculation	The gathering together of coagulated clumps of fine material to form floc.
flotation	The process of floating off the particulate matter present in water, usually after coagulation.
free available chlorine (FAC)	The chlorine present in chlorinated water in the form of hypochlorous acid and hypochlorite ion.
free available chlorine equivalent (FACE)	The **FAC** concentration that would have the same disinfecting power as the chlorine solution would have when adjusted to **pH** 8; see Figure A1.1 (page 123).
Giardia	A flagelated member of the **protozoa** family. *Giardia* infects the gastrointestinal tract of humans and certain animals. Cysts are the infective form of the organism excreted by the host. They are ovoid in shape and are from 8–12 µm long. *G. intestinalis (lamblia)* is the species usually responsible for human infection. *Giardia* causes abdominal cramps and diarrhoea, which is self-limiting in most cases.
groundwater	Water contained beneath the land surface. More particularly, water contained in the saturated zone of the soil, which can be extracted in usable quantities.

guideline value (GV) The value for an **aesthetic determinand** that, if exceeded, may render the water unattractive to consumers.

health protection officer A person so designated by the Director-General of Health under section 7A of the Health Act 1956.

helminth All types of worm, both free-living and parasitic. For most helminths water is not a transmission route, and the parasitic species are not considered to be **pathogens** of concern in New Zealand's drinking-waters.

housing The pressure vessel that is used to contain a cartridge or **bag filter**.

inactivation Rendering organisms (usually **micro-organisms**) incapable of infection. Usually achieved by **disinfection** or by high temperatures.

indicator organism A **determinand**, for example, ***E. coli*** or **faecal coliforms**, that is monitored to indicate the presence of faecal contamination.

indirect integrity test See **integrity test**.

infiltration gallery An artifical conduit, or series of conduits, used for collecting water, situated next to, or in, streams under layers of sands and gravel that provides a degree of prefiltration. Usually made from interconnected, buried, open-jointed or slotted pipes. Also referred to as river galleries but will often not be the same as **bank filtration**.

intake water The water that is taken into the treatment plant for treatment. This will be raw water together with any recycled or backwash water.

integrity test

Direct integrity test

A physical test applied to a membrane **unit** to identify and isolate integrity breaches. An integrity breach is defined as one or more leaks that could result in contamination of the **filtrate**. The direct integrity test must be applied to the physical elements of the entire membrane unit including membranes, seals, potting material, associated valving and piping, and all other components that, under compromised conditions, could result in contamination of the filtrate. See **membrane filtration**.

Indirect integrity test

Involves **monitoring** some aspect of **filtrate** water quality that is indicative of the removal of particulate matter. If a continuous direct integrity test is implemented that meets the **membrane filtration** resolution and sensitivity criteria, continuous indirect integrity **monitoring** is not required.

Langelier Saturation Index (LSI) A measure of the corrosive or scale-forming nature of water, depending on whether it will dissolve or precipitate calcium carbonate. The LSI is the **pH** of the water minus the **pH** at which the water will be in equilibrium with solid calcium carbonate. It is measured on a positive/negative scale with waters of a LSI of ¯0.5 or lower considered to be corrosive; waters with a LSI of +0.5 or more considered to be scale forming; and waters between ¯0.5 +0.5 considered to be well-balanced. The LSI is calculated using the calcium hardness, **alkalinity**, total dissolved solids and **pH** and is temperature related. It does not always correlate well with **plumbosolvency** in New Zealand waters so is not used to define plumbosolvency in the **DWSNZ**.

limit of detection See **method detection limit**.

LSI See **Langelier Saturation Index (LSI)**.

LT2ESWTR The Long Term 2 Enhanced Surface Water Treatment Rule (USEPA 2003d).

MAV See **maximum acceptable value (MAV)**.

maximum acceptable value (MAV) The concentration of a **determinand** below which the presence of the **determinand** does not result in any significant risk to a consumer over a lifetime of consumption. For **carcinogenic** chemicals, the MAVs set in the **DWSNZ** generally represent a risk of one additional incidence of cancer per 100,000 people ingesting the water at the concentration of the MAV for 70 years.

membrane filtration A pressure or vacuum driven separation process in which particulate matter larger than 1 µm is rejected by a non-fibrous, engineered barrier, primarily through a size-exclusion mechanism, and which has a measurable removal efficiency of a target organism that can be verified through the application of a **direct integrity test**. This definition is intended to include the common membrane technology classifications: **microfiltration (MF)**, **ultrafiltration (UF)**, **nanofiltration (NF)** and **reverse osmosis (RO)**. See **module** and **unit**.

method detection limit The constituent concentration that, when processed through the complete analytical method, produces a signal with a 99 percent probability that it is different from the blank. Seven replicated measurements of a solution containing the **determinand** of interest at a concentration near the estimated method detection limit are used to calculate the **standard deviation (s)**. The method detection limit is 3.14 x s.

MC Microcystin

MF See **microfiltration (MF)**.

microfiltration (MF)	A type of relatively low pressure membrane technology in which the pore-size of the membrane is in the order of 0.1 µm, so it can remove protozoa and most bacteria. See **membrane filtration**, **reverse osmosis (RO)**, **nanofiltration (NF)** and **ultrafiltration (UF)**.
micro-organism	A very small (microscopic) organism. Includes **viruses**, **bacteria**, **protozoa**, **algae** and **helminths**.
module	The smallest component of a membrane unit in which a specific membrane surface area is housed in a device with a **filtrate** outlet structure (USEPA 2003d).
monitoring	The sampling and analysis of a drinking-water supply to test for compliance with the **DWSNZ**, or for process control, by detecting changes in the concentrations of its constituent **determinands** or deviations of these from target values. In New Zealand, **monitoring** is the **water supplier**'s responsibility.
nanofiltration (NF)	A type of membrane technology in which the pore-size of the membrane is in the order of 0.001 µm, so it can remove **bacteria**, **viruses**, **protozoa** and chemical substances down to molecular weights of 200–1000 daltons. The cut-off for chemical substances is sufficiently small that some **disinfection by-product (DBP)** precursors will be removed. See **membrane filtration**, **reverse osmosis (RO)**, **microfiltration (MF)** and **ultrafiltration (UF)**.
network reticulation	A network under a network utility operator's control, that is, all parts of the drinking-water **distribution system**, including pipes and treated water (service) reservoirs.
NF	See **nanofiltration (NF)**.
nm	nanometre
non-chlorinated supplies	See **chlorination**.
non-compliant	A drinking-water supply that does not comply with the requirements of the Drinking-Water Standards for New Zealand.
non-continuously monitored chlorination	See **chlorination**.
non-detect	The situation when an organism being tested for is not detected in the sample.
NTU	Nephelomentric turbidity unit (see Appendix A1.5.8).

(oo)cyst	A thick-walled structure within which *Cryptosporidium* zygotes develop and which serves to transfer the organism to new hosts. A cyst is the non-motile dormant form of *Giardia* which serves to transfer the organism to new hosts.
operational requirement	Performance specifications necessary to ensure that an appliance or treatment process complies with its specifications.
ozonation	Treatment of water by dissolved ozone primarily for **disinfection** but also for the oxidation of chemical **determinands**.
parameter	A coefficient or factor in an expression or equation used to process data.
participating supply	Water supplies that serve fewer than about 500 people and that can demonstrate risks to public health are adequately managed through the implementation of an approved **PHRMP** or compliance schedule.
pathogen	An organism capable of inducing illness.
pesticide	A substance or mixture of substances used for the eradication or control of any pest. This includes behavioural and developmental modifiers, for example, plant growth regulators, desiccants or defoliants, but not fertilisers or animal remedies.
pH	A measure of the concentration of hydrogen ions in water. It is the negative logarithm to base 10 of the concentration of H^+ in the water. A low pH indicates an acidic water; a high pH shows the water is alkaline; a pH of 7 is neutral. The pH of water is particularly important in **water treatment processes** such as **coagulation** and **disinfection**.
PHRMP	See **Public Health Risk Management Plan (PHRMP)**.
Plumbosolvent	Able to dissolve lead (from Latin 'Plumbum' ~Pb)
potable water	**Drinking-water** that does not contain or exhibit any **determinand** to an extent that exceeds its **maximum acceptable value (MAV)** more frequently than allowed when the water quality is measured as specified in the **DWSNZ**. See also **wholesome drinking-water**.
precision	A measure of the degree of agreement among replicate analyses of a sample, usually expressed as the **standard deviation (s)**. See **accuracy** and **bias**.
presumptive coliform	**Bacteria** whose identification in the early stages of bacterial examination highlight the need for further identification of **coliform organisms**. If absent, it is not necessary to proceed with further identification of **coliform organisms**. See also ***E. coli***, **faecal coliform** and **total coliform**.

priority class	One of four classes of **determinand** defined in the **DWSNZ**. The priority classes are ranked according to the **determinand's** potential impact on public health if present in excess of its **maximum acceptable value (MAV)** in **drinking-water** and the quantity of the **determinand** present in the **water supply**.
protozoa	The Priority 1 protozoa are ***Giardia*** and ***Cryptosporidium***. See **priority class**.
public drinking-water supply	See **community drinking-water supply**.
Public Health Risk Management Plan (PHRMP)	Identifies the elements present in a supply. Identifies which of the four main barriers to **contaminants** are in place. Sets out a risk information table appropriate for the supply. Includes an improvements schedule, which identifies the preventive measures that have yet to be put in place; prioritises them for attention based on the risk they present to health and the availability of resources to provide them; sets a date by which they should be put in place; and identifies who has responsibility for doing this. Notes other **quality assurance** systems that have links to the PHRMP. Provides contingency plans applicable to the supply. Provides instructions for reviewing the PHRMP's performance and how it should be reviewed. Provides instructions for reporting: what reports should contain, who should receive reports and how often.
quality assurance	A means of maintaining good management of a process by systematically keeping records, checking equipment and personnel performance and procedures, for example, the ISO 9001:2000 Quality Management System standard.
quality control	The **monitoring** of a product's quality by sampling and measuring to check it complies with specifications.
radiological assessment	The determination of the radioactivity content in a water sample.
radiological determinands	In water quality analysis, radioactive substances, factors or elements in the **drinking-water**, which are determinable. Radioactivity in drinking-water is principally derived from the leaching of **radionuclides** from rocks and soil and from the deposition of **radionuclides** from the atmosphere. Examples are total alpha activity, excluding radon; total beta activity, including potassium and radon concentration.

radionuclide	A radioactive atomic nucleus.
raw water	Water intended for drinking that is after the abstraction point but has not yet received treatment to make it suitable for drinking.
RED	See **reduction equivalent dose (RED)**.
reduction equivalent dose (RED)	A calculated dose for a flow-through **UV** reactor that is based on biodosimetry. The RED is set equal to the UV dose in a collimated beam test that achieves the same level of **inactivation** of the challenge organism as measured for the flow-through reactor during bioassay testing.
referee method	The analytical methods definitive for demonstrating compliance with the **DWSNZ**. Alternative methods may be used, but these must provide results comparable to those obtained by the referee methods. In the event of any dispute about differences in analytical results, results obtained using the referee method will be deemed to be correct.
Register of Community Drinking-Water Supplies and Suppliers in New Zealand	A list of community drinking-water supplies in New Zealand published by the Ministry of Health. The register contains each drinking-water supply's details about water sources, treatment plants, **distribution zones**, site identification codes, Priority 2 **determinands** and public health grading.
regolith	The layer of unconsolidated solid material above the bedrock.
relative standard deviation	See **coefficient of variation**.
remedial action	Action taken in the event of a **transgression** to protect public health and to reduce the likelihood of a **transgression** again occurring for the same reason.
renal dialysis	A method of treatment of patients with a kidney disorder. Involves the diffusion of unwanted body electrolytes out of the patient across a semi-permeable membrane into dialysis water on the other side of the membrane. The dialysis water must be of a high quality to avoid the risk of any **contaminants** in the dialysis water diffusing back across the membrane and accumulating in the patient. The **DWSNZ** do not guarantee that water that meets the DWSNZ is suitable for renal dialysis.
residence time determination	Analysis of tritium, chlorofluorocarbon or sulphur hexafluoride concentrations in groundwater to determine the time the water has been isolated from the atmosphere.

reticulation	The network of pipes, pumps and **service reservoirs** that delivers the **drinking-water** from the **water treatment plant** to the consumers' boundary. See **network reticulation**.
reverse osmosis (RO)	The flow of water through a semi-permeable membrane under a pressure that is higher than the water's osmotic pressure. The semi-permeable membrane allows only water to pass through it, thus separating the water from most dissolved and suspended material, which is left behind. See also **membrane filtration**, **microfiltration (MF)**, **ultrafiltration (UF)** and **nanofiltration (NF)**.
RO	See **reverse osmosis (RO)**.
sanitary bore head protection	A **bore head** that effectively prevents contamination of the supply from the ground surface and complies with New Zealand drilling Standard 4411. Measures include: • a sealed pumping and piping system with some mechanism of backflow prevention mechanism • a grout pad and seal between the **bore** casing, pipework and the surrounding ground.
sanitary inspection	A survey and analysis of the physical environment to identify the existence and hazard posed by existing and potential sources of health hazards and environmental contamination.
STX	Saxitoxin
Second stage filtration	A filtration process consisting of rapid sand, dual media, GAC, or other fine grain media in a separate stage following rapid sand or dual media filtration. The first stage of filtration must be preceded by a coagulation step and both filtration stages must treat 100percent of the flow. A cap, such as GAC, on a single stage of filtration does not constitute second stage filtration.
secure groundwater	Water that is free from surface influences and free from contamination by harmful **micro-organisms**. It must be abstracted via a **bore head** demonstrated to provide sanitary protection. **Springs** and supplies from shallow **aquifers** with **bore** intakes less than 10 m are excluded.
sedimentation	The process in which solid particles settle out of the water being treated in a clarifier or settling tank.
service reservoir	A reservoir present in the **network reticulation** to manage water flow and pressure.
setback distance	In relation to **bank filtration**, the distance between the vertical **bore** and the **surface water** when the river/stream is in a flood with a 1 percent probability of recurrence, (some-times called a 'one in 100 year' flood).

SI units A system of coherent metric units (Système Internationale d'Unités) adopted by the General Conference on Weights and Measures, the international authority on units.

slow sand filtration A filter that consists of a bed of fine sand and relies on a biologically active layer on top of the sand, called *Schmutzdecke*, to filter out particles. The filtration rate is much slower than rapid gravity filtration.

spring Occurs when **groundwater** moves along the upper plane of an impervious rock formation that ends at the surface, or may also occur at rock fissures. This discharge is susceptible to surface contamination from domestic, industrial and agricultural waste discharges.

standard deviation(s) If a measurement is repeated many times under essentially identical conditions, the results of each measurement (x) will be distributed randomly about the mean value. If an infinite number of measurements were made, the true mean would be found, with all the results appearing about the mean in a 'normal distribution'. Measurements cannot be made an infinite number of times. Therefore, the true mean is estimated using a property of the normal distribution curve, the standard deviation (s), where:

$$s = \left[\sum (x - \bar{x})^2 / (n - 1)\right]^{1/2}$$

where:

x is the measured value

$\bar{x}$ is the estimated mean

n is the number of measurements made.

The standard deviation fixes the spread of the normal distribution and includes a fixed fraction of the values making up the curve. For example, 68.27 percent of the measurements lie within one standard deviation of the mean, 95.45 percent of the measurements lie within two standard deviations of the mean and 99.70 percent of the measurements lie within three standard deviations of the mean. In common usage, these are rounded off to 68 percent, 95 percent and 99 percent respectively. See **coefficient of variation**.

standardised variance

Standardised variance is the **standard deviation (s)** squared (equals variance or s^2), divided by the estimate of the mean ($\bar{x}$), that is:

$$s^2/\bar{x}$$

To express the value as a percentage, it is multiplied by 100. The standardised variance is smaller than the **coefficient of variation** when the **standard deviation** is less than one but greater when the **standard deviation** is greater than one. Nitrate concentrations are frequently close to the **limit of detection**, which can result in a high coefficient of variation. The standardised variance has been used in assessing the variation in nitrate data, as it provides a better match with known **groundwater** security status than the coefficient of variation.

surface water

The water on the land surface. It can be running (as in streams and rivers) or quiescent (as in lakes, reservoirs, impoundments and ponds). Surface water is produced by run-off of precipitation and by **groundwater** seeping through the top layers of soil. Surface water can also be defined as all water open to the atmosphere and subject to surface run-off.

surrogate

A **determinand** used to assess the likely presence or concentration of another **determinand** that is difficult to determine directly. For example, ***E. coli*** is used to assess the likely presence of specific pathogenic organisms, as it is a good **indicator organism** and is easier to test for than the **pathogens**.

surveillance

The process of checking the management of drinking-water supplies conforms to the specifications in the **DWSNZ**. Usually conducted by the public health agency.

tankered water

Water collected from an external source and delivered in a tank to a consumer's drinking-water storage system.

test result

The **test result** for a determinand concentration is the concentration actually measured by the analyst before any correction is made for experimental uncertainty.

thermotolerant coliforms

A subgroup of **total coliforms** that will grow on a specific selective medium when incubated at 44.5 ± 0.2°C. The presence of **faecal coliforms** indicates that faecal contamination has probably occurred and that steps need to be taken to ensure **pathogens** are not present. Included as **faecal coliforms** are: *Klebsiella* and ***E. coli***. See also **presumptive coliform**.

total coliform Genera in the family *Enterobacteriaceae*. **Bacteria** that will grow on a specific selective medium when incubated at 35°C ± 0.2°C. Used to indicate the probable contamination of water by organic material and that the possibility of faecal contamination needs to be checked. Total coliforms include the genera: *Erwinia, Klebsiella, Escherichia, Citrobacter* and *Enterobacte*r. See also **faecal coliform** and **presumptive coliform**.

transgression Of the **DWSNZ**, occurs when a **determinand** of any **priority class** that is present in the sample exceeds the **maximum acceptable value (MAV)** (a MAV transgression) or its allowable concentration specified in the **compliance criteria** or when the **transgression limit** of an **operational requirement** is exceeded (a performance transgression).

transgression limit The limit in the DWSNZ (**MAV** or **operational requirement**) that when exceeded defines a **transgression**. A **control limit** will be lower than a transgression limit.

turbidity A measure of the suspended particles in a sample that cause loss of clarity by scattering light. For the **DWSNZ**, turbidity is measured by nephelometry.

UF See **ultrafiltration (UF)**.

ultrafiltration (UF) A method of filtration in which particles of colloidal dimensions are separated from molecular and ionic substances by drawing the colloidal suspension (sol) through a membrane whose capillaries are very small (in the order of 0.003 μm). It is able to removed protozoa, **bacteria** and **viruses** from the water.

The mechanism of ultrafiltration is not simply a sieve effect, but depends on the electrical conditions of the membrane and colloid. See **membrane filtration**, **microfiltration (MF)**, **nanofiltration (NF)** and **reverse osmosis (RO)**.

ultraviolet light (UV) Radiation that has a wavelength shorter than 400 nm and that is therefore outside the wavelength range visible to the human eye.

unconfined aquifer A saturated water bearing formation that has a free water table and is not protected by an aquiclude from surface contamination.

undisinfected water Water that has not received any **disinfection**.

unit A membrane unit is defined as a group of membrane **modules** that share common valving that allows the unit to be isolated from the rest of the system for testing or maintenance.

United States Environmental Protection Agency (USEPA)	An agency of the federal United States government founded in 1970 with a mission to protect human health and the environment.
unloading	A breakthrough of particles held on a filter, usually caused by a pressure surge or other increase in the filtration rate.
USEPA	See **United States Environmental Protection Agency (USEPA)**.
UV	See **ultraviolet light (UV)**.
UV disinfection	**Disinfection** using electromagnetic radiation (light) in the range of 200–400 nm.
UV lamp	**LP lamp** A mercury vapour lamp that operates at an internal pressure of 0.001–0.01 torr (2×10^{-5} to 2×10^{-4} psi) and electrical input of 0.5 W/cm. This results in essentially monochromatic light output at 254 nm. **LPHO lamp** An LP mercury vapour lamp that operates under increased electrical input (1.5–10 W/cm), resulting in a higher **UV** intensity than LP lamps. It also has essentially monochromatic light output at 254 nm. **MP lamp** A mercury vapour lamp that operates at an internal pressure of 100–10,000 torr (2–200 psi) and electrical input of 50–150 W/cm. This results in polychromatic (or broad spectrum) output of UV and visible light at multiple wavelength, including the germicidal range.
validation test	Consists of establishing the operating conditions under which a process can deliver specified compliance requirements, then demonstrating whether a particular piece of equipment achieves these operating conditions.
virus	A very small parasitic organism that can reproduce only if it can colonise a living cell by 'hi-jacking' some of the host cell's metabolic processes. Submicroscopic particles of nucleic material enclosed in a protein coat. Viruses are responsible for several waterborne diseases such as infectious hepatitis and poliomyelitis (polio).
vulnerable population	Includes the populations of preschool facilities, primary schools, medical care facilities and aged care facilities and other at-risk groups as defined by the Ministry of Health.
water quality standards	The MAVs specified for health significant **determinands** and **indicator organisms** in the DWSNZ.

water supplier or water supply authority	Any person or entity that owns, or is responsible for operating, a drinking-water supply.
water treatment plant	The point where the drinking-water supply enters the **distribution system**, regardless of the treatment process.
water treatment process	A chemical, biological or physical process used to enhance the quality of a drinking-water supply before its distribution.
WHO	See **World Health Organization (WHO)**.
wholesome drinking-water	Potable water that does not contain any determinands that exceed the guideline values for aesthetic determinands in the DWSNZ.
World Health Organization (WHO)	An agency of the United Nations, founded in 1948. Its objective is the attainment by all peoples of the highest possible level of health (physical, mental and social, and not merely the absence of disease or infirmity).

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