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Drinking-water Standards for New Zealand 2005

Revised 2018

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Foreword

The availability of potable drinking-water for all New Zealanders is a fundamental requirement for public health.

There are six well-established principles for potable drinking water.

- Principle 1: A high standard of care must be embraced.
- Principle 2: Protection of source water is of paramount importance
- Principle 3: Maintain multiple barriers against contamination.
- Principle 4: Change precedes contamination
- Principle 5: Suppliers must own the safety of drinking water.
- Principle 6: Apply a preventive risk management approach

The Health Act 1956 protects the health and safety of people and communities by promoting adequate supplies of potable and wholesome drinking water from all drinking-water supplies. It provides for the Minister to issue or adopt drinking-water standards; and imposes a range of duties on drinking-water suppliers, including duties to monitor drinking water; and take all practicable steps to comply with the Drinking-Water Standards for New Zealand (the Standards).

Following the Government Inquiry into the Havelock North Drinking-Water Outbreak, I established a Drinking-Water Advisory Committee that considered the Inquiry's recommendations relating to the Standards and which advised me on a number of changes.

The Minister of Health has considered the advice provided by the Drinking-Water Advisory Committee and Ministry of Health officials and has approved an urgent change to the Standards to require enumeration testing for *E.coli* and total coliforms. The Minister has also approved a number of minor changes to the Standards to clarify or correct text within the Standards, to simplify compliance procedures, or to move material from these (mandatory) Standards to the (voluntary) *Guidelines for the Management of Drinking-Water Quality in New Zealand;* and to require routine monitoring of total coliforms.

I am pleased to release the *Drinking-water Standards for New Zealand (DWSNZ) 2005 (Revised 2018).*

The Drinking-Water Advisory Committee, with support from five specialist working groups (covering chemistry, microbiology, radiology, groundwater and water treatment & distribution) is continuing a comprehensive review of the Standards. The results of their deliberations will form the basis of consultation on further possible changes to the Standards in due course.

Dr Ashley Bloomfield
Director-General of Health

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1.1 Introduction

1.1.1 Minimum standards for drinking-water

Potable drinking-water, available to everyone, is a fundamental requirement for public health. The *Drinking-water Standards for New Zealand* (DWSNZ) define the minimum quality standards for drinking-water in New Zealand.

1.1.2 Health Act 1956

Section 69A of the Health Act 1956 states that the purpose of this part of the Act is to protect the health and safety of people and communities by promoting adequate supplies of potable and wholesome drinking-water from all drinking-water supplies, which requires drinking-water suppliers to take all practicable steps to comply with the drinking-water standards.

All drinking-water suppliers providing drinking-water to over 500 people must develop and implement a water safety plan to guide the safe management of their supply (Ministry of Health 2014).

The Act provides for the appointment of drinking-water assessors (DWAs); section 69ZL of the Act sets out their functions. Section 69ZD of the Act covers the duty to keep records and make them available; see section 1.6.15 of the companion publication to the DWSNZ, *Guidelines for Drinking-water Quality Management for New Zealand* (Ministry of Health) (the Guidelines).

1.1.3 Changes since the 2008 drinking-water standards

The revised DWSNZ are the result of a consensus among members of the Drinking-water Advisory Committee set up to advise the Ministry of Health.

1.2 Scope of the drinking-water standards

The two themes of the DWSNZ are:

- the maximum acceptable values (MAVs) or water quality standards**,** which define the quality specifications for all drinking-water
- the compliance criteria, which specify monitoring requirements and remedial actions to be followed when a transgression of a MAV occurs.

The DWSNZ are applicable to networked drinking-water supplies, as defined in the Health Act 1956.

The DWSNZ do not set out how a water supply should be managed. The Health Act covers the high-level obligations of a water supplier, and the Local Government Act 2002 covers broader management obligations. Those obligations specific to risks are covered by a supplier's water safety plan.

The DWSNZ do not set quality standards for water used for industrial or agricultural purposes. Bottled water is subject to the Food Act 2014. For people with certain medical conditions, or for uses of water for purposes other than drinking, additional or other water quality criteria may apply.

The public health safety of drinking-water is best protected if multiple barriers to contamination are in place. These barriers include:

- minimising the extent of contaminants in the source water that the treatment process must deal with
- removing undesirable soluble and particulate matter
- disinfecting to inactivate any pathogenic organisms that may be present
- protecting the treated water from subsequent contamination.

The Guidelines (Ministry of Health) provide additional information about:

- the management of water supplies from catchment to consumer
- the derivation of the concepts used in this publication
- the publications on which the DWSNZ are based.

The Guidelines include datasheets for:

- the determinands listed in this publication
- other determinands that may have health significance.

1.3 Structure of the document

Section 2 of this document 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. The section includes a table of aesthetic determinands with guideline values.

Section 3 discusses compliance with and transgressions of the water quality standards (determinands), and the general criteria used to determine whether a water supply complies with the DWSNZ. The section divides the determinands into three priority classes.

Sections 4–9 contain the microbial, chemical and radiological compliance criteria, which specify the sampling protocols and other requirements that need to be satisfied to demonstrate the drinking-water complies with the DWSNZ.

Section 10 covers the compliance requirements for small drinking-water supplies (those that serve fewer than 500 people).

Appendix 1 explains the units used in the DWSNZ. Appendix 2 covers some sampling and testing requirements.

In the preparation of the DWSNZ, extensive use was made of:

- *Guidelines for Drinking-water Quality* (WHO 2017)
- *National Primary Drinking Water Regulations: Long Term 2 Enhanced Surface Water Treatment Rule: Final Rule* (USEPA 2006a) and related documents.

1.4 Maximum acceptable values

The MAV of a chemical determinand is the highest concentration of a determinand in drinking-water that, on the basis of present knowledge, is considered not to cause any significant risk to the health of the consumer over 70 years of consumption of 2 litres per day of that water. Wherever possible, MAVs have been based on the latest World Health Organization (WHO) guideline values, adjusted to a body weight of 70 kg. The MAV of a micro-organism is its concentration in drinking-water above which there is a significant risk of contracting a waterborne (enteric) disease.

The WHO calls its guideline values provisional when there is a high degree of uncertainty in the toxicology and health data, or if there are difficulties in water treatment or chemical analysis. The DWSNZ adopt the same approach. Provisional MAVs (PMAVs) have also been applied to chemical determinands when the Ministry of Health has derived a MAV in the absence of a WHO guideline value. In terms of compliance with the DWSNZ, PMAVs are considered to be equivalent to MAVs.

1.5 Operational requirement values

Where MAVs cannot be (or are not) used to measure compliance, measurement of treatment efficacy is used as the surrogate method for establishing compliance.

When surrogate criteria are used, the DWSNZ specify operational requirements, compliance with which is considered to give a high level of confidence that the water will be safe to drink. Free available chlorine (FAC) and compliance with filter performance parameters such as turbidity are examples of this.

1.6 Population data

The population served by a drinking-water supply is taken to be that recorded in the Register of Drinking Water Suppliers for New Zealand. Monitoring frequency requirements for a supply are calculated on the base population serviced by the supply.

Where a population fluctuates seasonally, the monitoring frequency must be adjusted to reflect changes in population. The sampling frequency must be that required for the higher population for the duration of that higher population, plus at least two weeks before the population is expected to increase. For water supplies that are shut down or operate at a very small fraction of the peak rate, this period may be required to be extended to a month.

1.7 Components of drinking-water supply

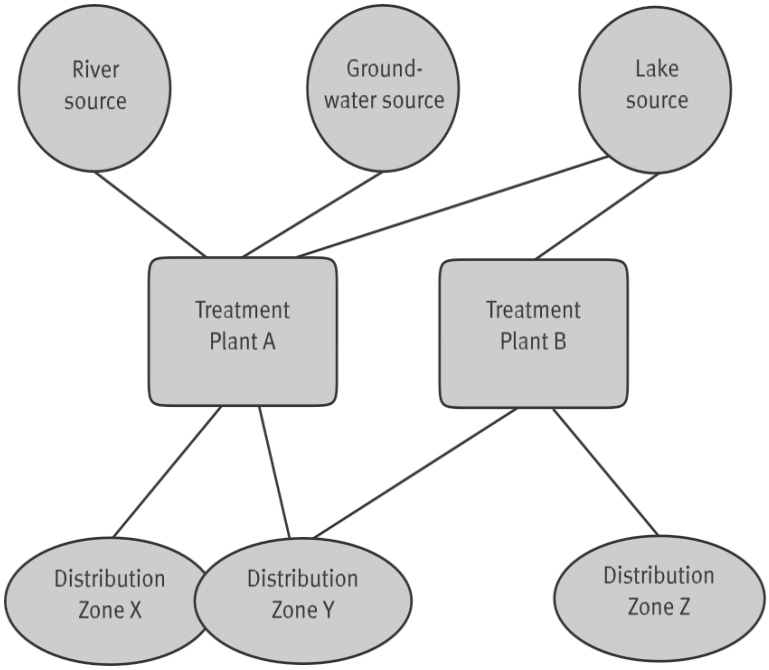
A drinking-water supply comprises one or more of each of the following (Figure 1.1):

- source of raw water[1]
- water treatment plant
- distribution system.

Compliance criteria are given for water leaving the treatment plant and in the distribution system. Water safety plans cover source water quality issues.

[1] The Ministry for the Environment's National Environmental Standard for Sources of Human Drinking-water requires regional councils to ensure that decisions on resource consents and regional plans consider effects on drinking-water sources.

Figure 1.1: Schematic diagram of drinking-water supply system



1.8 Appeal process

Water suppliers may appeal any decision or finding of a DWA in relation to compliance with the requirements of these standards using the following process.

1. The water supplier may submit an appeal in writing to the technical manager of the drinking-water assessment unit that issued the finding.
2. If the water supplier is still dissatisfied, they may use the appeal provisions in section 69ZW of the Health Act and request review by the Director-General of Health.

2 Water quality standards

2.1 Introduction

This is the principal section of the DWSNZ. It specifies the water quality standards to which all drinking-water supplies must comply.

Section 2.2 includes Tables 2.1–2.4, which constitute the MAVs.

Section 2.3 includes Table 2.5, which contains the guideline values for aesthetic determinands. These values are not part of the water quality standards, but the DWSNZ includes them as additional information.

Section 2.4 explains the abbreviations used in Tables 2.1–2.5. Appendix 1 explains units of measurement.

Samples collected for the analysis of metals need to be acidified following the laboratory's procedure. No further preparation of the aliquot taken for testing is necessary.

For the basis for and calculations of the MAVs and guideline values, see the datasheets in the Guidelines. The datasheets include determinands that the WHO found are unlikely to occur in drinking-water or occur at levels well below those at which toxic effects are observed. The datasheets include references.

2.2 The standards

Table 2.1: Maximum acceptable values for microbial determinands

Micro-organism	Maximum acceptable value[1]
Escherichia coli[2]	Less than one in 100 mL of sample
viruses	No values have been set due to lack of reliable evidence
total pathogenic protozoa	Less than one infectious (oo)cyst per 100 L of sample[3]

Notes:

1. These are maximum acceptable values 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.
3. The methods available for enumerating pathogenic protozoa are becoming less expensive and more reliable, but they are not yet suitable for routine monitoring of treated water quality. Although new methods of assessing the infectiousness of protozoa by using human cell cultures have been developed, they are not yet suitable for routine monitoring of *Cryptosporidium* contamination of drinking-water. The referee method cannot identify the species of *Giardia* or *Cryptosporidium*; nor can it determine the viability or infectivity of detected cysts or oocysts (ie, (oo)cysts). Until the methodology improves, results are to be reported as verified (oo)cysts.

Table 2.2: Maximum acceptable values for inorganic determinands of health significance

Name	MAV (mg/L)	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	
boron[1]	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	0.6	Total cyanides, short-term only
cyanogen chloride	0.4	Expressed in mg/L as CN total. DBP (chloramination)
fluoride[2]	1.5	
lead	0.01	
manganese	0.4	ATO
mercury	0.007	Inorganic mercury
molybdenum	0.07	
monochloramine	3	DBP (chlorination)
nickel	0.08	
nitrate, short-term[3]	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 must not exceed one
nitrite, long-term	0.2	Expressed in mg/L as NO_2. PMAV (long term)
nitrite, short-term[3]	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 must not exceed one
selenium	0.01	
uranium	0.02	PMAV

Notes:

Section 2.4 explains abbreviations that appear in the table.

1. The WHO guideline value (provisional) is 0.5 mg/L.
2. 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.
3. Now short-term only. The short-term exposure MAVs for nitrate and nitrite have been established to protect against methaemoglobinaemia in bottle-fed infants.
4. For information about determinands of possible health significance but which do not have a MAV, refer to the datasheets in the Guidelines.

Table 2.3: Maximum acceptable values for organic determinands of health significance

Name	MAV (mg/L)	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
azinphos methyl	0.004	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	0.4	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)phthalate	0.009	
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	Pesticide. 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}
1,2-dichloroethene	0.06	Total of cis and trans isomers
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
1,4-dioxane	0.05	For excess lifetime cancer risk of 10^{-5}

Name	MAV (mg/L)	Remarks
diuron	0.02	Pesticide. PMAV
EDTA (editic acid)	0.7	
endrin	0.001	Pesticide
epichlorohydrin	0.0005	PMAV
ethylbenzene	0.3	ATO
fenoprop	0.01	Pesticide
hexachlorobutadiene	0.0007	
hexazinone	0.4	Pesticide. PMAV
homoanatoxin-a	0.002	Cyanotoxin. PMAV
isoproturon	0.01	Pesticide
lindane	0.002	Pesticide
MCPA	0.002	Pesticide
mecoprop	0.01	Pesticide
metalaxyl	0.1	Pesticide. PMAV
methoxychlor	0.02	Pesticide
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)
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
picloram	0.2	Pesticide. PMAV
pirimiphos methyl	0.1	Pesticide. PMAV
primisulfuron methyl	0.9	Pesticide. PMAV
procymidone	0.7	Pesticide. PMAV
propazine	0.07	Pesticide. PMAV
pyriproxifen	0.4	Pesticide
saxitoxins	0.003	Cyanotoxin. Expressed as STXeq PMAV
simazine	0.002	Pesticide
styrene	0.03	ATO
2,4,5-T	0.01	Pesticide
terbacil	0.04	Pesticide. PMAV
terbuthylazine	0.008	Pesticide
tetrachloroethene	0.05	
thiabendazole	0.4	Pesticide. PMAV
toluene	0.8	ATO
trichloroacetic acid	0.2	DBP (chlorination)
trichloroethene	0.02	PMAV

Name	MAV (mg/L)	Remarks
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 must 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)	0.6	ATO
1080	0.0035	Pesticide. PMAV

Notes:

1. Section 2.4 explains abbreviations that appear in the table.
2. For information about determinands of possible health significance but which do not have a MAV, refer to the datasheets in the Guidelines.

Table 2.4: Maximum acceptable values in becquerel per litre 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

2.3 Other determinands

Table 2.5: Guideline values for aesthetic determinands

Determinand	GV	Unit	Comments
aluminium	0.10	mg/L	Above this, complaints may arise due to depositions or discoloration
ammonia	1.5	mg/L	Odour threshold in alkaline conditions
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	mg/L	Taste threshold
	0.01		Odour threshold
colour	10	TCU	Appearance
copper	1	mg/L	Staining of laundry and sanitary ware (MAV 2 mg/L)
1,2-dichlorobenzene	0.001	mg/L	Taste threshold
	0.002		Odour threshold (MAV 1.5 mg/L)
1,4-dichlorobenzene	0.0003	mg/L	Odour threshold
	0.006		Taste threshold (MAV 0.4 mg/L)
2,4-dichlorophenol	0.0003	mg/L	Taste threshold
	0.04		Odour threshold
ethylbenzene	0.002	mg/L	Odour threshold
	0.08		Taste threshold (MAV 0.3 mg/L)
hardness (total) (Ca + Mg) as $CaCO_3$	200	mg/L	High hardness causes scale deposition, scum formation. Low hardness (<100) may be more corrosive
	100–300		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	mg/L	Staining of laundry
	0.10		Taste threshold (MAV 0.4 mg/L)
monochlorobenzene	0.01	mg/L	Taste and odour threshold
pH	7.0–8.5		Should be between 7 and 8. Most waters with a low pH have a high plumbosolvency. Waters with a high pH have a soapy taste and feel. A pH less than 8 is preferable 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 and odour			Should be acceptable to most consumers
temperature			Should be acceptable to most consumers, preferably cool
toluene	0.03	mg/L	Odour
	0.04		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		
1,2,3-trichlorobenzene	0.01	mg/L	Odour threshold
1,2,4-trichlorobenzene	0.005	mg/L	Odour threshold

Determinand	GV	Unit	Comments
1,3,5-trichlorobenzene	0.05	mg/L	Odour threshold
2,4,6-trichlorophenol	0.002	mg/L	Taste threshold
	0.3	mg/L	Odour threshold (MAV 0.2 mg/L)
turbidity	2.5	NTU	Appearance. See compliance criteria for effects on disinfection
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

Notes:

1. Potable water that does not contain or exhibit any determinands that exceed these guideline values is defined as wholesome water.
2. Section 2.4 explains abbreviations that appear in the table.

2.4 Abbreviations used in tables 2.1–2.5

The following abbreviations are used in tables 2.1–2.5.

ATO — Concentrations of the substance at or below the health-based guideline value that may affect the water's appearance, taste or odour: see Table 2.5

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

GV — Guideline value

MAV — Maximum acceptable value

MC-LR — Microcystin-LR

NTU — Nephelometric turbidity unit

PMAV — Provisional MAV (because it is provisional in the WHO Guidelines (WHO 2017) or the WHO has no guideline value but the DWSNZ have retained a MAV or developed their own)

STXeq — Saxitoxin-equivalent

TCU — True colour unit. The colour after the sample has been filtered. One TCU is equivalent to 1 Hazen unit and to 1 Pt/Co unit. For more information, see Guidelines, section 18.2.1

THM — Trihalomethane, of which there are four: bromoform, bromodichloromethane, chloroform and dibromochloromethane

WHO — World Health Organization

3 Compliance and transgressions

3.1 Introduction

This section introduces the compliance criteria set out in sections 4–10 to assess whether the level of compliance with the water quality standards (section 2) is acceptable.

The DWSNZ specify the minimum compliance 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 assessment of bacterial, chemical and radiological compliance requires that the MAVs or operational requirements specified in the DWSNZ be monitored.

Apart from secure bore water, all source waters are assumed to contain faecal bacteria and other pathogens, so require some form of disinfection or process that will reliably remove or inactivate those elements.

Raw water from surface sources and non-secure bore water require treatment that qualifies for 2, 3 or 4 log credits, depending on the protozoal risk arising from the quality of the source water. Routine monitoring for protozoa in treated water is currently impracticable, so treatment performance is assessed against operational requirements.

Sample sites must be representative of the water being tested. Procedures for sample collection, preservation, transport and storage, test methods and reporting must be agreed beforehand with the Ministry of Health recognised laboratory that will carry out the analysis. If a recognised laboratory is not used, the Ministry of Health must approve these procedures in writing. Recognised laboratories are recorded at:
www.health.govt.nz/water and www.drinkingwater.org.nz

If testing the water supply for other than compliance purposes indicates a possible health risk, the results must be reported to the DWA.

Correspondence regarding the application of the provisions of the Act to a particular water supply must specify the relevant site identification codes as listed in the Register of Drinking-water Suppliers for New Zealand.

3.1.1 Compliance

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

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

1. The concentration of a determinand in a sample of the drinking-water does not exceed the MAV more often than is permitted in Appendix A1.4.
2. An operational requirement does not move outside its limit for more than its allowed frequency or duration of the compliance monitoring period.

3. The number of measurements made for each compliance criterion is equal to or greater than that specified in the DWSNZ; for intermittent supplies, variations must be agreed with the DWA.

4. Sampling, standardising, testing and reporting procedures meet the requirements of the DWSNZ.

5. The requirements of the compliance criteria have been met throughout the previous 12 months.

6. The remedial actions specified in the DWSNZ and water safety plans have been carried out when there has been a transgression or an excursion beyond an operational requirement.

The compliance monitoring period is the period that a MAV or an operational requirement is monitored to check that it does not move outside its limit for more than the allowed frequency or duration. The compliance monitoring period varies from a day to a year, depending on the determinand and the circumstances. Its purpose is to enable sufficient time to gather data for assessment of compliance in a statistically meaningful manner. For each supply component water suppliers must elect the compliance criteria they intend to achieve in order to demonstrate compliance with the DWSNZ. Any changes to the elected compliance criteria must be agreed with the DWA.

Monitoring is not required while a process is not operating, or while online monitoring equipment is taken offline for servicing or calibration. If a process is stop/start, water suppliers need to agree compliance monitoring requirements with the DWA; this may include manual testing.

The allowable number of MAV exceedances (Table A1.4) is calculated on the basis that there is 95 percent confidence that the MAV is exceeded for no more than 5 percent of the time. To meet this, a supply needs to be monitored at least 38 times during the compliance monitoring period. In the interests of affordability, a lesser level of confidence has been accepted for communities of up to 500 people (section 10).

In section 5 (protozoal compliance), each qualifying treatment process is assigned a number of log credits based on the percentage removal or inactivation achieved by that process. If the sum of the log credits of each treatment process in operation meets or exceeds the operational requirements needed for effective treatment of the plant inlet water, the plant will be in protozoal compliance.

If the operational requirements for a particular process meet their performance specifications, the log credits received become those specified in the relevant sections. Failure to meet an operational requirement will not cause the supply to fail compliance so long as it can achieve the necessary log credit total (section 5.2.1) by summing the log credits from other processes being employed.

Organisations conducting compliance or validation testing must be recognised for the purpose by the Ministry of Health. This requires demonstration of compliance with the relevant clauses of the *General Requirements for the Competence of Testing and Calibration Laboratories* (NZS ISO/IEC 17025) (IANZ 2005). Special procedures may be authorised in writing by the Ministry for small or remote drinking-water supplies.

The DWA must assess the competence of the analyst for commonly performed treatment plant or distribution system analyses (field tests) (see sections 69ZL(1)(e) and (f) and 69ZP(1)(h) of the Act). Analysts must be certified as competent if carrying out compliance testing. Field tests include FAC, ozone, chlorine dioxide, pH, temperature, turbidity, particle counting, direct

integrity, differential pressure, ultraviolet light (UV) irradiance, and some *E. coli* tests. For the standardisation of online instruments, see Appendix 2.

Laboratories conducting chemical tests may use the test methods for which International Accreditation New Zealand (IANZ) has assessed them and found them to be competent to perform. Laboratories conducting tests for bacteria in drinking-water compliance need to use a referee method specified in the DWSNZ, or a method that has been calibrated against a referee method: see Ministry of Health 2011.

3.1.2 Transgressions and non-compliance

Section 3.1.1 lists six requirements that suppliers need to meet to achieve compliance with the DWSNZ. As soon as a supplier is aware that there has been a failure to meet any of these requirements, it must advise the DWA and take the appropriate remedial action.

The supplier's monitoring programme should include additional samples to meet any deficiencies that arise from a failure to comply with the requirements of the DWSNZ. These additional results may offset any subsequent failure to carry out adequate monitoring, provided the DWA considers the circumstances giving rise to the deficit are justifiable.

Water suppliers may use the appeal provisions in the Act if they disagree with a determination of non-compliance (see section 1.8).

A major transgression is an occurrence that immediately threatens the safety of the consumers of the drinking-water. Most major transgressions are likely to result from inadequate control of a treatment process or a failure to protect the distribution system. A major transgression may involve a situation not covered by the DWSNZ. Major transgressions can be identified by any of the following.

- the presence in the treated drinking-water of:
  - excessive concentrations of *E. coli* (more than 10 per 100 mL)
  - pathogens at a level of concern
  - cyanotoxins or chemical determinands at a concentration sufficient to cause acute adverse health effects (ie, much higher than the MAV)
- the treatment system's inability to disinfect to the level necessary to achieve satisfactory disinfection
- the treatment or distribution system's inability to provide an adequate barrier to chemicals or micro-organisms
- high levels of illness in the community indicating a potential waterborne disease outbreak.

Major transgressions are serious. The water supplier must carry out the actions specified in the DWSNZ immediately, which includes informing the DWA so the DWA can help to identify the steps needed to protect consumers. In the case of a major transgression, a medical officer of health may issue a water supplier with a compliance order to take appropriate action to protect public health under section 69ZZH of the Act.

3.2 Continuous monitoring requirements

Continuous monitoring of parameters to assess compliance must meet the following requirements.

1. The separation between data records is not to be more than:
    a. one minute for measurements at the treatment plant of:
        i. turbidity
        ii. ozone concentration
        iii. differential pressure
        iv. flow
        v. parameters for UV disinfection (section 5.16.3, Table 5.6)
        vi. parameters used for indirect integrity testing for membrane filtration (section 5.11.2)
    b. five minutes for measurements at the treatment plant of:
        i. chlorine concentration
        ii. pH
        iii. chlorine dioxide concentration
    c. 15 minutes for measurements in the distribution system.

    Compliance with the DWSNZ requires some determinands not to exceed a certain value for more than three, five or 15 minutes. This requires accuracy in time measurement and recording to ensure no short-term transgressions go unrecorded.

2. Continuous monitors used for compliance testing must be standardised at least as frequently as recommended by the equipment suppliers and must provide an alarm system that prompts remedial action, without delay, to rectify any fault.

3. When disinfection dosing or its monitoring fails to meet the relevant criteria, there is no longer confidence that the water supply is potable. The required response is covered in section 4.2.9.

4. Where turbidity measurement is required at the treatment plant, all filters and treatment streams must have independent monitors. As an interim measure for small supplies where filters may 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.

3.3 Priority classes for drinking-water determinands

The DWSNZ divide determinands of public health significance into three classes to minimise monitoring costs without compromising public health: Priority classes 1–3.

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 category, Priority 3, 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 other animals may be the source. Determinands that fall into this category in New Zealand include pathogenic bacteria, protozoa and viruses.

E. coli, a common gut bacterium living in warm-blooded animals, is used as an indicator of the contamination of water by excrement.

Priority 1 determinands are:

- *E. coli*
- protozoa (*Cryptosporidium*[2] and *Giardia*).

Priority 1 determinands apply to all drinking-water supplies and must be monitored in all supplies because they constitute major public health risks. Secure bore water (section 4.4) and water that has been granted interim bore water security status do not need to be monitored for protozoa.

Compliance with the bacterial criteria is determined by conventional bacteriological techniques or when the treatment process meets specified performance requirements. Protozoal compliance is achieved when the treatment process used meets specified performance requirements.

The criteria the DWSNZ use for protozoal compliance are based on the use of:

1. turbidity, to assess the effectiveness of conventional treatment using coagulation plus filtration (direct filtration or filtration with sedimentation or dissolved air flotation), diatomaceous earth filtration and slow sand filtration
2. particle counting, once a relationship between particle counts and filtration efficiency has been established
3. direct integrity testing of membrane filtration plants
4. indirect integrity testing (such as pressure drop, turbidity and some operating conditions) for bag filters, cartridge filtration and membrane filtration
5. contact time (C.t values), monitoring the chemical disinfectant's residual and operating conditions to assess the adequacy of disinfection
6. specified operating conditions for effective UV disinfection and cartridge filtration
7. demonstrations that bore water is secure.

[2] *Cryptosporidium* is the reference protozoan. It is more difficult to treat than *Giardia*, so 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 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 as Priority 2 must be monitored to establish compliance with the DWSNZ. See Guidelines, sections 10.2.6 and 10.3.

The assignment of a determinand to Priority 2 in a given drinking-water supply is based on surveillance monitoring and knowledge of the sources of health-significant determinands in the catchment, treatment processes and distribution system, based on the Priority 2 Chemical Determinands Identification Programme.

The DWA responsible for assessing the drinking-water supply notifies the water supplier of the designation after consulting the supplier and reviewing the evidence. Water suppliers may use the appeal provisions in the Act if they disagree with the designation (see section 1.8).

Priority 2 determinands are divided into four types: Priorities 2a, 2b, 2c and 2d.

- *Priority 2a* determinands are 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 2b* determinands are 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 flushed protocols.

  Cyanotoxins can develop rapidly in surface waters, and many treatment processes will not remove them. There is no simple relationship between their occurrence and the concentrations of the cyanobacteria that produce them. Because of this, and because they are very toxic, the monitoring requirements differ from those of most other Priority 2b chemical determinands.
- *Priority 2c* determinands are chemical determinands of health significance that may appear in consumers' drinking-water having arisen from their plumbing or fittings.

  Plumbosolvent water is a category of drinking-water in which metals of health concern are generally found in the first portion of water collected from the tap but occur at a much lower concentration after flushing the tap; metals in the water after flushing are Priority 2b determinands. Priority 2c determinands are produced by the corrosion of the consumer's tap and associated fittings so that one or more metals (eg, lead, nickel, cadmium or antimony) dissolve or scour into the water. See Guidelines, sections 10.2.6, 10.3.3 and 10.4.2.

  Similarly, the copper MAV may be exceeded at the consumer's tap, particularly when water containing free (aggressive) carbon dioxide causes corrosion of copper tubing.

  See sections 8.2.1.4 and 8.3.5 for issues related to chemical compliance for Priority 2c determinands.
- *Priority 2d* determinands are micro-organisms of health significance that have been demonstrated to be present in the drinking-water supply.

  Any micro-organism may be listed as a Priority 2d 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 2d if a specific contamination situation or epidemiological grounds exist. The monitoring protocols that apply will be specified when the micro-organisms are assigned Priority 2d status and will usually include a catchment assessment to try to identify the source of the contamination.

A Priority 2 determinand may be reassigned to Priority 3 with the DWA's consent when monitoring demonstrates that the Priority 2 assignation is no longer appropriate (section 8.2.2).

3.3.3 Priority 3 determinands

The water supplier does not have to monitor Priority 3 determinands to demonstrate compliance with the DWSNZ. Priority 3 determinands of health significance may become Priority 2 if the DWA considers this warranted.

Priority 3 determinands comprise:

- chemical and radiological determinands of health significance not known to occur in the drinking-water supply at greater than 50 percent of the MAV
- micro-organisms of health significance that could be present in the water supply
- determinands of aesthetic significance that may occur in water supplies.

Determinands listed in Tables 2.2–2.4 are Priority 3 unless they have been assigned to Priority 2a or Priority 2b for a particular supply.

Pathogenic micro-organisms are Priority 3 unless they have been assigned to Priority 2d for a particular supply. The DWA will set compliance criteria depending on the circumstances.

Aesthetic determinands with guideline values (see Table 2.5) are classified as Priority 3 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. An aesthetically unacceptable drinking-water supply may cause people to change to an alternative and potentially unsafe supply or treatment process. For this reason, it is preferable that water suppliers monitor these determinands.

4 Bacterial compliance criteria

4.1 Introduction

For bacterial compliance testing, *E. coli* is used as the indicator organism for contamination of drinking-water by faecal material. If present in drinking-water leaving the water treatment plant or in a distribution zone, the immediate response specified in the following sections must be followed and a record of the remedial actions provided to the DWA.

Separate bacterial compliance criteria have been established for:

- water leaving the treatment plant (section 4.2)
- water in the distribution system (section 4.3)
- bore water security and its ongoing compliance (section 4.4).

4.1.1 Compliance criteria for drinking-water leaving the treatment plant

To demonstrate bacterial compliance for water leaving the treatment plant, one of the bacterial compliance criteria 1 to 5 must be met. Bore water supplies are covered in section 4.4.

When there is no disinfection, or if chloramination is used, criterion 1 must be used. The criteria for supplies disinfected with chlorine, chlorine dioxide, ozone and UV are in sections 4.2.2 to 4.2.5. Water suppliers may use compliance criterion 1 provided they have previously nominated this. Compliance monitoring periods for bacterial compliance are listed in Table 4.1.

Table 4.1: Compliance monitoring periods for water leaving the treatment plant

Determinand or operational requirement	Population served	Compliance monitoring period
Manual monitoring		
E. coli[1]	Up to 5000	One year
	Over 5000	One quarter
free available chlorine, turbidity and pH[2]	Up to 500	One year
	501–5000	One quarter
Continuous monitoring		
chlorine dioxide, turbidity and pH[3] free available chlorine, turbidity and pH[4]	All	One day

Notes:

For bacterial compliance monitoring of ozone and UV disinfection, see sections 5.15 and 5.16 respectively.

1. Does not apply to criterion 2A.
2. Refers to criterion 2B only.
3. If using section 4.3.3.1 option 1, see section 5.14.
4. Refers to criterion 2A only.

4.2 Compliance criterion 1 for drinking-water leaving the treatment plant

The following requirements apply to water leaving the treatment plant when *E. coli* monitoring is the only method used to demonstrate bacterial compliance.

1. Water leaving the treatment plant must be monitored for *E. coli* at a frequency equal to or greater than that specified in section 4.2.8.1, Table 4.2, for the relevant population band.

2. The number of samples in which *E. coli* is found must be equal to or less than the allowable number of exceedances given in Appendix A1.4, over the compliance monitoring period (Table 4.1).

3. The sampling and analytical requirements specified for *E. coli* in sections 4.2.6.2, 4.2.7.1 and 4.2.8.1 must be met.

4. Remedial action: see section 4.2.9 and Figure 4.1 for remedial actions if *E. coli* (or equivalent) is found in any sample.

4.2.2 a Compliance criterion 2A for drinking-water disinfected with chlorine

Criterion 2A applies when chlorination is continuous; otherwise criterion 1 must be used. The FAC is continuously monitored and FACE is calculated. 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. Section 6.3.7 of the Guidelines includes a formula for converting FAC to FACE at different pH values. Also see Guidelines, sections 15.2.5, 15.5.1.1, 17.4.1 and 17.4.4.

Criterion 2A allows bacterial compliance to be demonstrated without *E. coli* monitoring. The following requirements must be met.

1. The sampling and analytical requirements in sections 4.2.6 and 4.2.7 must be met, where applicable.

2. The FAC, pH and turbidity must be monitored continuously (sections 3.2 and 4.2.8.2 to 4.2.8.4).

3. The chlorine C.t value (Appendix A1.3.4) must be at least 6 for at least 98 percent of the compliance monitoring period, taking account of short-circuiting in the contact tank (Guidelines, section 15.2.9). A minimum retention of five minutes is required.

4. Measurements of the water's turbidity must satisfy the following requirements. See Figure 4.1 for remedial actions.

    a. The turbidity is less than 1.0 nephelometric turbidity unit (NTU) for at least 95 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.

5. If any of the requirements of section 4.2.2 are not met, perform the remedial actions in section 4.2.9 and Figure 4.1.

4.2.2 b Compliance criterion 2B for non-continuously monitored chlorine disinfected water leaving the treatment plant supplying populations up to 5,000

Criterion 2B applies to drinking-water that receives 'non-continuously monitored chlorination' before leaving a treatment plant. Plants in which the chlorine is always dosed to achieve a FACE of at least 0.20 mg/L but that do not satisfy other requirements of criterion 2A are classed as receiving 'non-continuously monitored chlorination'. To comply with criterion 2B requirements, the following requirements must be met.

1. The water leaving the treatment plant must be 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 to which the water supply belongs.

2. The number of 100 mL samples in which *E. coli* is found must be equal to or less than the allowable number of exceedances given in Appendix A1.8, Table A1.4, over the compliance monitoring period (Table 4.1).

3. The analytical and sampling requirements in sections 4.3.6 and 4.3.7.

4. The FAC, pH and turbidity must be monitored at least at the frequencies specified in sections 4.3.8.2 to 4.3.8.4 respectively and summarised in Table 4.2b.

5. The FACE must not be less than 0.20 mg/L in any sample.

6. The chlorine contact time must be more than 30 minutes, allowing for short-circuiting in the contact tank (advice on contact time is in the Guidelines, section 15.2.9).

7. 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 A1.4, over the compliance monitoring period (Table 4.1).
    b. The turbidity does not exceed 2.0 NTU in any sample.

4.2.3 Compliance criterion 3 for water disinfected with chlorine dioxide

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 one of the following.

1. Satisfying the protozoal compliance requirements by using chlorine dioxide (section 5.14) also achieves bacterial compliance; no additional monitoring is required.

2. If chlorine dioxide is being used to achieve bacterial compliance only, the requirements of section 4.2.2 must be satisfied, except that references to FAC monitoring are replaced by monitoring chlorine dioxide plus FAC (if present). The concentrations of chlorine dioxide and FAC may be summed. If any of the requirements of sections 4.2.3 are not met, perform the remedial actions in section 4.2.9 and Figure 4.1 (or Figure 5.2, if relevant).

4.2.4 Compliance criterion 4 for water disinfected with ozone

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.

Satisfying the protozoal compliance requirements by using ozone (section 5.15) also achieves bacterial compliance; no additional monitoring is required.

If ozone disinfection is used to achieve only bacterial compliance the following must be achieved.

1. The ozone dose must result in a C.t value of at least 1.0 mg.min/L (eg, a residual of 0.10 mg/L after 10 minutes in the reactor).
2. All water must pass through the ozone contactor.
3. The ozone concentration and flow must be monitored at frequencies at least those specified in section 4.2.8.6. Ozone sampling and standardisation are covered in 5.15.2(2) and 5.15.3. For continuous monitoring, the requirements of section 3.2 must be met. For supplies serving up to 500 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 C.t value must be calculated at the frequency specified in section 4.2.8.6, and for:
    a. continuous monitoring: the C.t value determined from the measured ozone residual and contact time must be at least 1.0 for more than 95 percent of the compliance monitoring period
    b. non-continuous monitoring: the number of C.t values determined from the measured ozone residual and contact time that fail to meet the C.t value of 1.0 must not exceed the number allowed in Appendix A1.4 over the compliance monitoring period.
5. *E. coli* monitoring:
    a. water leaving the treatment plant must be monitored for *E. coli* at a frequency at least that specified in section 4.2.8.1 and Table 4.2
    b. the number of samples in which *E. coli* is found must not exceed the allowable number of exceedances in Appendix A1.4 over the compliance monitoring period
    c. the sampling and analytical requirements specified for *E. coli* in sections 4.2.6, 4.2.7.1 and 4.2.8.1 must be met.
6. The turbidity of the water passing through the reactor:
    a. for continuous monitoring must not exceed 2.0 NTU for more than 5 percent of the compliance monitoring period
    b. for non-continuous monitoring the number of samples with turbidity greater than 2.0 NTU must not exceed the number allowed in Appendix A1.4 over the compliance monitoring period
    c. must be monitored according to the requirements of sections 4.2.7.4 and 4.2.8.4.
7. See section 5.15.2 for the compliance monitoring periods for C.t values.
8. If any of the requirements of section 4.3.4.1 are not met, perform the remedial actions in section 4.2.9 and Figure 4.1 (or Figure 5.2, if relevant).

4.2.5 Compliance criterion 5 for water disinfected with ultraviolet light

To achieve bacterial compliance the UV appliance must deliver a reduction equivalent dose of at least 40 mJ/cm^2 (section 5.16). For bacterial compliance purposes, UV appliances must have been validated with MS2 organisms or equivalent, not T1 or equivalent (Guidelines section 8.5.6). Otherwise compliance must be met by using bacterial compliance criterion 1, 2, 3 or 4.

4.2.6 Compliance sampling and on-site analytical procedures

4.2.6.1 General

Compliance testing must be conducted by laboratories recognised by the Ministry of Health for this purpose. The competence of persons conducting field tests must be assessed by a DWA (section 3.1.1). Procedures for sample collection and storage, testing and reporting must be appropriate (sections 3.1, 3.2).

Referee methods for Priority 1 determinands and related operational requirements are in Appendix A2, which includes procedures for standardisation and verification, where appropriate. Sampling sites and frequencies are discussed in sections 4.2.7 and 4.2.8 (water leaving the treatment plant), and 4.3.3 and 4.3.4 (water in the distribution zone).

4.2.6.2 *Escherichia coli*

Samples must be collected aseptically, using sodium thiosulphate to remove any disinfection residual if necessary. Testing should start within six hours of sample collection, and where this is not possible must not be delayed more than 24 hours after collection. Sample bottles must be transferred in a dark container. 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 arrival in the laboratory, they must be stored in a refrigerator at a temperature not exceeding 5°C. See Guidelines, section 6.4.1.

For compliance testing, a method that enumerates total coliforms and *E. coli* must be used. Section 5.3 of the Guidelines discusses the significance of positive total coliform results.

4.2.7 Sampling sites for bacterial compliance of water leaving the treatment plant

4.2.7.1 *Escherichia coli*

Samples 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 serving up to 500 people with only one distribution zone, samples prescribed to be taken from water leaving the treatment plant may be taken from the distribution zone instead. This is on condition the 'treatment plant' samples are taken from the first available tap after the treatment plant and sampling is at the frequency specified in Table 4.2. 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.

The samples prescribed to be taken from water leaving the treatment plant may be omitted for supplies to a single building (or a complex of not more than three buildings networked by reticulated pipework) that serve a population of less than 150 people.

4.2.7.2 Disinfectants

Chemical disinfectants are very reactive so must be measured in the field. Care is required in selecting the sample site when checking online instruments. See Guidelines, section 15.5.1.3.

Samples for FAC (and, if relevant, chlorine dioxide) 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. The disinfectant residual measurement must be made as close as practicable to where the *E. coli* samples are taken.

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 its concentration in the 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 the water leaving the treatment plant becomes the value used to demonstrate compliance.

Appliances used for disinfection with UV light must have a built-in, online UV sensor. Ozone dosing equipment for supplies serving a population greater than 500 must have a built-in sensor to continuously monitor the ozone residual.

4.2.7.3 pH

Samples must be taken close to but downstream of where the disinfectant is measured.

4.2.7.4 Turbidity

Samples must be taken close to where the disinfectant is measured. There must be no settling of particles in the line between the sample point and instrument (for a discussion on sampling, see the Guidelines, section 17.2).

For plants that continuously monitor the turbidity of water leaving each filter, it is acceptable to calculate the turbidity of the water leaving the treatment plant by averaging the individual turbidity measurements.

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

4.2.8 Sampling frequencies for compliance of water leaving the treatment plant

4.2.8.1 *Escherichia coli*

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

Section 1.6 discusses the sampling frequency for water supplies that experience temporary population increases.

No monitoring is required while a treatment plant is out of service. The water supplier must record the period when the treatment plant is off-line and ensure by appropriate monitoring that the source is free of *E. coli* or that the plant is operating at its full treatment capability when placed back on line. A sample for *E. coli* testing must be taken within one hour of start-up.

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 the treatment plant

Supply type	Population served[1]	Minimum sampling frequency	Maximum days between samples[2]	Minimum days of the weeks used
No or inadequate disinfection[3] (monitoring by *E. coli* only)	Up to 500	Weekly	13	5
	501–10,000	Twice a week	5	6
	More than 10,000	Daily	1	7
Chlorinated: non-continuously monitored[4] (criterion 2B)	Up to 500	Fortnightly	22	3
	501–5000	Weekly	13	5
Ozone disinfected (criterion 4)[5]	All	Fortnightly	22	3

Notes: This table applies to all bacterial criteria except criteria 2 and 3, and when protozoal compliance exempts further monitoring.

1. Sampling frequencies for *E. coli* in supplies servicing fewer than 500 people are discussed in section 10.
2. 'Five days between' means, for example, if a sample is taken on Thursday, the next sample must be taken on or before Tuesday.
3. Supplies with no or inadequate disinfection must use criterion 1; others do so by choice.
4. Non-continuously monitored chlorination is covered in section 4.2.2 b.
5. No *E. coli* monitoring is needed if the relevant protozoa criteria are satisfied.
6. This table applies to all bacterial criteria except criteria 2A and 3, and when protozoal compliance exempts further monitoring.

Table 4.2b: Minimum sampling frequency for free available chlorine, pH and turbidity in criterion 2B drinking-water leaving the treatment plant

Population served	Minimum sampling frequency	Maximum days between samples	Minimum days of the week used
Up to 500	13 per quarter (weekly)	11	5
501–5000	39 per quarter (three times a week)	4	7

Note: 'Three days between' means, for example, if a sample is taken on Monday, the next sample must be taken on Thursday.

4.2.8.2 Free available chlorine disinfection

All plants with chlorination that supply a population greater than 5,000 must monitor FAC continuously. Continuous monitors must meet the requirements specified in section 3.2.

Manual disinfectant residual sampling frequencies must be increased if there are any circumstances that may give rise to an increased risk of faecal contamination.

4.2.8.3 pH

For criteria 2A and 3, the pH must be monitored continuously. Continuous monitors must meet the requirements specified in section 3.2. For criterion 2B, the pH of the water leaving the treatment plant must be monitored at the same time and frequency as the FAC is measured to enable the FACE to be determined.

4.2.8.4 Turbidity

All water treatment plants using bacterial compliance criteria 2A and 3 must monitor turbidity continuously. Continuous monitors must meet the requirements specified in section 3.2. For bacterial criterion 2B the turbidity must be monitored at the frequency specified in Table 4.2b.

For bacterial criterion 4 (ozone disinfection), turbidity must be monitored at the same frequency as for protozoal compliance (section 5.15.2, requirement 5).

For bacterial criterion 5 (UV disinfection), turbidity must be monitored at the same frequency as for protozoal compliance (Table 5.6).

Plants using membrane filtration to comply with the protozoal compliance criteria do not need to measure or compute the turbidity of the final water, provided the turbidity is always less than 0.10 NTU in the water leaving each filter unit.

4.2.8.5 Chlorine dioxide

All supplies disinfected with chlorine dioxide must meet the disinfectant requirements of either section 4.2.2 or 4.2.3 as appropriate, measuring chlorine dioxide instead of chlorine. Continuous monitors must meet the requirements specified in section 3.2.

4.2.8.6 Ozone and flow

Satisfying the protozoal compliance requirements by using ozone (section 5.15) also achieves bacterial compliance; no additional monitoring is required.

Otherwise, 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 meet the requirements specified in section 3.2. Supplies serving a population up to 500 must monitor the ozone residual and calculate the C.t value daily.

4.2.8.7 UV disinfection

If using UV light with a reduction equivalent dose of at least 40 mJ/cm^2, the monitoring requirements of section 5.16, Table 5.6 apply.

4.2.9 Response to transgressions in drinking-water leaving the treatment plant

Contaminated water leaving the treatment plant can affect the whole community so immediate action is required if a positive *E. coli* test result occurs; see Figure 4.1. Additional responses are required for secure bore water (section 4.4.4).

Immediate action must be taken when the minimum FACE, chlorine dioxide, ozone C.t value or UV dose (criteria 2 to 5) is not achieved, or the turbidity exceeds the maximum specified, thereby compromising the efficacy of the disinfection.

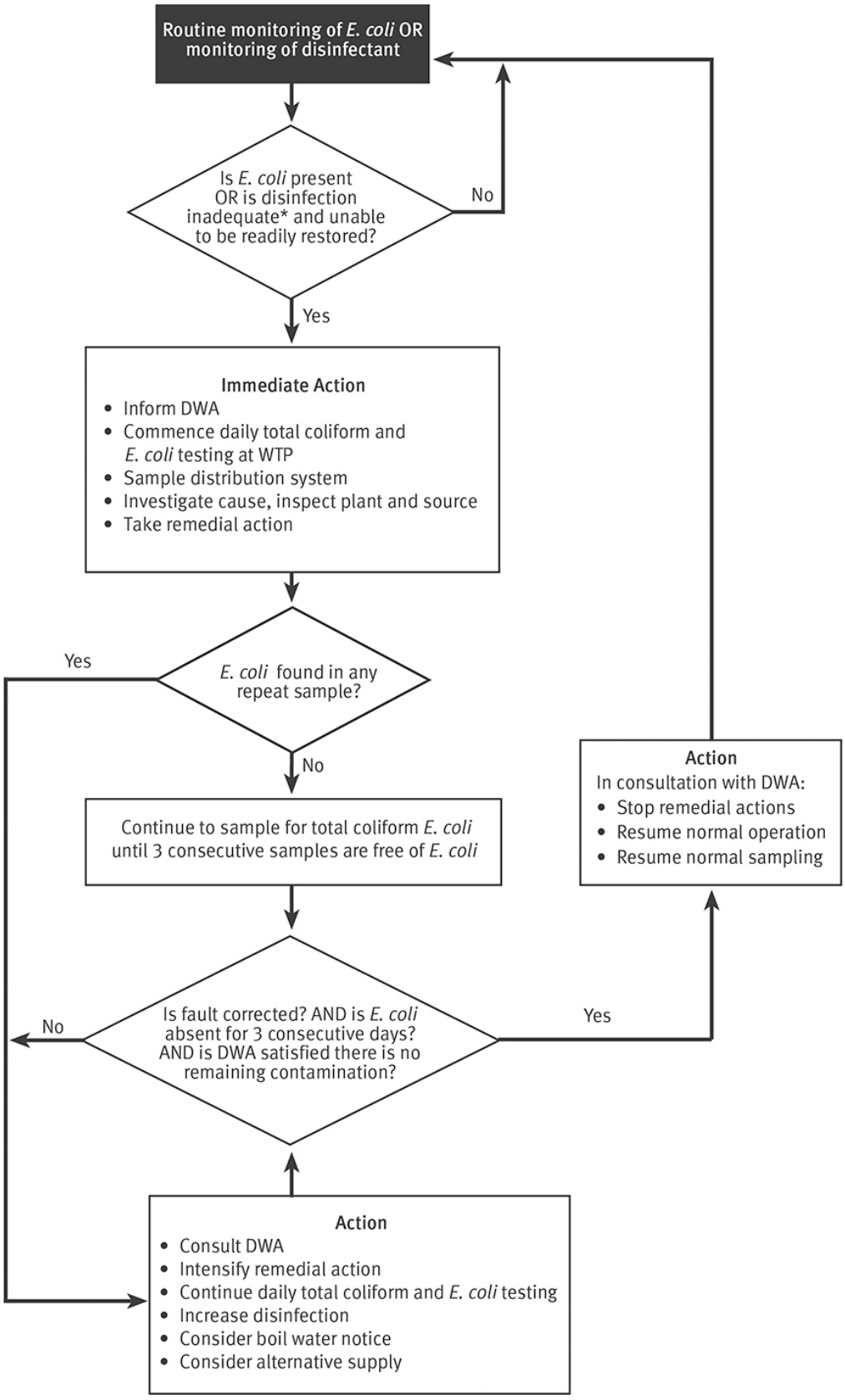
If the immediate investigation shows that faulty online monitoring is the cause, carry out a minimum of twice-daily manual measurement of the disinfectant, pH, turbidity (and flow if required) until the instrumentation is performing satisfactorily.

If the immediate investigation shows that disinfection dosage is faulty, the actions to be taken are summarised in Figure 4.1. These actions may be modified to suit particular circumstances with the DWA's agreement. Further actions are suggested in the Guidelines, section 6.5. 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 cause of 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.

Samples collected as a result of a transgression or breach 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.

Figure 4.1: Response to a transgression in drinking-water leaving the treatment plant



Notes:

* Inadequate disinfection occurs in the following situations.

- For FACE and chlorine dioxide (criteria 2A, 2B and 3): when the residual in the water leaving the plant is less than 0.20 mg/L for more than an hour or falls below 0.10 mg/L.
- Ozone (criterion 4): when the ozone C.t value is not achieved.
- UV (criterion 5): when the target UV dose or intensity is not achieved.
- When turbidity or UV transmittance are outside the compliance criteria.

4.3 Compliance criteria, drinking-water in the distribution system

A distribution system comprises one or more distribution zones. Compliance is required for each zone. Water suppliers must nominate either bacterial compliance criterion 6A or criterion 6B.

Bacterial compliance criterion 6B may be applied to chlorinated water supplies serving a population greater than 500 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.

The compliance monitoring period for bacterial compliance in the distribution system is one year.

The term 'disinfectant residual' means FAC in chlorinated systems, and the sum of the residual chlorine dioxide and any FAC in systems disinfected with chlorine dioxide.

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

Bacterial compliance criterion 6A, using only *E. coli* monitoring, must be used when the residual in the distribution system is less than 0.20 mg/L FAC or chlorine dioxide (measured as ClO_2).

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 of sampling for *E. coli* meet the requirements of sections 4.3.3 and 4.3.4 respectively.
3. The number of samples in which *E. coli* is found is equal to or less than the allowable exceedances listed in Appendix A1.4.
4. The sampling and analytical procedures comply with section 4.2.6.

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

Bacterial compliance criterion 6B, using partial substitution of *E. coli* monitoring by FAC or chlorine dioxide monitoring, may be used:

- in water supply zones servicing a population greater than 500
- when the residual maintained in the distribution system is at least 0.20 mg/L FAC or chlorine dioxide (measured as ClO_2).

To comply with partial substitution in criterion 6B, the requirements of section 4.3.1 must be met, together with all of the following requirements.

1. Water leaving the treatment plant complies with section 4.2.2 (criterion 2A) or section 4.2.3 (criterion 3).

2. The disinfectant residual concentration is monitored in the distribution zone at the sites and frequencies specified in sections 4.3.3 and 4.3.4.

3. The number of *E. coli* samples substituted by disinfectant residual tests does not exceed 75 percent of the number specified in Table 4.3a (column 2).

4. All samples in the distribution system contain a disinfectant residual concentration of at least 0.20 mg/L, except in occasional areas of low flow where the disinfectant concentration may diminish to 0.10 mg/L. If the disinfectant residual is found to be less than 0.10 mg/L in any particular sample, *E. coli* must be tested for.

4.3.3 Sampling sites for compliance in the distribution zone

The sampling plan must provide geographical coverage of the distribution system and must take into consideration the following.

1. All samples must be taken from regular sampling points, such as pumping stations, service reservoirs and taps within the distribution zone.

2. The sampling plan must include frequently visited sites to enable some assessment of trends, and sites visited on rotation to enhance geographical coverage.

Taps installed specifically for sampling purposes, attached directly to a street main and contained in locked cabinets are preferred to consumers' household taps.

The selection of sample sites is discussed further in Chapter 6 of the Guidelines. Chapter 16 of the Guidelines discusses monitoring during distribution system maintenance and construction.

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

Population served[2]	Minimum number of *E. coli* samples per quarter with no disinfectant residual substitution (criterion 6A)	Minimum number of samples per quarter where disinfectant residual determination substitutes 75 percent of *E. coli* testing[3] (criterion 6B)	
		E. coli	Disinfectant residual
Up to 500	3	*Not applicable*	*Not applicable*
501–5000	13	7	93
5001–10,000	16	7	93
10,001–15,000	19	7	93
15,001–20,000	22	7	93
20,001–25,000	25	7	93
25,001–30,000	28	7	93
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. If there is any failure to take or deliver samples or to adhere to the specified sampling frequency requirements, resampling must take place as soon as practicable and the DWA must be advised. The DWA may grant an exemption, if the reasons for the failure are justifiable (section 3.1.2).
2. When the population increases, additional sampling must be performed so the sampling frequency is that specified for the population actually present (section 1.6).
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 (section 4.3.3). Use calendar quarters: January to March, April to June, July to September, and October to December. Ninety-three days per quarter means daily.

4.3.4 Sampling frequencies in a distribution zone

4.3.4.1 Compliance criterion 6A

The sampling frequencies for total coliforms and *E. coli* in drinking-water in the distribution zones are shown in Table 4.3a. For supplies serving more than 500 people monitoring must be carried out on different days throughout the weeks as shown in Table 4.3b.

Table 4.3b: Sampling intervals for total coliforms and *E. coli* in the distribution zone

Number of samples collected per quarter	Maximum interval between samples (days)	Minimum number of days of the week used
3	45	2
4–7	22	3
8–12	16	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

Note:

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

- if there is no replacement of *E. coli* by FAC, 52 *E. coli* samples are required per quarter (Table 4.3a)
- 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).

If 13 *E. coli* samples are required, the maximum sampling interval is 11 days, with samples to be collected on five different days of the week.

4.3.4.2 Compliance criterion 6B

Total coliform, *E. coli* and disinfectant residual sampling frequencies are shown in Table 4.3b. For populations of 30,000 or more, the sampling frequencies were calculated as follows:

a. (*E. coli* tests specified in column 2 of Table 4.3a if no substitution with disinfectant residual determination is done) x ([100−percent of *E. coli* tests replaced]/100).

b. Testing must be carried out on different days throughout the week as shown in Table 4.3b, not exceeding the specified interval.

For populations of 30,000 or more, the sampling frequencies for the disinfectant residual were calculated as follows:

a. (*E. coli* tests that would be required in column 2 of Table 4.3a if no substitution with disinfectant residual determination is done) x 4 x [percent of *E. coli* tests replaced]/100.

b. Disinfectant residual sampling must be carried out at least daily. 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.

Section 4.3.6 discusses transgression and consumer complaint samples.

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

These procedures are the same as detailed in section 4.2.6.

4.3.6 Remedial actions involving criteria 6A and 6B

Figure 4.2 details the response stages. These requirements may be modified to suit particular circumstances by agreement with the DWA.

If disinfectant levels fall below 0.20 mg/L (criterion 6B), the cause must be investigated immediately. If the fall in the level is due to:

- faulty dosage, sample for *E. coli* according to criterion 6A until the disinfectant levels have been restored for two days
- faulty monitoring, conduct twice-daily manual residual testing until repaired.

If the FAC level drops below 0.10 mg/L, *E. coli* monitoring must be carried out according to criterion 6A. Criterion 6B monitoring may resume after disinfectant levels have been restored above 0.20 mg/L for two days. The response to a positive *E. coli* sample must include the following steps (see the Immediate Action box in Figure 4.2):

1. Immediately inform the DWA.
2. Begin collection of daily follow-up samples for *E. coli* enumeration from the original positive sample location and also locations downstream from the first positive site.
3. If no fault in the distribution system is immediately apparent and no routine *E. coli* sample was taken from water leaving the treatment plant at about the time the positive sample was taken from the distribution zone, then test for *E. coli* in the water leaving the treatment plant also.
4. Investigate possible causes of the positive sample (see Guidelines, chapter 6).
5. Correct any faults found during the investigation.

The required actions must be applied promptly and reported fully.
If any results from follow-up sampling are equal to or greater than 10 *E. coli* per 100 mL, the DWA must be consulted immediately and actions required to reduce the risk of illness, such as the issue of a 'Boil Water' notice, increasing the disinfectant dose or flushing the system, must be carried out. Investigations into the reason for the contamination must be intensified. In this situation, reliance only on the level of residual disinfectant in the water leaving the treatment plant is not sufficient to eliminate the plant as the source of contamination.

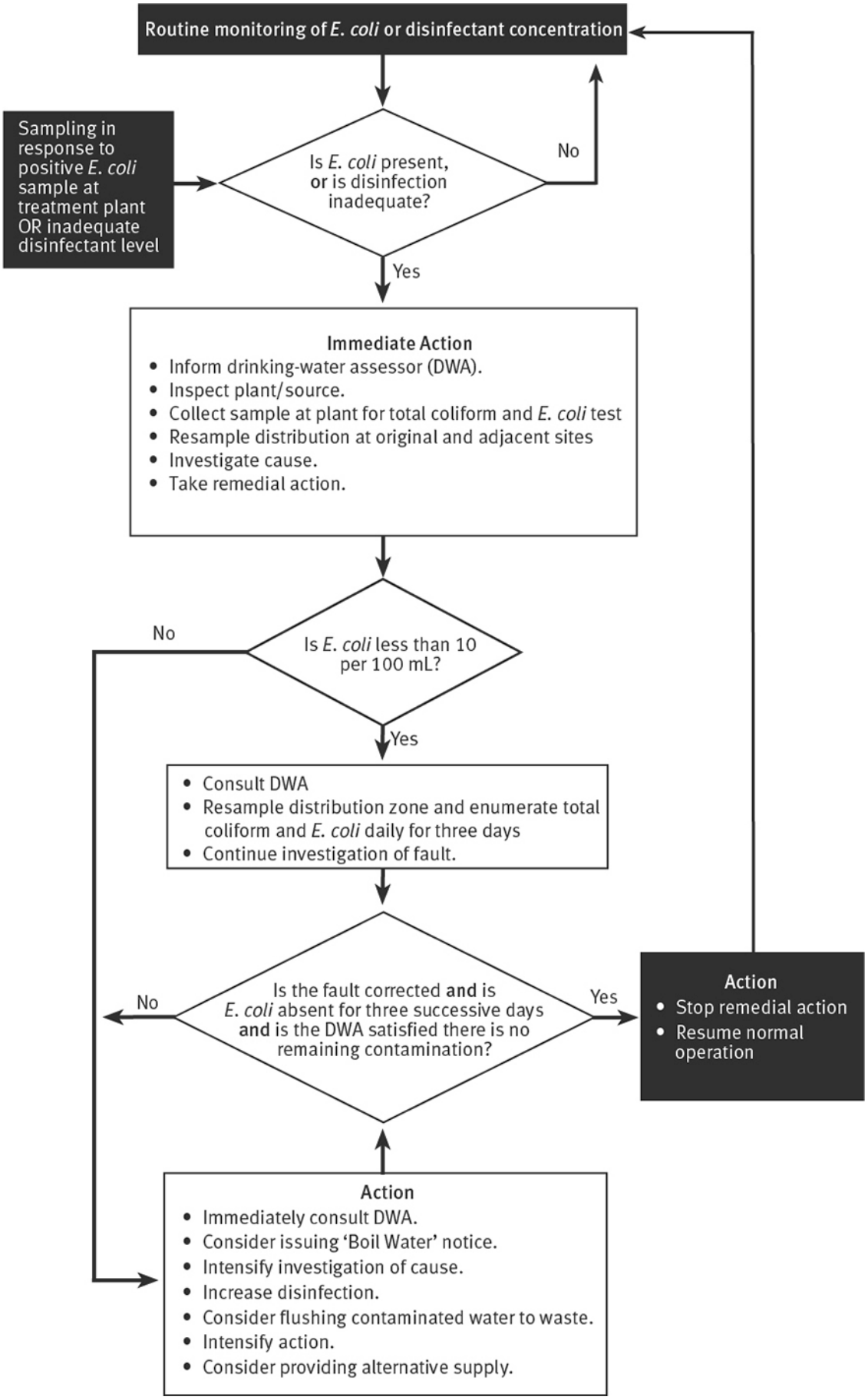
If any follow-up sample contains one to nine *E. coli* per 100 mL, the DWA must be informed and investigations must continue and any faults identified must be corrected.

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
- any remedial action is complete.

Samples collected as a result of a transgression or breach of an operational requirement 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. Consumer complaint samples are not counted as part of the routine compliance monitoring programme.

Figure 4.2: Response to a transgression in a drinking-water supply distribution zone



4.4 Bore water security and compliance

4.4.1 Introduction

Bore water is considered secure when it can be demonstrated that contamination by pathogenic organisms is unlikely because the bore water is not directly affected by surface or climate influences, as demonstrated by compliance with bore water security criteria 1 (section 4.4.2), 2 (section 4.4.3) and 3 (section 4.4.4).

Spring water, and bore water that is not classed as secure, are considered equivalent to surface water.

Where a treatment plant receives water from both secure and non-secure bore water, the supply must be classified as arising from non-secure bore water while the non-secure bore water is contributing to the treatment plant.

If secure bore water receives treatment that could allow microbiological contamination, the water leaving the treatment plant must satisfy one of the bacterial criteria in section 4.2.

If secure bore water is chlorinated to maintain a chlorine residual in the distribution system, no additional bacterial compliance monitoring is required of the water leaving the treatment plant.

Once water from a bore has been declared secure, section 4.4.6 outlines the ongoing compliance monitoring requirements.

The bacterial compliance criteria for bore water entering the distribution system are covered in section 4.3.

Section 4.4.5 applies to multiple bores drawing from the same aquifer.

4.4.2 Bore water security criterion 1

A lack of surface or climate influences on the groundwater must be demonstrated by one of:

- water younger than one year not being detectable in the aquifer
- the lack of significant variability in determinands that are linked to surface effects.

Compliance with this criterion may be demonstrated in one or more of three ways.

4.4.2.1 Demonstration 1: Residence time

A residence time determination carried out by a laboratory recognised by the Ministry of Health for the purpose must show 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.

The residence time determination must be based on measurements of the concentration of tritium and chlorofluorocarbon and sulphur hexafluoride.

4.4.2.2 Demonstration 2: Constant composition

When testing a minimum of 12 samples spaced regularly over one to three years, variations in the concentrations of all of the following determinands do not exceed a:

- coefficient of variation of 3 percent in conductivity
- coefficient of variation of 4 percent in chloride concentration
- standardised variance of 2.5 percent in nitrate concentration (expressed as milligrams of NO_3-N/L).

For examples of the calculation and advice on sampling and analysis, see the Guidelines, section 3.2.4.2.

If the concentration of any one of these determinands is near its 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.

4.4.2.3 Demonstration 3: Verified model

If the residence time determination is not possible due to the presence of non-meteoric chlorofluorocarbons, sulphur hexafluoride and tritium, and the water quality variation criteria do not satisfy the requirements for secure bore water status, the following method may be considered.

A verified hydrogeological model demonstrating that the bore is extracting water from a confined aquifer may be acceptable. The model must have been published in a peer-reviewed scientific journal, and be derived from a conservative evaluation of hydrogeologic parameters, and be suitable for the aquifer in question. The 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 an independent person or people deemed qualified by the Ministry of Health.

4.4.3 Bore water security criterion 2

The bore head must be judged to provide satisfactory protection by a person recognised as an expert in the field.

The bore head must be sealed at the surface to prevent the ingress of surface water and contaminants, and the casing must not allow ingress of shallow groundwater. 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, Standards New Zealand (2001)), including providing an effective backflow prevention mechanism, unless agreed by the DWA.

The supply's water safety plan 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 so contamination of the groundwater cannot occur (for further discussion, see the Guidelines, section 3.2.3).

4.4.4 Bore water security criterion 3: *Escherichia coli* must be absent from bore water

There are two sets of requirements for demonstrating the absence of *E. coli* in bore water.

1. Water from bores complying with bore water security criterion 1, and from unconfined aquifers more than 30 m deep drawing from a source for which hydrogeological evidence indicates that the bore water is likely to be secure, may be given interim secure status for the first 12 months of operation, provided:

   a. they are monitored for *E. coli* in accordance with Table 4.4 and note 1

   b. no *E. coli* is detected; if *E. coli* is found, see section 4.4.7.3.

   Status as a secure bore water in this group requires compliance with all three bore water security criteria.

2. Bore water abstracted 10 to 30 m deep, drawn from an unconfined aquifer, will be considered secure, provided:

   a. it is monitored for *E. coli* for 5 years in accordance with Table 4.4 and note 2

   b. no *E. coli* is detected; if *E. coli* is found, see section 4.4.7.4. Status as a secure bore water in this group requires compliance with bore water security criteria 2 and 3.

Until this water is classified as secure, it is considered equivalent to surface water. For bacterial compliance, see section 4.2. The protozoal log credit requirements for surface waters are in Table 5.1.

4.4.4.1 *Escherichia coli* monitoring

The sampling site is preferably at the bore head, but must precede any treatment, blending or storage. The monitoring procedures must comply with the requirements of section 4.2.6.

If the bore is used irregularly or intermittently, variations to the sampling frequency specified in Table 4.4 must be agreed with the DWA.

Table 4.4: Minimum sampling frequency for *E. coli* in bore water

Supply type	Population served[6]	Minimum sampling frequency	Maximum days between samples
Bore waters with interim security,[1] bores 10 to 30 m deep,[2] the bore representing a bore field,[3] provisionally secure bores[4]	Up to 500[7]	Weekly	13
	501–10,000	Twice a week	5
	More than 10,000	Daily	1
Secure bore water supplies[5]	All	Monthly	45 (135)

Notes:

1. Monitoring requirements for bore water granted *interim secure* status may be reduced to one sample per month for the remaining nine months independent of population band (maximum of 45 days between samples) provided no *E. coli* has been detected during the first three months (section 4.4.4).
2. Monitoring requirements for bores *10–30 m deep* drawing from unconfined aquifers may be reduced to monthly (maximum of 45 days between samples) for the final four years and nine months provided no *E. coli* has been detected during the first three months.
3. Monitoring requirements for the bore representing a *multiple bore field* may be reduced to monthly independent of population band (maximum of 45 days between samples) provided no *E. coli* has been detected during the first

three months (section 4.4.5). As a prerequisite, all bores drawing from the same field must have no *E. coli* in three consecutive monthly samples.

4. Monitoring requirements for secure bore water that has been downgraded to provisionally secure may be reduced to one sample per month for the remaining nine months independent of population band (maximum of 45 days between samples) provided no *E. coli* has been detected during the first three months (sections 4.4.7.1 and 4.4.7.2).
5. Monitoring requirements for *secure bore water supplies* may be reduced to one sample per quarter (maximum of 135 days between samples) after no *E. coli* has been detected in 12 consecutive months of sampling after the bore water has been granted fully secure status.
6. If the bore is not the sole source, determine the population band by agreement with the DWA.
7. Sampling frequencies for *E. coli* in supplies servicing fewer than 500 people are discussed in section 10.
8. If the bore is used irregularly, variations to the sampling frequency must be agreed with the DWA.

4.4.5 Multiple bores serving drinking-water supply

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

Reduced monitoring may be justified when it can be demonstrated that the bores supplying a single pumping station or distribution zone draw from the same aquifer. A verified hydrogeological model demonstrating that the bores all draw from the same aquifer may be acceptable to support an application for a reduced monitoring regime. The model must have been published in a peer-reviewed scientific journal and be suitable for use for the aquifer in question. The model must be derived from a conservative evaluation of hydrogeologic parameters and all assumptions specified. Such a model must be verified to the satisfaction of an independent person or people recognised as expert in the field.

To justify reduced monitoring in these circumstances, the water supplier must show that:

- 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
- each bore head meets bore water security criterion 2 (section 4.4.3).

The bore(s) chosen to represent the aquifer must be the one(s) most vulnerable to contamination. The sampling frequency must be in accordance with the requirements of Table 4.4.

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

4.4.6 Ongoing compliance for secure bore water

To demonstrate continued compliance with bore water security criterion 1, using:

- demonstration 1, the residence time must be re-assessed every five years, or earlier if the DWA specifies it is necessary
- demonstration 2, the determinands used to verify the bore water as secure must be tested annually to check that the results remain within the original range
- demonstration 3, a hydrogeological model must confirm every five years that the bore is extracting from a confined aquifer.

To demonstrate continued compliance with bore water security criterion 2, the bore head protection must be reviewed at least every five years and the water supply owner must report any changes to the DWA.

To demonstrate continued compliance with bore water security criterion 3 the water must be monitored, preferably at the bore head but before any treatment or storage, at a frequency at least that specified in Table 4.4, and detect no *E. coli*.

4.4.7 Response to *Escherichia coli* detection in bore water

Section 4.2.9 covers the minimum responses that must be followed if *E. coli* is found in any sample of drinking-water entering the distribution system, including the relevant responses in Figure 4.1. For bore waters, there are two additional requirements.

- Compliance with bore water security criterion 2 (section 4.4.3) must be confirmed as soon as practicable.
- Compliance with bore water security criterion 3 must be confirmed by additional *E. coli* monitoring in sections 4.4.7.1–4.4.7.5).

If a bore water becomes non-secure, to re-establish security all the procedures for demonstrating security outlined in section 4.4 must be carried out again.

4.4.7.1 Secure bore water

When *E. coli* is found in a sample of secure bore water, the supply will be given provisional secure status for the following 12 months of operation, provided:

- it is monitored for *E. coli* in accordance with Table 4.4 for the first three months after the positive *E. coli* sample was obtained
- it is monitored monthly for the remaining nine months
- no *E. coli* is detected during the 12-month provisional period.

A provisionally secure bore water that satisfies the above requirements will revert to its original secure status.

4.4.7.2 Provisionally secure bore water

If *E. coli* is obtained in a sample of provisionally secure bore water during the 12-month monitoring period, the water must be reclassified immediately as non-secure. If a secure bore water is classified as provisional more than twice in five years, retention of its secure status is at the discretion of the DWA.

4.4.7.3 Interim secure bore water

If a sample of bore water that has been given interim secure status (section 4.4.4) contains *E. coli*, the 12-month interim sampling regime must recommence (Table 4.4). If *E. coli* is found in a second sample during the 12-month interim period, the water must be reclassified immediately as non-secure.

4.4.7.4 Bores 10 to 30 m deep, drawn from unconfined aquifers

If any sample collected upstream of the treatment process contains *E. coli* during the five-year proving period, a repeat sample must be collected as soon as practicable for enumeration of *E. coli*, and daily thereafter until two consecutive samples are free from *E. coli*. If three consecutive samples contain *E. coli*, or if one repeat sample contains 10 or more *E. coli* per

100 mL, the five-yearly proving period must recommence. If any *E. coli* are found again during the five-year proving period, the bore will be considered to be supplying surface water.

4.4.7.5 Multiple bores

If a sample from the representative bore contains *E. coli* the bore is reassessed as provisionally secure, and monitored accordingly, as for secure bore water (section 4.4.7.1).

If *E. coli* is not detected when re-sampling the bore (Figure 4.1, immediate action box), the other bores do not need to be tested. If *E. coli* is detected in one or more of these repeat samples, all bores must be tested for *E. coli*. If any of these bores contains *E. coli*, the bore field will be considered provisionally secure, see section 4.4.7.2, and all bores must be sampled accordingly.

5 Protozoal compliance criteria

5.1 Introduction

Protozoa such as *Cryptosporidium* and *Giardia* may occur in New Zealand surface waters and non-secure bore waters. Their cysts or oocysts (collectively (oo)cysts) are found in the faeces of humans and animals (wild, farm and domestic). Infectious protozoa are Priority 1 determinands.

The risk associated with secure bore water is lower than that of surface waters. Secure and interim secure bore waters (section 4.4.4) are considered to comply with the protozoal compliance criteria.

Protozoa can be removed by filtration or inactivated by disinfection using ozone, chlorine dioxide or UV light. Inactivation renders a micro-organism incapable of reproduction, so it is unable to infect a host. Chlorine can be effective in inactivating *Giardia*, bacteria and viruses, but not *Cryptosporidium*.

The compliance criteria for protozoa are based on the probability that the treatment process has inactivated (by disinfecting to achieve the prescribed C.t value) or removed (by achieving target filtrate turbidity) any protozoa present.

Cryptosporidium is the most infectious[3] and most difficult protozoan to remove or inactivate. The compliance criteria are constructed on the principle that if a 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 contaminated raw water than for cleaner raw water
- acknowledge any additive effect of successive different treatment processes on the removal of protozoa where more than one treatment process is used
- use log-removal efficacy of *Cryptosporidium* for a range of treatment processes
- specify the use of validated equipment (where appropriate), monitoring programmes and treatment performance measures
- require appropriate remedial actions to be taken.

5.2 Cumulative log credit approach

The risk of infection from drinking-water contaminated by waterborne protozoa is affected by the:

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

To take account of the additive effect of a series of treatment processes on the removal of protozoa, 'log credits' are used, *Cryptosporidium* being used as the reference organism (see Guidelines, section 8.3). Section A1.3.10 relates percentage removal to logarithms.

[3] Methods for assessing the infectiousness of protozoa are not yet suitable for routine monitoring, so all (oo)cysts are considered infectious.

The cumulative effect of successive treatment processes can be calculated by adding the log credits of all the qualifying processes in use.

Protozoal non-compliance occurs when one of the following occurs.

- A treatment process does not satisfy the conditions required to achieve the log credit specified for it in the DWSNZ, resulting in the treatment plant not reaching the total log credits required.
- The monitoring or operational requirements specified in the relevant sections are not met or exceed the number allowed in Appendix A1.4.
- Incorrect monitoring procedures are used (eg, inadequate sampling, incorrect standardisation of metering equipment or analyses not carried out by a laboratory recognised for the purpose).

5.2.1 Procedures for determining protozoal log credit requirements

5.2.1.1 Bore water supplies

Secure and interim secure bore water (section 4.4) is deemed to satisfy the protozoal compliance criteria (ie, no protozoal log credits are required).

Non-secure bore water (springs, and groundwater that does not produce secure bore water) are considered equivalent to surface water so need to meet protozoal compliance. If bacterial compliance is met by chlorination, and these waters meet bore water security criterion 2, acknowledgement of underground attenuation processes reduces the protozoa log credit requirement to 2.

5.2.1.2 Source water from surface catchments

The default requirement for protozoa in surface waters is 3-log inactivation or removal. Water safety plans include an assessment of the catchment; if this indicates that 4-log credits may be required, *Cryptosporidium* monitoring is needed. *Cryptosporidium* monitoring is not required if the water supplier elects to provide 4-log credits.

The monitoring programme must comprise at least 26 samples collected over a 12-month period at approximately equal time intervals to attempt to ensure representative samples and minimise seasonal bias. The samples must be tested quantitatively for *Cryptosporidium* oocysts. Subject to the services offered by the laboratory and delivery service, samples should be taken to cover every day of the week, and must cover at least Monday to Friday three times during the sampling programme. The DWA will advise water suppliers of the log credit requirement; water suppliers may use the appeal provisions in the Act if they disagree (see section 1.8).

Table 5.1: Log credit requirements for surface waters

Cryptosporidium, mean oocysts per 10 litres	Log credits
0.75 or more	4
< 0.75	3

The log credit assessment must be repeated in response to any of:

- catchment activities that indicate a likely increase in oocyst numbers
- an intention by the water supplier to employ treatment with a reduced protozoal log removal rating
- an outbreak of waterborne protozoal infection linked to the water supply that is not explained by a lapse in protozoal treatment.

If the review suggests the log credit requirement has increased, resulting in the need to upgrade the water treatment process, the water supplier shall address how and when they will do this in their water safety plan.

A source water that receives a higher level of treatment than required (eg, 3 log removals for a 2-log categorisation) only needs to be reviewed if the source water quality is assessed to have deteriorated.

5.2.1.3 Recycling

Water treatment plants that recycle waste streams must:

- return the recycle stream so that it undergoes the full treatment process
- provide flow equalisation such that the instantaneous total return rate does not exceed 10 percent of the plant inflow, unless otherwise approved by the DWA
- monitor the recycle stream continuously for turbidity; separation between data points must not exceed one minute.

Turbidity monitoring is required to demonstrate that the recycled water has received effective solids/liquid separation.

These rules do not apply to water from rapid granular media filters being diverted during restart after backwash (often called 'filter to waste').

The required monitoring and control must be in place as required in section 69C of the Act.

5.2.2 Sampling and testing

5.2.2.1 Sampling location

The sampling location for collection of samples for *Cryptosporidium* testing must be:

1. upstream of any pre-treatment process that contributes log credits to the overall treatment process: sampling may be from the raw water at the point of abstraction (raw water intake) if requirements 2 and 3 are also met
2. in the case of selective abstraction schemes with a choice of abstraction points, at the inlet to the treatment plant
3. at each raw water intake when a water supply can be drawn from more than one source water: calculate the weighted average based on the flows from each stream. Alternatively, the inlet water to the treatment plant may be monitored, provided all source waters are being abstracted at a rate consistent with operational practice
4. downstream of the return point of any recycled liquid wastes. Samples are collected while the recycle is operating.

5.2.2.2 Analytical method and calculation

Analysis of raw water protozoa must be carried out in a laboratory with IANZ accreditation for such work. Results are to be reported as *Cryptosporidium* oocysts per 10 litres and *Giardia* cysts per 10 litres.

The mean number of *Cryptosporidium* oocysts per 10 litres will be used to determine the minimum protozoal log credits that the treatment system must provide to achieve compliance, as per Table 5.1. In calculating the mean value, all 'less than' values are to be treated as zeros. The number of oocysts counted must be normalised using the formula:

$$N_R = N_C \text{ X } 40 \text{ / \% recovery}$$

where N_R is the number reported and N_C is the number counted.

5.2.3 Log credits for treatment processes

All water entering the distribution system must have passed through the treatment process.

Section 8.3.2 of the Guidelines explains which treatment processes can be combined for the purposes of being awarded log credits.

Water suppliers may apply to the Ministry of Health to have the treatment process in sections 5.3–5.16 assessed for a different log credit rating, based on a demonstration of performance. Water suppliers may also apply to have other treatment processes assessed for a formal log credit rating. This is covered in section 5.17. For further information, see the Guidelines, section 8.4.5.

5.2.4 Preventive and remedial actions

Water suppliers must investigate the treatment process as soon as the compliance monitoring results exceed those specified in the relevant section. See Figure 5.1 for treatment processes involving filtration, and Figure 5.2 for disinfection processes.

If the investigation results in the overall treatment process failing to achieve the total log credits required, the supplier must inform the DWA.

The water supplier must identify the cause of the transgression, and must take actions specified in the water safety plan to restore the process to a compliant condition. The water supplier must document the investigation and actions it has taken.

5.2.5 Annual compliance

Water suppliers must meet the annual compliance criteria set out in the relevant sections for each treatment process during each compliance monitoring period over 12 consecutive months.

5.3 Bank filtration of source water: treatment compliance criteria

Note the difference between bank filtration and an infiltration gallery (see Guidelines, section 8.4.1 and 12.3.1).

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 or lake, not groundwater. To do this, the system must have been in use for at least two years and sufficient data collected for an assessment of the system's ability to meet the requirements in 5.3.1 under a variety of conditions.

If there is uncertainty as to whether the bank filtration process meets the specifications in this section, the log credit requirement can be determined by monitoring *Cryptosporidium* in the abstracted water rather than the source water, thereby taking advantage of any reduction in *Cryptosporidium* numbers. If this is done, no log credits are available from the bank filtration process.

5.3.1 Log credit assessment

The credits available are based on the setback distance.[4] A setback distance of:

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

To obtain this credit the process must meet the following requirements when treated water is being delivered to consumers.

1. Core samples from the regolith surrounding the well contain at least 10 percent fine-grained material (less than 1.0 mm diameter) in at least 90 percent of their length.
2. The water is drawn from an unconsolidated, predominantly sandy aquifer.
3. Measurements of the turbidity of the water satisfy the following.
    a. For continuous monitoring, the turbidity does not exceed:
        i. 1.0 NTU for more than 5 percent of the time over the compliance monitoring period (see section 5.3.2)
        ii. 5.0 NTU for the duration of any three-minute period.
    b. For manual (or non-continuous) sampling:
        i. the number of samples with turbidity greater than 1.0 NTU does not exceed the number allowed in Appendix A1.4 over the compliance monitoring period (see section 5.3.2)
        ii. the turbidity does not exceed 5.0 NTU in any sample.
4. Documented evidence shows the turbidity does not exceed 2 NTU during the week after a flood that affects the source water (for further discussion, see the Guidelines, section 8.4.1.1).

[4] 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.

5.3.2 Monitoring

The protozoal compliance monitoring requirements are as follows.

1. Water suppliers must monitor the turbidity of the water leaving the bank filtration process for a population of:
    a. 5,000 or more – continuously
    b. fewer than 5,000 – at least daily.
2. For continuously monitored parameters, water suppliers must meet the requirements of section 3.2. The compliance monitoring periods are:
    a. for continuous turbidity monitoring – one month
    b. for daily turbidity monitoring – one quarter.

5.4 Coagulation, sedimentation and filtration processes: treatment compliance criteria

This treatment 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. Modifications to the sedimentation process such as ballasted sand and buoyant media are also acceptable (see Guidelines, Chapter 13).

5.4.1 Log credit assessment

1. To obtain 3.0 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 granular media design (gravity or pressure equivalent).
    b. Measurements of the turbidity of the water leaving each filter satisfy the following requirements.
        i. For continuous monitoring, the turbidity does not exceed:
            A. 0.30 NTU for more than 5 percent of the time over the compliance monitoring period
            B. 0.50 NTU for more than 1 percent of the time over the compliance monitoring period
            C. 1.0 NTU for the duration of any three-minute period.
        ii. For manual (or non-continuous) sampling (only for supplies up to 500):
            A. the number of samples with turbidity greater than 0.30 NTU does not exceed the number allowed in Table A1.4 over the compliance monitoring period
            B. not more than one sample exceeds 0.50 NTU over the compliance monitoring period
            C. the turbidity does not exceed 1.0 NTU in any sample.

2. Alternative for when rapid granular media filtration does not immediately follow the chemical coagulation/sedimentation process; called coagulation-enhanced pre-sedimentation in the *Long Term 2 Enhanced Surface Water Treatment Rule: Final Rule* (LT2ESWTR) (USEPA 2006a).

   To obtain 0.5 log credits for the coagulation/sedimentation process alone, water suppliers must meet the following conditions:

   a. Coagulant must be added continuously.

   b. The sedimentation process must achieve at least a 70 percent reduction in turbidity each month.

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, requirement 5.

5.4.2 Monitoring

The protozoal compliance monitoring requirements are as follows.

1. Water suppliers must measure the turbidity of the water leaving each filter at the frequencies specified in Table 5.2. They must report each filter's performance separately. Sample lines should be short and sample flows high enough to prevent adsorption or precipitation.

2. Water suppliers serving a population of up to 500 may monitor turbidity manually.

3. For continuously monitored parameters, suppliers must meet the requirements of section 3.2.

4. Water suppliers may use particle counting as an alternative to turbidimetry (see Guidelines, section 8.6.2.2) provided they have established and documented the relation between particle counts and process performance and set transgression limits to the satisfaction of the DWA.

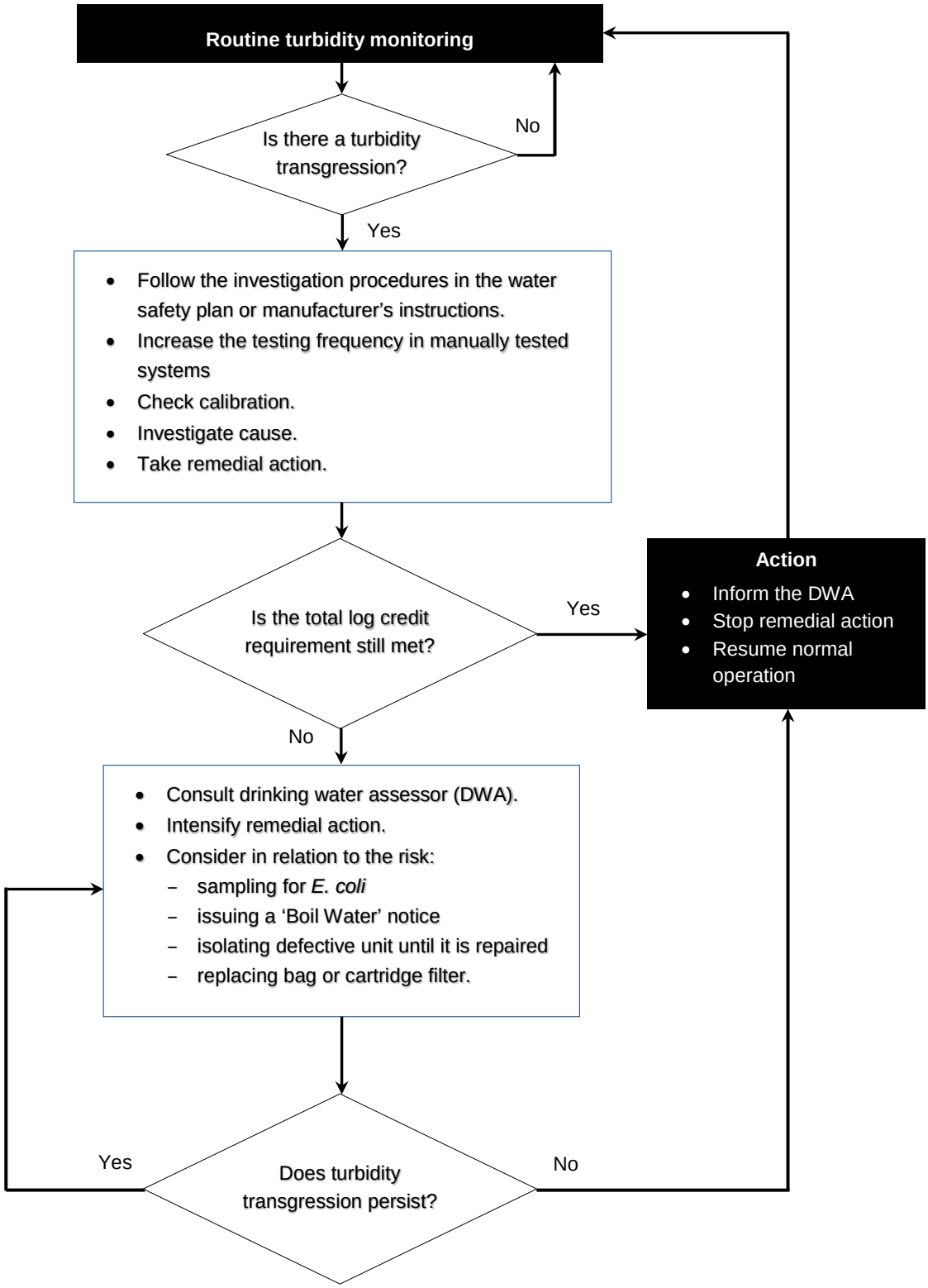
5. Where the coagulation/sedimentation process is not immediately followed by rapid granular media filtration, suppliers must measure the turbidity of the raw water and the water leaving the sedimentation process at the frequency specified in Table 5.2.

6. Table 5.2 specifies the compliance monitoring period.

Table 5.2: Minimum turbidity measurement frequency and compliance monitoring period

Population served	Number of turbidimeters for continuous monitoring	Minimum measurement frequency (manual measurement)	Compliance monitoring period	
			Continuous	Manual
More than 500	One on each filter (or housing)	*Not applicable*	One month	*Not applicable*
Up to 500	One per filter or pair of filters (or housing)	Twice a week per filter (or housing)	One month	One year

Figure 5.1: Response to turbidity transgression in water after treatment



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 when a water supplier is delivering treated water to the consumer.

1. Filtration is of a rapid granular media design (gravity or pressure equivalent).
2. Measurements of the turbidity of the water leaving each filter satisfy all the following requirements.
    a. For continuous monitoring the turbidity does not exceed:
        i. 0.30 NTU for more than 5 percent of the time over the compliance monitoring period
        ii. 0.50 NTU for more than 1 percent of the time over the compliance monitoring period
        iii. 1.0 NTU for the duration of any three-minute period.
    b. For manual (or non-continuous) sampling (only for supplies up to 500):
        i. the number of samples with turbidity greater than 0.30 NTU does not exceed the number allowed in Table A1.4 over the compliance monitoring period (Table 5.2)
        ii. not more than one sample exceeds 0.50 NTU over the compliance monitoring period
        iii. the turbidity does not exceed 1.0 NTU in any sample.

5.5.2 Monitoring

The protozoal compliance monitoring requirements are as follows.

1. Water suppliers must measure the turbidity of the water leaving each filter at the frequencies specified in Table 5.2. The water supplier must report each filter's performance separately. Sample lines should be short and sample flows high enough to prevent adsorption or precipitation.
2. Water suppliers serving a population of up to 500 may monitor turbidity manually, or continuously with one turbidimeter per filter, or shared between two filters, in which case they must sample each filter sequentially (no blending) for five minutes.
3. For continuously monitored parameters, suppliers must meet the requirements of section 3.2.
4. Water suppliers may use particle counting as an alternative to turbidimetry (see Guidelines, section 8.6.2.2), provided they have established and documented the relation between particle counts and process performance and set transgression limits to the satisfaction of the DWA.
5. Table 5.2 specifies the compliance monitoring period.

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, water suppliers must meet the following requirements (see Guidelines, sections 8.4.2 and 13.7).

1. All water passes through a second filtration stage, which consists of rapid sand, dual media, granular activated carbon or other fine grain media in a separate stage after granular media filtration. A cap, such as granular activated carbon, on a single stage of filtration will not qualify for this credit.
2. The treatment train includes chemical coagulation before the first filters.
3. Turbidity measurements of the combined second-stage filtrate must not exceed:
    a. 0.15 NTU for more than 5 percent of the time
    b. 0.50 NTU for the duration of any three-minute period.

5.6.2 Monitoring

The protozoal compliance monitoring requirements are as follows.

1. Water suppliers must measure the turbidity of the water leaving the second-stage filtration process continuously, or calculate it from the mean turbidity from online turbidimeters on each filter.
2. For continuously monitored parameters, water suppliers must meet the requirements of section 3.2.
3. The compliance monitoring period is one month.

5.7 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), water suppliers must meet the following additional criteria during periods when treated water is being delivered to the consumer. (See Guidelines, sections 8.4.2 and 13.7.)

Turbidity measurements of the filtrate from the combined filters must not exceed:

a. 0.15 NTU for more than 5 percent of the time over the compliance monitoring period
b. 0.30 NTU for more than 1 percent of the time over the compliance monitoring period
c. 0.50 NTU for the duration of any three-minute period.

5.7.2 Monitoring

The protozoal compliance monitoring requirements are as follows.

1. Water suppliers must measure the turbidity of the combined water from all filters continuously, or calculate it from the mean turbidity from online turbidimeters on each filter.
2. For continuously monitored parameters, water suppliers must meet the requirements of section 3.2.
3. The compliance monitoring period is one month.

5.8 Individual filter performance: treatment compliance criteria

5.8.1 Log credit assessment

To obtain 1.0 protozoa log credit over and above the credit for coagulation, sedimentation and filtration (or coagulation and direct filtration), water suppliers must meet the following additional criteria during periods when filtered water is going to supply. Treatment plants that receive the additional 1.0 log credit for individual filter performance cannot also receive the additional 0.5 log credit for combined filter performance. (See Guidelines, sections 8.4.2 and 13.7.)

Turbidity measurements of the water leaving each filter must not exceed:

a. 0.10 NTU for more than 5 percent of the time
b. 0.30 NTU for more than 1 percent of the time
c. 0.50 NTU for the duration of any three-minute period in any filter.

5.8.2 Monitoring

The protozoal compliance monitoring requirements are as follows.

1. Water suppliers continuously measure the turbidity of the water leaving each filter unit.
2. For continuously monitored parameters, water suppliers must meet the requirements of section 3.2.
3. The compliance monitoring period is one month.

5.9 Diatomaceous earth filtration: treatment compliance criteria

5.9.1 Log credit assessment

To obtain 2.5 protozoa log credits, the treatment process (described in the Guidelines, sections 8.4.3 and 14.2), must meet the following requirements during periods when water suppliers are producing filtered water.

1. The minimum diatomaceous earth pre-coat thickness that will reliably remove protozoa in different raw water conditions is determined by testing.

2. 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 (for further discussion, see the Guidelines, section 8.4.3.1).

    a. For continuous monitoring, the turbidity does not exceed:

        i. 0.30 NTU for more than 5 percent of the time over the compliance monitoring period

        ii. 0.50 NTU for more than 1 percent of the time over the compliance monitoring period

        iii. 1.0 NTU for the duration of any three-minute period

        iv. the turbidity of the water feeding the filter for the duration of any three-minute period.

    b. For manual (or non-continuous) sampling (only for supplies up to 500):

        i. the number of samples with turbidity greater than 0.30 NTU does not exceed the number allowed in Appendix A1.4 over the compliance monitoring period

        ii. not more than one sample exceeds 0.50 NTU over the compliance monitoring period

        iii. the turbidity does not exceed 1.0 NTU in any sample

        iv. the turbidity does not exceed the feed water turbidity in all samples.

5.9.2 Monitoring

The protozoal compliance monitoring requirements are as follows.

1. Water suppliers must measure the turbidity of the water leaving each filter unit at the frequencies specified in Table 5.2. Suppliers must monitor the feed water turbidity at the same frequency as the filtered water. Suppliers must monitor each filter's performance separately. Sample lines should be short and sample flows high enough to prevent adsorption or precipitation.

2. Water suppliers serving a population of up to 500 may monitor turbidity manually, or continuously with one turbidimeter per filter, or shared between two filters, in which case they must sample each filter sequentially (no blending) for five minutes.

3. For continuously monitored parameters, water suppliers must meet the requirements of section 3.2.

4. For compliance monitoring periods, see Table 5.2.

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 (see Guidelines, sections 8.4.3 and 14.3), water suppliers must meet the following requirements during periods when they are producing filtered water.

1. The filter does not dry out.
2. Water suppliers do not dose disinfecting chemicals leaving a residual disinfectant upstream of the filter beds.
3. Following maintenance, water suppliers do not deliver filtered water to consumers until the filtration process has been demonstrated to be effective.
4. Water suppliers operate the filters at a steady surface loading rate, which is less than 0.35 $m^3/m^2/h$.
5. The temperature of the water entering the filter does not drop below 6°C for more than 24 hours.
6. Measurement of the turbidity of the water leaving each filter must satisfy the following conditions.
    a. For continuous monitoring, the turbidity does not exceed:
        i. 0.50 NTU for more than 5 percent of the time over the compliance monitoring period
        ii. 1.0 NTU for the duration of any three-minute period
        iii. the turbidity of the water feeding the filters for the duration of any three-minute period.
    b. For manual (or non-continuous) sampling (only for supplies up to 500):
        i. not more than one sample exceeds 0.50 NTU over the compliance monitoring period
        ii. the turbidity does not exceed 1.0 NTU in any sample
        iii. the turbidity does not exceed the turbidity of the water feeding the filters in all samples.

5.10.2 Monitoring

The protozoal compliance monitoring requirements are as follows.

1. Water suppliers must measure the turbidity of the water leaving each filter unit at the frequencies specified in Table 5.2. Suppliers must monitor the feed water turbidity at the same frequency as the filtered water. Suppliers must report each filter's performance separately. Sample lines should be short and sample flows high enough to prevent adsorption or precipitation.
2. Water suppliers serving a population of up to 500 may monitor turbidity manually, or continuously with one turbidimeter per filter, or shared between two filters, in which case they must sample each filter sequentially (no blending) for five minutes.
3. For continuously monitored parameters, water suppliers must meet the requirements of section 3.2.
4. Water suppliers must measure the temperature of the raw water entering the filters daily.
5. Water suppliers must measure the flow rate through each filter at least daily.
6. For compliance monitoring periods, see Table 5.2.

5.11 Membrane filtration: treatment compliance criteria

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 micrometre 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. (See Guidelines, sections 8.4.3, 8.5.5 and 14.4.)

Membrane filtration includes microfiltration, ultrafiltration, nanofiltration and reverse osmosis.

A membrane filter plant may be an assembly of units, trains or modules or even a single membrane. 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 on the manufacturer's certification of the log removal that the filter plant can deliver. The manufacturer's certificate (or validation) must specify the operational and maintenance requirements to ensure 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. It must also document the challenge, or other, tests that were carried out to verify the log credit rating. The *Membrane Filtration Guidance Manual* (USEPA 2005) outlines a suitable verification procedure).

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. 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 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 provides documentation of the procedures that have been used to validate the log credit rating claimed.
2. The water supplier carries out the continuous indirect integrity tests set out in section 5.11.2 on each unit.

3. In addition to routine direct integrity testing (section 5.11.2), the water supplier carries out additional direct integrity testing as soon as practicable 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 lower maximum turbidity limit as part of the validation requirements, the water supplier must adopt this in place of the 0.10 NTU. Alternatively, 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.

    b. The membrane filter unit has been out of service. The testing must be done before the unit is returned to service.

4. The filtrate turbidity does not exceed the turbidity of the feedwater for the duration of any three-minute period.

5. The water supplier does not use any membrane filter unit while it has failed its direct integrity test.

6. 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, in relation to the claimed log credits.

7. Validation testing must have third-party verification by an agency accredited to ISO/IEC 17025 (IANZ 2005) or by the Measurement Standards Laboratory of New Zealand (or accreditation to an equivalent standard accepted by the Ministry of Health).

5.11.2 Monitoring

The protozoal compliance monitoring requirements are as follows.

1. The water supplier must perform direct integrity tests on each membrane filter unit at least daily and must follow the manufacturer's test procedure, including any special provisions for operating a new filter unit.

2. The water supplier must undertake indirect integrity testing by continuously monitoring the turbidity of the filtrate from each membrane filter unit.[5] To satisfy requirement 4 in section 5.11.1, the water supplier must monitor the turbidity of the water feeding the membrane filter continuously. Alternatively, if the manufacturer specifies a different continuous indirect integrity monitoring test, the water supplier must use this, and must achieve the operating targets. This alternative test must demonstrate that the membrane filtration process is achieving a removal efficiency equal to or greater than log credits awarded to the plant.

3. For continuously monitored parameters, water suppliers must meet the requirements of section 3.2.

4. Any additional monitoring required by the manufacturer to demonstrate that the filter is performing within specification must follow the procedures and frequency stated by the manufacturer.

5. The compliance monitoring period, where applicable, is one month.

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

5.12 Cartridge filtration: treatment compliance criteria

A cartridge filter plant consists of a set of housings (or pressure vessels), each containing one or more cartridge filters.

Multiple stages of cartridge filters will not qualify for more than 2.0 log credits.

5.12.1 Log credit assessment

To obtain 2.0 protozoa log credits for cartridge filtration, water suppliers must meet the following requirements during periods when they are producing filtered water.

1. Each cartridge has a certified *Cryptosporidium* or cyst removal efficiency of at least 3 log. The cartridge supplier's certification is acceptable provided an appropriately accredited inspection body has performed the testing, and it meets one of the following:
    a. the USEPA (2010)'s *Long Term 2 Enhanced Surface Water Treatment Rule: Toolbox Guidance Manual* Part 8: Bag and Cartridge Filters
    b. the (oo)cyst reduction conditions of *Drinking Water Treatment Units: Health effects*, NSF/ANSI 53 (NSF, ANSI 2002)
    c. the (oo)cyst removal requirements of a standard formally recognised by the Ministry of Health as being equivalent (eg, AS/NZS 4348:1995 in conjunction with AS/NZS 3497:1998 (updated 2001)).
2. Water suppliers must meet the following additional requirements:
    a. The cartridge is single-open-ended, plug-in style, sealed in the housing with o-rings.
    b. When scaling up, the field cartridge is the same diameter and construction as the test cartridge, and the cartridge is of uniform construction over its entire length with no joins or joiners; heat-bonded joins are suitable.
    c. An automatic air release valve is installed on the top of the filter housing.
    d. A default maximum headloss of 150 kPa is set unless the manufacturer can demonstrate that performance is maintained beyond that. Water suppliers must replace cartridges before the terminal pressure drop is reached.
    e. New/replacement cartridges and plants that operate an on/off regime are run to waste for the first five minutes they come online; this should be during the slow start process, and does not have to be at the full flow rate, but sufficient to wash out any impurities.
    f. The installed equipment is identical (or validated as equivalent) to the equipment tested during the certification process.
3. Measurements of the turbidity of the water leaving each housing must satisfy the following requirements, except where the water contains colloidal material that has been shown to be consistently below 1 μm, when the DWA may approve alternative criteria (see Guidelines, section 8.4.3.4).
    a. For continuous monitoring, the turbidity does not exceed:
        i. 0.50 NTU for more than 5 percent of the time over the compliance monitoring period
        ii. 1.0 NTU for the duration of any three-minute period
        iii. the turbidity of the water feeding the cartridges for the duration of any three-minute period.

b. For manual (or non-continuous) sampling (only for supplies up to 500):
   i. the number of samples with turbidity greater than 0.50 NTU does not exceed the number allowed in Appendix A1.4 over the compliance monitoring period
   ii. the turbidity does not exceed 1.0 NTU in any sample
   iii. the turbidity does not exceed the feed water turbidity in all samples.

4. Individual cartridges are clearly labelled with the manufacturer's name and the part number that relates to the certification.

5. A slow opening/closing valve is fitted ahead of each housing, and the filtrate passes either through a pressure surge valve or directly to a tank before any subsequent process or pumping.

6. The flow through each housing is measured as specified in Table 5.3. A restrictor (or other acceptable technique) that maintains the flow below the certified maximum operating rate is fitted to each housing.

7. Differential pressure measurements across the housing are recorded to confirm that the minimum differential pressure always exceeds the differential pressure corresponding to a clean filter established during commissioning, and is 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.

5.12.2 Monitoring

The protozoal compliance monitoring requirements are as follows.

1. Turbidity
   a. Water suppliers must measure turbidity (or particle counts) in the water leaving each housing at the frequencies specified in Table 5.3. Sample lines should be short and sample flows high enough to prevent adsorption or precipitation. Water suppliers serving a population of up to 500 may monitor turbidity manually, or continuously with one turbidimeter per filter housing, or shared between two housings, in which case they must sample each sequentially (no blending) for five minutes.
   b. If suppliers use particle counting instead of turbidity, they must monitor particles in the 2–5 μm size range in the water leaving each housing. The transgression limit 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.
   c. Water suppliers must monitor the feed water turbidity (or particle counts) at the same frequency as the filtered water is monitored.

2. Differential pressure: water suppliers must measure the differential pressure across each housing at the frequencies specified in Table 5.3. Suppliers must make differential pressure measurements immediately after cartridge replacement to ensure proper seating and no damage to the cartridge. They must do this at maximum water flow rate (a post-filtration waste valve can be installed to achieve maximum flow).

    a. For continuous monitoring, differential gauges or pressure transducers:
        i. are fitted to each housing
        ii. have a 1.0 kPa accuracy.

    b. For manual monitoring (ie, for populations of up to 500), pressure gauges:
        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).

3. For continuously monitored parameters, water suppliers must meet the requirements of section 3.2.

Table 5.3: 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	Continuous	Continuous
501–10,000	Continuous[1]	Continuous	Continuous	Twice a week
500 or less	Twice a week	Daily[3]	Twice a week	Not required

Notes:

1. Measurement on each housing.
2. Particle counting is optional.
3. Obtained from water meter readings.

5.13 Bag filtration: treatment compliance criteria

A bag filter unit comprises a single bag filter or a pair of bag filters operating in series or parallel. Multiple stages of bag filters will not qualify for more than 1.0 log credit.

5.13.1 Log credit assessment

To obtain 1.0 protozoa log credit for bag filtration, water suppliers must meet the following requirements during periods when they are producing filtered water.

1. The bag filter has a certified *Cryptosporidium* removal efficiency of 2.0 log removal or greater. Water suppliers may adopt the equipment or appliance supplier's certification, provided:
    a. it meets one of:
        i. the USEPA's (2010) *Long Term 2 Enhanced Surface Water Treatment Rule: Toolbox Guidance Manual* Part 8: Bag and Cartridge Filters
        ii. the (oo)cyst reduction conditions of *Drinking Water Treatment Units: Health effects*, NSF/ANSI 53-2012 (and subsequent revisions)
        iii. the (oo)cyst removal requirements of a standard formally recognised by the Ministry of Health as being equivalent (eg, AS/NZS 4348:1995 in conjunction with AS/NZS 3497:1998 (updated 2001)).
    b. an appropriately accredited inspection body has performed the testing
    c. the tests are made on entire units, including filtration media, seals and other components integral to the process
    d. the installed equipment is identical (or validated as equivalent) to the equipment tested during the certification process.
2. Measurements of the turbidity of the water leaving each bag must satisfy the following requirements, except where the water contains colloidal material that has been shown to be consistently below 1 μm, when the DWA may approve alternative criteria (see Guidelines, section 8.4.3.3).
    a. For continuous monitoring, the turbidity does not exceed:
        i. 0.50 NTU for more than 5 percent of the time over the compliance monitoring period
        ii. 1.0 NTU for the duration of any three-minute period
        iii. the turbidity of the water feeding the bag filter for the duration of any three-minute period.
    b. For manual (or non-continuous) sampling (only for supplies up to 500):
        i. the number of samples with turbidity greater than 0.50 NTU does not exceed the number allowed in Appendix A1.4 over the compliance monitoring period
        ii. the turbidity does not exceed 1.0 NTU in any sample
        iii. turbidity does not exceed the feed water turbidity in all samples.
3. Bag filters are clearly labelled with the manufacturer's name and the part number that relates to the certification.
4. A slow opening/closing valve is fitted ahead of each housing, and the filtrate passes either through a pressure surge valve or directly to a tank before any subsequent process or pumping.

5. The flow through each housing is measured as specified in Table 5.3. A restrictor that maintains the flow below the certified maximum operating rate is fitted to each bag or unit.

6. Differential pressure measurements across the bag or unit are recorded to confirm that the minimum differential pressure always exceeds the differential pressure corresponding to a clean filter established during commissioning, and is kept within the manufacturer's recommendations.

5.13.2 Monitoring

The protozoal compliance monitoring requirements are as follows.

1. Turbidity

    a. Water suppliers must measure turbidity (or particle counts) in the water leaving each filter unit at the frequencies specified in Table 5.3. Sample lines should be short and sample flows high enough to prevent adsorption or precipitation. Water suppliers serving a population of up to 500 may monitor turbidity manually, or continuously with one turbidimeter per filter housing, or shared between two housings, in which case they must sample each sequentially (no blending) for five minutes.

    b. If suppliers use particle counting instead of turbidity, they must monitor particles in the 2–5 μm size range in the water leaving each housing. The transgression limit 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.

    c. Water suppliers must monitor the feed water turbidity (or particle counts) at the same frequency as the filtered water is monitored.

2. Differential pressure: water suppliers must measure the differential pressure immediately after each bag replacement to check the bag is properly seated and no damage has occurred. Suppliers must take differential pressure measurements at maximum flow. Suppliers must fit a valve and drain to waste after the filter and flow restrictor and ensure it is open when they take and record the pressure reading.

    a. For continuous monitoring, differential gauges or pressure transducers:
        i. are located to each bag or pair of bags operating in as a unit
        ii. have a 1.0 kPa accuracy.

    b. For manual monitoring (ie, for populations of up to 500), pressure gauges:
        i. are located before and after each bag or pair of bags operating as a unit
        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).

3. For continuously monitored parameters, water suppliers must meet the requirements of section 3.2. The flow to each bag filter or unit must be measured as specified in Table 5.3.

5.14 Chlorine dioxide: treatment compliance criteria

5.14.1 Log credit assessment

The credits available are based on the demonstration of inactivation as stated in the table of chlorine dioxide C.t values (Table 5.4). For guidance in determining contact times, see Guidelines, sections 8.6.2.5 and 15.2.9, and *Toolbox Guidance Manual* (USEPA 2010).

Table 5.4: C.t values (min.mg/L) for *Cryptosporidium* inactivation by chlorine dioxide

Log credit	Water temperature (°C)[1]					
	1	5	10	15	20	25
0.25	153	107	69	45	29	19
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

Notes:

- C.t values between the indicated temperatures may be determined by interpolation.
- Chlorine dioxide is measured as ClO_2.

Water suppliers must meet the following requirements when the water reaches the first consumer.

1. The measured C.t value is not less than:
    a. the C.t value given in Table 5.4 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 5.4 for the claimed log credit and measured water temperature for the duration of any five-minute period (or no more than two readings in five minutes).
2. Measurements of the turbidity of the water being disinfected satisfy all the following requirements.
    a. For continuous monitoring, the turbidity does not exceed:
        i. 1.0 NTU for more than 5 percent of the compliance monitoring period
        ii. 2.0 NTU for the duration of any three-minute period.
    b. For manual (or non-continuous) sampling:
        i. the number of samples with turbidity greater than 1.0 NTU does not exceed the number allowed in Appendix A1.4 over the compliance monitoring period (see section 5.14.2)
        ii. the turbidity does not exceed 2.0 NTU in any sample.
3. The chlorite concentration in the water does not exceed a concentration of 0.8 mg/L. Chlorite is potentially a Priority 2a determinand (see section 8.3.3).

5.14.2 Monitoring

The protozoal compliance monitoring requirements are as follows.

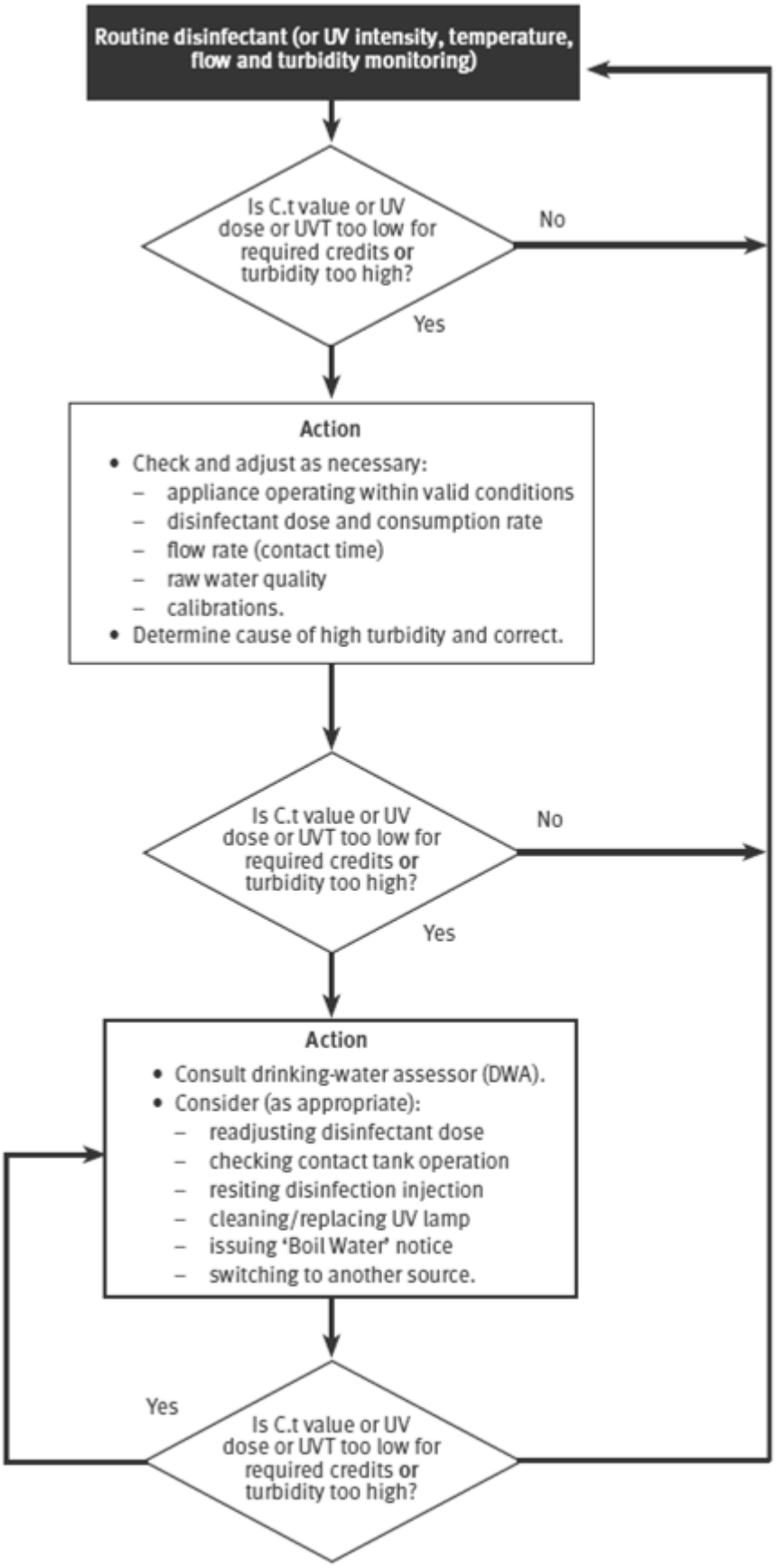
1. The chlorine dioxide sampling site is at a point where the adequacy of the residual and the minimum disinfection contact time[6] can be demonstrated clearly, but before the first consumer.
2. Water suppliers must monitor the chlorine dioxide residual continuously.
3. Water suppliers must measure the flow continuously.
4. Water suppliers must measure the water temperature daily, if it has been shown to vary by less than 2°C in 24 hours over a month in summer; otherwise, they must make measurements at least every four hours. Suppliers must make measurements at the same location at which they measure the chlorine dioxide residual or in the raw water.
5. Water suppliers must measure the turbidity of the water leaving the disinfection process:
   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 500 or fewer people.
6. For continuously monitored parameters, suppliers must meet the requirements of section 3.2.
7. When the chlorite concentration is likely to exceed 50 percent of the MAV, suppliers must establish a monitoring programme to the DWA's satisfaction.

The compliance monitoring period for:

- C.t values is one month
- turbidity is:
  - a month for continuous readings
  - a quarter for manual readings for populations of 5,001–10,000
  - a year for manual readings for populations of up to 5,000.

[6] 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).

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



5.15 Ozone disinfection: treatment compliance criteria

5.15.1 Log credit assessment

The credits available are based on the demonstration of inactivation as stated in the table of ozone C.t values (Table 5.5). For discussions on determining contact times, see the Guidelines, section 8.4.4.2, and *Toolbox Guidance Manual* (USEPA 2010).

Table 5.5: C.t values[1] (min.mg/L) for *Cryptosporidium* inactivation by ozone

Log credit	Water temperature (°C)[2]					
	1	5	10	15	20	25
0.25	5.8	4.0	2.5	1.6	1.0	0.6
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 0.25–5.0 mg/L. For further information, see Guidelines, section 8.4.4.1.
2. C.t values between the indicated temperatures may be determined by interpolation.

Water suppliers must meet the following requirements.

1. The C.t value determined from the measured ozone residual and flow rate, adjusted to incorporate the effects of ozone decay and reactor hydraulics (for further information, see Guidelines, sections 8.4.4.2 and 8.6.2.5) meets the following requirements.
    a. For continuous monitoring, the C.t value is not less than:
        i. 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 5.15.2)
        ii. 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.
    b. For manual (or non-continuous) sampling:
        i. the number of calculated C.t values failing to attain the C.t value given in Table 5.5 for the claimed log credit and measured water temperature does not exceed the number allowed in Appendix A1.4 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 5.5 for the claimed log credit and measured water temperature.
2. 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).

3. Measurements of the turbidity of the water being disinfected satisfy the following.
    a. For continuous monitoring, turbidity does not exceed:
        i. 1.0 NTU for more than 5 percent of the compliance monitoring period (see section 5.15.2)
        ii. 2.0 NTU for the duration of any three-minute period.
    b. For manual (or non-continuous) sampling:
        i. the number of samples with turbidity greater than 1.0 NTU does not exceed the number allowed in Appendix A1.4 over the compliance monitoring period (see section 5.15.2)
        ii. turbidity does not exceed 2.0 NTU in any sample in the compliance monitoring period.
4. Water suppliers validate equipment as described in the *Toolbox Guidance Manual* (USEPA 2010) or a standard the Ministry of Health has formally recognised as equivalent.

Note that the turbidity requirements apply only when ozone is used for disinfection. They do not apply to the use of ozone for treatment before filtration for the purpose of controlling colour, organic matter or disinfection by-products.

5.15.2 Monitoring

The protozoal compliance monitoring requirements are as follows.

1. Water suppliers must monitor the ozone residual:
    a. continuously for supplies serving more than 500 people
    b. daily for supplies serving 500 or fewer people.
2. The residual ozone sampling site must be at a point in the contactor where the adequacy of the minimum disinfection contact time can be demonstrated clearly (for further information, see Guidelines, section 15.5.4). The site for the ozone online 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 value experienced by the water will be 90 percent of the C.t that gives 0.5 log credits (Table 5.5).
3. C.t value calculations for supplies are as follows.
    a. For supplies serving more than 500 people, calculations must be continuous.
    b. For supplies serving 500 or fewer people, calculations must be daily, using ozone concentration measurements made at the peak hourly flow. Contact times do not have to be determined daily, only the concentration, but after the initial determination of the contact time it must be re-evaluated if modifications affect the process hydraulics.
4. Water suppliers must measure the water temperature daily, if it has been shown to vary by less than 2°C in 24 hours over a month in summer, and otherwise make measurements at least every four hours. Suppliers must make measurements at the same location at which they measure the ozone residual or in the raw water. For batch process plants they must measure the temperature of each batch.

5. Water suppliers must measure the turbidity of the water leaving the disinfection process:
   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 500 or fewer people.
6. Water suppliers must make flow measurements continuously if serving more than 500 people. For supplies serving 500 or fewer people suppliers must fit a flow restrictor 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, water suppliers must meet the requirements of section 3.2.
8. When the bromate concentration is likely to exceed 50 percent of the MAV, water suppliers must establish a monitoring programme 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:
  - a month for continuous readings
  - a quarter for manual readings for populations of 5,001–10,000
  - a year for manual readings for populations of up to 5,000.

5.15.3 Standardising the ozone analyser

Ozone analyser standardisation 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 standardised against the indigo method, Standard Methods 4500-ozone (APHA 2012), at least once every six months by a Ministry of Health-recognised laboratory. The preferred method for standardising the online ozone analyser is described in the Guidelines, section 15.5.4.

5.16 Ultraviolet light disinfection: treatment compliance criteria

5.16.1 Log credit assessment

The protozoal log credits available for UV disinfection are based on the UV dose (fluence) delivered by validated UV reactors or appliances.

To obtain the claimed protozoa log credit for UV disinfection, water suppliers must meet the following requirements.

1. UV irradiance, measured by the UV intensity meter (UV sensor), is not less than:
    a. the value (established by validation) required to achieve the claimed log credit for more than 5 percent of the compliance monitoring period (see section 5.16.3)
    b. 80 percent of the value (established by validation) required for the claimed log credit for the duration of any three-minute period.
2. The water entering the UV reactor has done one of the following (a or b).
    a. The water has passed through a cartridge filter nominally rated at a 5-µm or smaller pore size that has sufficient rigidity to remove contaminants and prevent unloading of these contaminants caused by pressure surges. Also, the filtered water has a turbidity that never exceeds 2.0 NTU (see Table 5.6 for monitoring frequency) except where the turbidity has been shown to be due to colloidal material that is consistently below 1 µm, when the DWA may approve alternative criteria (for further discussion, see Guidelines, section 8.4.4.3).
    b. The water has met the following turbidity requirements.
        i. For continuous monitoring, the turbidity does not exceed:
            A. 1.0 NTU for more than 5 percent of the compliance monitoring period (see section 5.16.3)
            B. 2.0 NTU for the duration of any three-minute period.
        ii. For manual (or non-continuous) sampling:
            A. the number of samples with turbidity greater than 1.0 NTU does not exceed the number allowed in Appendix A1.4 over the compliance monitoring period
            B. the turbidity does not exceed 2.0 NTU in any sample.
        iii. For bore water supplies serving a population of up to 500, turbidity monitoring may cease if all samples for two years have a turbidity less than 1.0 NTU.
3. UV disinfection systems that do not automatically adjust the UV dose as the UV transmittance (UVT) varies must ensure the UVT remains inside its validated conditions by monitoring the UVT (measured at 253.7 nm) of the water flowing through the reactor. The monitoring requirements for such systems are as follows.
    a. For supplies serving a population of over 500:
        i. for continuous monitoring, the water entering the UV reactor has a UVT that:
            A. is not less than 95 percent of the lowest transmittance for which the reactor has been validated for more than 5 percent of the time over the compliance monitoring period

B. is not less than 90 percent of the lowest transmittance for which the reactor has been validated for more than 2 percent of the time over the compliance monitoring period

C. does not read less than 80 percent (measured in a 10 mm cell) for the duration of any three-minute period

ii. for manual (or non-continuous) sampling:

A. the number of samples with transmittance less than 95 percent of the lowest transmittance for which the reactor has been validated does not exceed the number allowed in Appendix A1.4 over the compliance monitoring period

B. no sample has less than 90 percent of the lowest transmittance for which the reactor has been validated

C. no sample has less than 80 percent transmittance (in a 10 mm cell)

b. For supplies serving a population of up to 500, the water entering the UV reactor has the following UVT requirements:

i. no sample has less than 80 percent transmittance (in a 10 mm cell)

ii. UVT monitoring of bore water supplies may cease if all samples for two years have a reading greater than 90 percent (measured in a 10 mm cell).

4. The equipment is operated within the flow range for which it was validated for at least 95 percent of the time.

5.16.2 Validation

The UV disinfection equipment manufacturer is responsible for obtaining and providing certification of validation; the equipment must be validated to meet the required log credit using one of:

- the *Ultraviolet Disinfection Guidance Manual* (USEPA 2006b): variable log credits
- DVGW Technical Standard W294 (DVGW 2006): 3 log credits
- öNORM M5873 (Osterreichisches Normungsinstitut 2001): 3 log credits
- NSF/ANSI 55 (NSF, ANSI nd) for Class A systems (for populations of up to 5000): 3 log credits
- a validation procedure acceptable to the Ministry of Health.

Validation documentation must be provided to the DWA in the 'Template for UV Disinfection: evidence of validation' included in Chapter 8 of the Guidelines. The template includes:

1. Validation testing of UV reactors must determine a range of operating conditions the reactor can monitor and under which the reactor delivers the required UV dose to achieve the target log credit. These operating conditions must include, at least:

a. flow rates

b. UV intensity (fluence rate) as measured by a UV intensity sensor

c. UV lamp status

d. minimum UVT of the water for which the UV reactor has been validated to achieve the target inactivation.

2. The validated operating conditions determined by this testing must account for the:
    a. UVT or absorbance of the water
    b. lamp type
    c. lamp burn-in time, fouling and ageing
    d. water temperature
    e. measurement uncertainty of online sensors
    f. UV dose distributions arising from the velocity profiles through the reactor
    g. failure of UV lamps or other critical system components
    h. inlet and outlet piping or channel configurations of the UV reactor.

3. Validation testing must include the:
    a. full-scale testing of a reactor that conforms uniformly to the UV reactors to be used at the treatment plant
    b. inactivation of a test micro-organism whose dose response characteristics have been quantified with a low pressure mercury vapour lamp.

5.16.3 Monitoring

The protozoal compliance monitoring requirements are as follows.

1. Water suppliers must meet the monitoring requirements stated in Table 5.6 and associated notes.

2. The standardisation and replacement of the sensors, using the manufacturer's instructions, must meet the following requirements.
    a. Duty sensors:
        i. Suppliers must check the standardisation of the sensor, which must be located at the same point in the reactor as that used for the validation, at least monthly against the reference sensor.[7]
        ii. Water suppliers serving up to 500 people may use a second duty sensor instead of a reference sensor when conducting the monthly standardisation of the duty sensor.
    b. Reference sensors:
        i. The reference sensor must be standardised at least annually in accordance with *Ultraviolet Disinfection Guidance Manual* (USEPA 2006b) or other traceable procedure, with third-party verification given by an agency accredited to ISO/IEC 17025 (IANZ 2005) for this type of standardisation, or by the Measurement Standards Laboratory of New Zealand (or accreditation to an equivalent standard accepted by the Ministry of Health).
        ii. Alternatively, after 12 months the supplier can use the reference sensor as a duty sensor and purchase a new standardised sensor for use as a reference sensor.

3. For continuously monitored parameters, water suppliers must meet the requirements of section 3.2.

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

[7] The sensors should be the same as those used during the validation. The sensor designated as the reference sensor must receive limited exposure to UV light and be stored so that its integrity and accuracy are maintained.

Table 5.6: Minimum monitoring requirements for ultraviolet disinfection

Population served	Parameter	Minimum monitoring frequency (or control)
More than 10,000	Flow (each reactor)[1]	Continuous
	Turbidity[1]	Continuous
	UV intensity[1]	Continuous
	UVT[2]	Continuous
	Lamp outage	Continuous
501–10,000	Flow (each reactor)[1]	Continuous
	Turbidity[1]	Continuous
	UV intensity[1]	Continuous
	UVT[2]	Twice a week[3]
	Lamp outage	Continuous
101–500	Flow (total)[1]	Continuous
	Flow (each reactor)[4]	Flow restrictor
	Turbidity	Weekly[5]
	UV intensity[1]	Continuous
	UVT[2]	Weekly[3,6]
	Lamp replacement hour meter	Continuous
	Lamp outage	Continuous
100 or fewer	Flow (each reactor)	Flow restrictor
	Turbidity	Monthly[5]
	UV intensity[1]	Continuous
	UVT[2]	Monthly[6]
	Lamp replacement hour meter	Continuous
	Lamp outage	Continuous

Notes:

For a description of UVT (or absorbance) units, see Appendix A1.3.11. For discussion on the measurement of UVT, see the Guidelines, section 8.6.2.6 and the datasheet.

1. Water suppliers must install an alarm to alert the operator in the event of the parameter being outside the range of its validated limits.
2. If the UV dose is automatically adjusted as the UVT of the water flowing through the reactor varies, water suppliers must measure UVT online, but do not need to record the results for compliance purposes.
3. May be reduced to monthly if after 12 months' monitoring, transmittance is not less than that for which the reactor has been validated.
4. Flow restriction is an alternative to continuous flow measurement in individual reactors for populations of up to 500.
5. Monitoring of bore water turbidity may cease if all samples for two years have a turbidity less than 1.0 NTU.
6. Monitoring of bore water UVT may cease if all samples for two years have a UVT greater than 90 percent (measured in a 10-mm cell).

5.17 Alternative processes: treatment compliance criteria

Water suppliers may apply to the Ministry of Health to have other treatment processes assessed for a log credit rating. Water suppliers may also apply for a variation for treatment that performs:

- demonstrably better than its compliance criteria
- to a lesser but reliable level than that specified in its compliance criteria or validation.

Information supporting the application must include (as a minimum):

- the site code of the supply
- a description of the quality of the raw water that will be treated
- a description of the treatment process and its limitations
- the intended maximum (and minimum, if relevant) treatment and flow rates
- the operating parameters that need to be met to confirm the claimed log removal
- for a new process, results from a bench-scale or pilot plant challenge test
- for a new process, a quantitative description of the performance of the full-scale process elsewhere, including details of (oo)cyst removal/inactivation or equivalent, including:
  - a description of the water the process treated
  - the treatment rates or loading rates the data provided relate to
  - monitoring results
- for a re-rating of an existing process, demonstration of *Cryptosporidium* removal efficiency (or equivalent) over a full range of expected operating conditions.

The supporting data must have been generated by organisations accredited by appropriate accreditation agencies.

A treatment plant cannot gain additional log credits using this section if it is already claiming log credits for individual processes. For example, a coagulation–sedimentation–filtration plant (section 5.4) cannot claim demonstration of performance log credits if it is already claiming log credits for enhanced combined filter performance (section 5.7).

Treatment plants claiming 3 log credits for a disinfection process cannot increase this by a demonstration of performance; when a water supply needs more than 3 log credits for protozoal compliance, a filtration technique must provide the additional log credits (ie, the application of the multiple-barrier principle).

If a new process or variation satisfies the above requirements, the Ministry of Health will develop compliance criteria specific to that process and site.

For further discussion, see Guidelines, section 8.4.5.

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 that 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 are coagulation and filtration, and UV treatment is less effective at killing viruses than the other disinfectants the DWSNZ recognise. The UV disinfection criteria in section 5.16 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, water suppliers should use at least two disinfectants, one of which may be chlorine, to provide adequate protection against viruses as well as protozoa.

7 Cyanotoxin compliance criteria

7.1 Introduction

Cyanotoxins are produced by cyanobacteria (also 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 bore waters. However, bores less than 10 m deep and spring water could contain cyanotoxins due to run-off or seepage from ponded water or nearby wet soil that supports the growth of cyanobacteria.

Although cyanotoxins are chemical determinands, several factors, such as their ability to reach health-significant levels rapidly, mean their monitoring requirements are different from those of other chemical determinands.

7.2 Management protocols

When source water has previously experienced algal blooms or the DWA judges it to be at risk of bloom development, the following requirements apply.

1. Water suppliers must 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 50 percent of the MAV.
2. Water suppliers must develop a protocol that:
    a. identifies which determinands or observations are to be monitored for assessing the development of cyanobacteria
    b. specifies the actions that the supplier will take 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).
3. Water suppliers must collect source water samples for analysis of cyanotoxins (section 7.3.2).
4. Water suppliers must 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.

Laboratories that undertake cyanobacteria cell counts and cyanotoxin analysis appear in the Ministry of Health's Register of Recognised Laboratories for New Zealand at:

- www.health.govt.nz/water
- www.drinkingwater.esr.cri.nz
- www.ianz.govt.nz/

7.3 Priority 2b determinands

7.3.1 Identification of Priority 2b determinands

A cyanotoxin is assigned as a Priority 2b determinand in the water leaving the 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 its MAV
- based on the outcome of the investigations discussed 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
- a trend of decreasing toxin concentration.

7.3.2 Compliance requirements for Priority 2b determinands

Once a cyanotoxin is assigned as a Priority 2b determinand to a supply, water suppliers must meet the requirements in this section.

7.3.2.1 Sampling frequency

Water suppliers must sample source water, raw water and water from the treatment plant or distribution zone at least twice weekly for cyanotoxin analysis, until the cyanotoxin is reclassified as a Priority 3 determinand.

7.3.2.2 Sampling location

Water suppliers must carry out sampling of source water 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 (for further discussion, see Guidelines, section 9.5).

Water suppliers must take samples for cyanotoxin analysis of treated water from water leaving the treatment plant, or from the distribution zone if cyanotoxin breakthrough is suspected.

7.3.2.3 Analytical requirements

Water suppliers may only use laboratories recognised by the Ministry of Health for the purpose for the compliance testing of cyanotoxins.

7.3.3 Remedial actions

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

When a transgression occurs, water suppliers must investigate the cause as soon as practicable. For guidance on investigating the causes of transgressions, see the Guidelines, Chapter 9.

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

- inform the DWA
- provide consumers with an alternative source of water until toxin analysis of the water in the distribution system shows the cyanotoxin concentration to have diminished to below 50 percent of the MAV in three successive samples
- 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 determinands of health significance being present in drinking-water at levels that present a significant health risk.

Chemical constituents of drinking-water may come from the:

- source water
- treatment process
- distribution system
- consumers' plumbing.

Sections 8.2–8.4 detail how water suppliers will demonstrate compliance for those determinands that have been designated as Priority 2 for a particular supply. (See section 3.3 for a general discussion about priority classes.)

8.2 Compliance criteria

Three types of Priority 2 chemical determinands exist.

- *Priority 2a*: Chemical determinands that could be introduced into the drinking-water supply by chemicals at the treatment plant 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, cyanotoxins (see section 7) and determinands introduced into the drinking-water from the water supplier's piping or other construction materials.
- *Priority 2c*: Chemical determinands of health significance, usually a metal that may appear in tap water, having arisen from consumers' plumbing or fittings. When the concentration of a metal in a non-flushed sample, less its concentration in a flushed sample, is more than 50 percent of the MAV, the metal is assigned Priority 2c.

  Priority 2c determinands arise from a property of the water supply, called 'plumbosolvency' in these standards. The DWSNZ do not cover elevated concentrations of metals of health concern caused by poor grade domestic plumbing, fittings or faulty installation.

Water suppliers must monitor determinands specified by the Ministry of Health as Priority 2a or Priority 2b to establish compliance with the DWSNZ. Priority 2a or Priority 2b determinands may be specific to individual distribution zones, or the treatment plant if the determinand applies to more than one zone. Chapter 10 of the Guidelines discusses appropriate sampling sites.

8.2.1 Compliance criteria for Priority 2 determinands

8.2.1.1 General

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

1. Sampling and analysis must comply with the requirements of the DWSNZ.

2. When more than one determinand with a MAV that causes similar toxicological effects is present, the sum of the ratios of the concentration of each determinand to its respective MAV must not exceed one. In the DWSNZ, this applies to nitrate/nitrite, trihalomethanes (THMs), the haloacetic acids and haloacetonitriles.

3. The number of transgressions found, when sampling is carried out at the frequency specified, must not exceed the allowable number of transgressions in Appendix A1.4. This table refers to the number of samples taken at equal intervals over the compliance period. For Priority 2 determinands, the compliance monitoring period is one year. In most cases, the number of samples tested during a year will be less than 76, in which case each transgression will result in non-compliance.

4. Water suppliers must follow the procedure outlined in section 8.4 when determinands exceed the MAV.

Figure 8.1 illustrates how to establish compliance of Priority 2a and 2b determinands with the DWSNZ. Figure 8.1 also shows that if the results of all the samples required to be collected in 12 months (see Table 8.1) are less than 50 percent of the MAV, the determinand reverts to Priority 3 (see section 8.2.2).

8.2.1.2 Compliance criteria for Priority 2a determinands

Compliance can be demonstrated by using the certified analysis of water treatment chemicals and calculating whether any determinands are Priority 2a.

8.2.1.3 Compliance criteria for Priority 2b determinands

Priority 2b determinands comprise two 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.

8.2.1.4 Compliance criteria for Priority 2c determinands

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 the water may dissolve metals from fittings if it lies in the plumbing, for example, overnight. Waters with a high carbon dioxide content also dissolve metals.

If the concentration of a metal in unflushed samples taken from consumers' taps less its concentration in flushed samples is more than 50 percent of the MAV, the DWSNZ call the water supply plumbosolvent.

Experience with New Zealand water supplies has shown that lead is the main metal of health concern found in unflushed samples taken from consumers' taps. Some waters have been shown to cause copper to exceed its MAV in unflushed samples due to corrosion of the copper tubing.

Option a

All drinking-water supplies are assumed to be plumbosolvent unless demonstrated not to be by following option b. Where there is no evidence that the water is not plumbosolvent, water suppliers servicing more than 500 people must follow 1 and 2:

1. Publish in a newspaper twice a year a public notice provided by the Ministry of Health.
2. Provide this public warning to all consumers at least twice a year; for example, with each water supply bill or water rate demand.

For general advice about plumbosolvent waters and flushing away metals of health concern, see Guidelines, sections 10.2.2, 10.2.6, 10.3.3 and 10.4.2.

Option b

When a water supplier wishes to demonstrate that the water from its supply is not plumbosolvent, it may use the procedures detailed in sections 10.3.3 and 10.4.2 of the Guidelines.

8.2.2 Compliance criteria for Priority 3 determinands

Priority 3 chemicals do not have to be monitored, unless assigned a Priority 2 determinand.

A Priority 2a or Priority 2b 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 must continue at least quarterly 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.

8.3 Monitoring requirements

8.3.1 Sampling sites for Priority 2a determinands

If water suppliers do not use the procedure described in section 8.2.1.2, they may carry out sampling of Priority 2a determinands that are introduced with water treatment chemicals in the drinking-water leaving the treatment plant or from the distribution zone if the determinand concentration is unlikely to change during distribution.

8.3.2 Sampling sites for Priority 2b determinands

Water suppliers may monitor Priority 2b Type 1 determinands (those unlikely to vary in the distribution system) in the drinking-water leaving the treatment plant or in the distribution zone if this is more convenient.

Water suppliers must sample Priority 2b Type 2 determinands (those that may vary in the distribution system), which have a source in the distribution system, or which react in or with it, from only the distribution zone.

Water suppliers must select distribution zone sampling sites 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, suppliers must collect samples for monitoring disinfection by-products (Priority 2b Type 2 determinands) from sampling sites near the ends of the distribution system, but should only collect samples if the disinfection process has been operating normally for several days beforehand.

8.3.3 Monitoring frequencies for Priority 2a determinands

Table 8.1 summarises sampling frequencies.

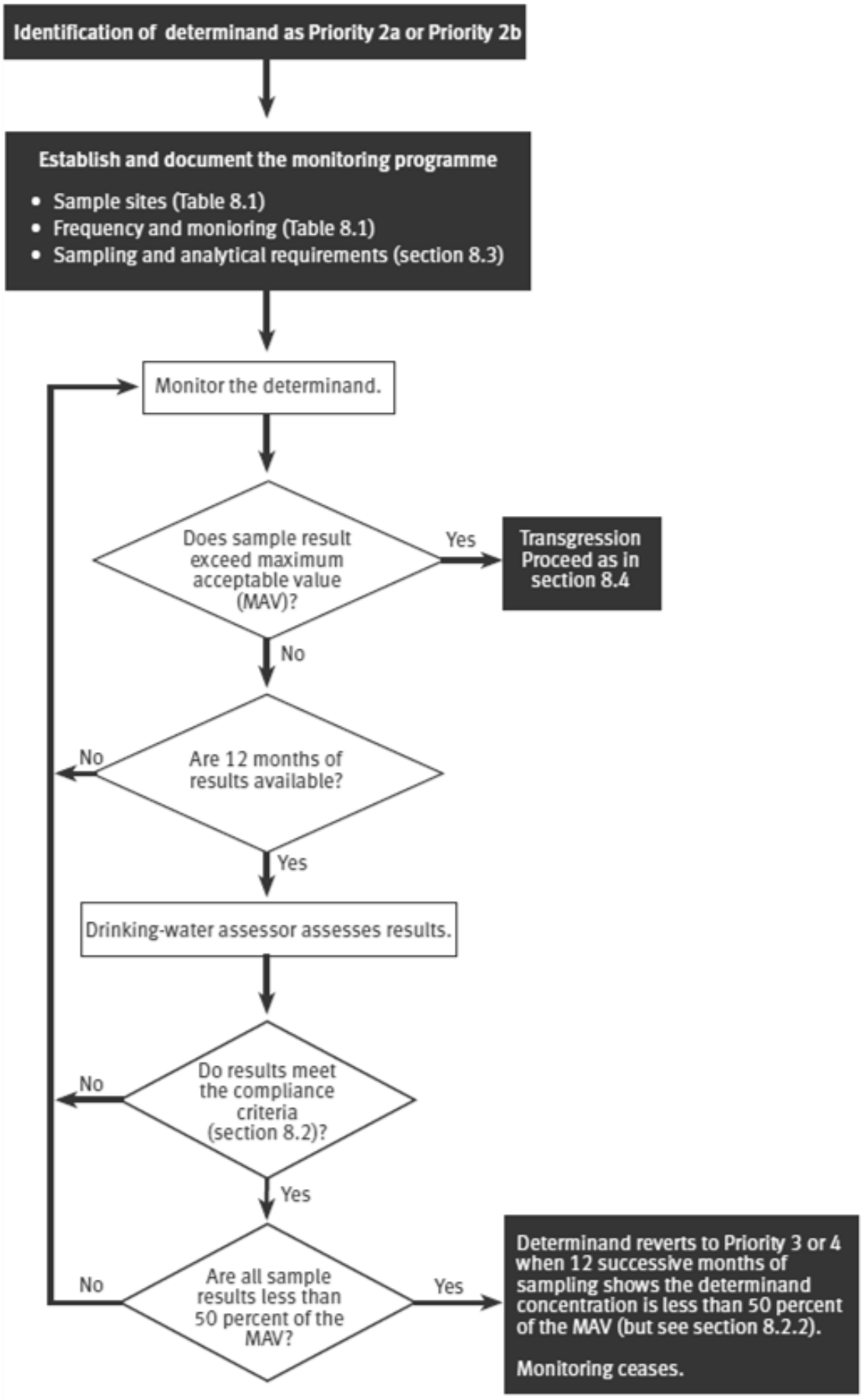
The monitoring programme must include sufficient additional samples to meet any deficiencies that arise from a failure to comply with the programme prescribed in the DWSNZ (see section 3.1.2).

Water suppliers can use process monitoring results to demonstrate compliance provided the sampling and analysis meet the requirements of the DWSNZ. (See section 3.2, and Guidelines, section 10.3.2.)

Additional sampling and analysis is required when a change in operating conditions could affect the concentrations of determinands of health significance; 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 (in this case the water supplier must also advise the DWA).

Figure 8.1: Establishing compliance of Priority 2a and 2b determinands



8.3.4 Monitoring frequencies for Priority 2b determinands

Table 8.1 summarises sampling frequencies.

The monitoring programme must include sufficient additional samples to meet any deficiencies that arise from a failure to comply with the programme the DWSNZ prescribe (see section 3.1.2).

Water suppliers must monitor 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, at least monthly, from at least one site.

Water suppliers must monitor Priority 2b Type 2 determinands, whose concentration may change in the distribution system, in relevant distribution zones. Suppliers must collect monthly samples from at least three fixed sites, and collect sufficient extra random samples throughout the year to detect any spatial variability and effects from the distribution system.

When selecting the number of sites and samples, water suppliers must consider matters such as the size of the distribution system and the relevant zones, the determinand concerned, any seasonality and the number of source waters and/or treatment plants involved.

Table 8.1: Monitoring requirements for Priority 2a and Priority 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	13
			Chlorine: weekly[1]	13
			All others: monthly	45
2b, Type 1	Drinking-water leaving the treatment plant[2]	1	Monthly	45
2b, Type 2	Distribution zone	Sufficient to reflect the problems associated with the determinand in relation to the materials used (corrosion products) and reaction time for disinfection by-products	Monthly, from each of at least three selected locations	45

Notes:

1 The weekly free available chlorine samples are to demonstrate the maximum acceptable value (5 mg/L) is not exceeded. This is not to be confused with the requirements of any bacterial compliance criteria.

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

8.3.5 Monitoring procedures for Priority 2a, 2b and 2c determinands

Water suppliers must confirm procedures for sampling, sample preservation, storage and sample transport 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), water suppliers must provide the sampling schedule for the year's monitoring programme to the DWA before the programme starts.

Water suppliers must collect samples for Priority 2a and 2b determinands, obtained from the treatment plant or the distribution zone, 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. Suppliers must use a flush volume of at least 20 L. (See Guidelines, section 10.4.)

Section 8.2.1.4 presents the Option a procedure for Priority 2c determinands. Sections 10.3.3 and 10.4.2 of the Guidelines cover Option b.

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 limit of detection for each determinand ideally should be one-fifth, or less, of the MAV for that determinand. This may not be possible for all determinands. All analytical reports must include the limit of detection and uncertainty of test methods (see Appendix A1.2). For further discussion on testing, see Guidelines, section 17.5.

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 exceedances is not more than that detailed in section 8.2.1.1, requirement 3.

Water supplies must take appropriate action to minimise risks to public health. After a supplier has confirmed an exceedance, it must advise the DWA immediately, investigate the cause of the exceedance and take appropriate action.

Water suppliers must record all incidents of exceedance, including monitoring results, actions taken and outcomes.

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

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 ingested or 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. 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 different radio-toxicities, and an accurate determination of the exposure requires a detailed radioanalytical assessment. A quick, 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 an upper limit to be set for exposure from ingestion and the third test allows an upper limit to be set for exposure from the 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 2 L 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

Water suppliers must not exceed the MAVs given in Table 2.4 for radiological determinands.

9.4 Monitoring requirements

The National Centre for Radiation Science provides analytical and radiological advisory services appropriate for drinking-water testing.

The monitoring frequency for radiological determinands is 10 years for bore water supplies.

Before connection to a reticulated drinking-water supply, water from new underground sources must be tested for total alpha activity, total beta activity and radon. The National Centre for Radiation Science will specify the sampling requirements. Because the MAV for total beta activity excludes potassium-40, the water also needs to be tested in a chemical analytical laboratory for potassium (see Guidelines, Chapter 11 for estimating the potassium-40 component).

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 National Radiation Laboratory. 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 Exceedance of radiological maximum acceptable value

If the total alpha-concentration exceeds the MAV, the water must be analysed for uranium-238, uranium-234 and radium-226, and a radiological assessment must be undertaken.

If the total beta-concentration exceeds the MAV, the water must be analysed for radium-228 and any other beta-emitting radionuclides that may be present, and a radiological assessment undertaken.

If one of the radiological MAVs is exceeded, the National Radiation Laboratory advises the DWA and the water supplier of the remedial action to be taken.

10 Small water supplies

10.1 Introduction

This section applies to drinking-water supplies serving up to 500 people as defined in section 69G of the Health Act 1956 (definitions of small drinking-water supply and neighbourhood drinking-water supply).

The DWSNZ have two main components:

- the water quality standards, which specify the maximum acceptable values (MAVs) at which the risk of disease or illness from drinking the water is negligible (section 2)
- the compliance criteria, reporting requirements and remedial actions, which define the checks needed to demonstrate the water supply is not exceeding these standards. The stringency of these checks reflects the level of risk that the water supply poses.

The water quality standards are the same for all water supplies, regardless of size or type, because they relate to human health effects. The compliance criteria provide different levels of certainty that the standards are being met, balancing the risks to public health and costs.

Small and neighbourhood drinking-water supplies have two options for demonstrating compliance with the water quality standards.

1. Comply with the requirements in sections 4 and 5 and 7–9.
2. Follow a water safety plan compliance criteria approach (sections 10.2–10.5).

10.2 Compliance requirements

Water suppliers must meet the following compliance requirements.

1. A drinking-water assessor (DWA) must have approved a water safety plan, and the supplier must be implementing the plan.
2. Appropriate bacterial, protozoal and chemical treatment, as determined from the catchment assessment in the water safety plan, must be in use (Table 10.1).
3. Water suppliers must monitor water quality and ensure it meets the requirements of section 10.4.
4. Waters suppliers must undertake the remedial actions that have been specified in the water safety plan when a MAV is exceeded or treatment process controls are not met.

When the water supplier can show it has met these requirements, the supply will be deemed to comply with the DWSNZ, otherwise the compliance requirements for the supply revert to those in sections 4 and 5 and 7–9.

10.3 Treatment requirements

10.3.1 Background

Treatment requirements to remove chemical contaminants are typically based on the average concentration present or thought to be present. In drinking-water, chemicals just exceeding their MAV typically take a long time (months or years) to cause health problems.

For microbial contaminants, requirements to remove or inactivate pathogens are typically based on the maximum predicted contamination levels, rather than average levels, because the effects of microbial contaminants can occur in just hours or days, so the greatest health risk is caused when contamination peaks.

As a minimum requirement, water suppliers must operate and monitor treatment processes according to the manufacturer's instructions.

10.3.2 Microbial treatment requirements

Water needs to be treated before it is considered safe to drink. The exception is bore water supplies that have been demonstrated to be secure (section 4.4), for which no additional treatment is required; otherwise treatment is required to provide a barrier to contamination. If there is any doubt about the quality of the source water, treatment is required.

Water suppliers should identify the likely nature and extent of contamination in the water source as part of the catchment assessment component of the development of the water safety plan for the water supply. In completing the catchment assessment, suppliers should give consideration to the types of potential contamination sources identified in Table 10.1.

10.3.2.1 Rainwater supplies

Rainwater collection systems may contain bacteria, sometimes protozoa (generally at low levels) and particulate matter. Water suppliers should note the following.

- Chlorination is adequate to inactivate the bacteria.
- Cartridge filtration can remove the protozoa (see Notes in Table 10.1).
- Chlorine dioxide, ozone or UV treatment can inactivate both the bacteria and the protozoa.

Section 19.4 of the *Guidelines for Drinking-water Quality Management for New Zealand* (Ministry of Health 2017 (the Guidelines) covers the collection and storage of roof water.

10.3.2.2 Bore water supplies

All secure bore waters need to satisfy bore water security criterion 1 (section 4.4.2), and bore water security criterion 2 (section 4.4.3).

See section 4.4.4 for information on how to demonstrate continued compliance with secure bore water criteria 1 and 3. No treatment is required for secure bore water supplies.

Non-secure bore water is likely to be contaminated with micro-organisms, which can be inactivated by disinfection with chlorine, chlorine dioxide, ozone or UV light (see Notes in Table 10.1).

Springs and bore water drawn from a depth of less than 10 m must be treated as surface water.

10.3.2.3 Surface water supplies

Table 10.1 sets out a scheme for identifying default treatment requirements based on the maximum contamination levels estimated to be present in source waters from catchments with particular characteristics. Alternative approaches can be adopted where these can be justified (see section 5).

10.3.3 Chemical treatment requirements

Water suppliers must identify potential sources of chemical contamination (including cyanotoxins) of the source waters or during the treatment process in their water safety plans and deal with them by an appropriate process.

Suppliers should take steps to minimise the amount of contaminant entering the source water, and use an appropriate treatment process if further reduction in the concentration is needed to produce potable drinking-water.

10.4 Water quality monitoring

10.4.1 General

Water suppliers must carry out sampling according to a predetermined plan. Suppliers must agree procedures for the collection, preservation, storage and transport of samples beforehand with the laboratory carrying out the analysis, except where the Ministry of Health authorises special procedures for isolated drinking-water supplies.

Only a laboratory recognised by the Ministry of Health as competent to carry out the drinking-water compliance testing may carry out analyses, except where the Ministry of Health authorises special procedures or field analyses (see section 3.1.1).

Water suppliers must specify in the water safety plan the appropriate steps for providing assurance of satisfactory drinking-water quality management when they cannot send a microbial sample to a recognised laboratory within the required period at the frequency described, because the supply is:

- isolated from courier routes
- temporarily inaccessible (eg, due to severe weather)
- not monitored by a person certified by a DWA as competent to undertake compliance monitoring.

10.4.2 Bacterial monitoring

Water suppliers must conduct compliance monitoring for *Escherichia coli* (*E. coli*) at least three monthly with a maximum interval between successive samples of 135 days. Suppliers must take samples from randomly selected locations throughout the distribution system. Section 4.2.6 covers sampling requirements.

Suppliers may use rapid-test methods for *E. coli* that are acceptable to the Ministry of Health for compliance monitoring.

Table 10.1: Microbial treatment for surface water supplies of different levels of risk

Summary of catchment type as identified in the catchment assessment of the water safety plan	Minimum treatment requirements	Explanation
Catchment with controlled human access and no livestock	*Bacterial treatment and very low protozoal risk* Prefiltration or selective abstraction[1] followed by chlorine disinfection[2] or *Bacterial and 2-log protozoal treatment* Prefiltration or selective abstraction[1] followed by UV disinfection[3]	Disinfection is required to inactivate bacterial pathogens, such as *Campylobacter* spp. and *Salmonella* spp. that are known to be present in wildlife.
Catchment with no sewage discharges or human habitations and no intensive livestock operations harbouring gatherings of pre-weaned and juvenile stock	*Bacterial and 3-log protozoal treatment* Prefiltration or selective abstraction[1] followed by UV[3] or ozone[6] disinfection or Cartridge filtration[4] followed by chlorine disinfection[2] Cartridge filtration[5] followed by UV disinfection[3]	Disinfection is required to treat bacterial pathogens such as *Campylobacter* spp. and *Salmonella* spp. that are known to be present in stock and wildlife, and the removal or disinfection of moderate levels of protozoan pathogens found in stock animals.
Catchment with septic tanks and/or sewage discharges from human habitations and/or intensive livestock operations harbouring gatherings of pre-weaned and juvenile stock	*Bacterial and 4-log protozoal treatment* Membrane filtration[4] followed by chlorine disinfection[2] or Cartridge filtration[5] followed by UV[3] or ozone[6] disinfection	Disinfection is required to treat bacterial pathogens such as *Campylobacter* spp. and *Salmonella* spp. that are known to be present in stock, sewage and wildlife; pathogens such as norovirus and hepatitis A virus that are known to be present in sewage; and high levels of protozoan pathogens found in stock animals.

Notes:

1 Selective abstraction (achieving a turbidity less than 1 NTU) means taking source water only at a time when it is least contaminated. This ensures substances that may interfere with disinfection are avoided and/or reduced to levels that will not overwhelm disinfection (eg, large particles, turbidity, chlorine demand and UV-absorbing substances need to be kept within acceptable levels).

2 To meet greater than 0.5 mg/L free available chlorine after 30 minutes' contact with pH less than 8.5 or equivalent C.t.

3 The UV unit must meet (and operate within the specifications of) one of the following standards: NSF/ANSI 55 Class A (NSF, ANSI n.d.); DVGW Technical Standard W294 (DVGW 2006); öNORM M5873 (Osterreichisches Normungsinstitut 2001); or equivalent (ie, to deliver at least 40 mJ/cm^2 validated reduction equivalent dose at the UV transmittance and turbidity present).

4 Pore size must be less than or equal to 1 µm absolute, or tested and rated to remove at least 99.9 percent (3-log) of *Cryptosporidium* spp. oocysts, and the vendor must guarantee the system will meet defined performance standards.

5 The final cartridge before the UV reactor must have a pore size no greater than 5 µm (nominal) and be a rigid cartridge (ie, not pleated, fabric or wound string).

6 Ozone treatment must achieve 3-log inactivation as per section 5.15.

10.4.3 Protozoal monitoring

The operational requirements that water suppliers need to monitor to demonstrate protozoal compliance are dependent on the water treatment process being used. The water safety plan must specify the monitoring programme adopted.

10.4.4 Chemical monitoring

When water suppliers find any chemical in the distribution system at greater than 50 percent of its MAV, they must note this in the water safety plan and monitor the chemical at least annually until they find its concentration to be less than 50 percent of its MAV in three consecutive samples, and identify a reason for the drop in concentration.

If water suppliers use chlorine as a disinfectant and suspect the presence of disinfection by-products, they must take samples as far downstream of the point of disinfection as practicable.

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 or other metals in the supply. Section 8.2.1.4 covers the compliance criteria for plumbosolvent water.

10.5 Responses required when a MAV is exceeded or treatment failure is detected

Water suppliers must use the sampling plan to determine whether the MAV or operational requirements:

- are exceeded continually
- are exceeded seasonally or intermittently
- have exceeded the transgression limits as the result of a once-only event.

Water safety plans must define actions required to be taken when a MAV is exceeded, and must contain, but are not limited to, the following elements.

- When water suppliers detect *E. coli* in a sample they must immediately take action to discover the reason and minimise the likelihood of a recurrence (see Figure 4.2).
- When a treatment process fails to perform within its operational requirements, defined in the water safety plan, water suppliers must agree remedial action with the DWA, and carry this out.
- Water suppliers must conduct a sanitary inspection of the water supply.
- If a water supplier issues a permanent 'boil water' notice, it must display approved signage next to all taps connected to the supply.
- If the concentration of any chemical exceeds its MAV, water suppliers must agree remedial action with the DWA, and carry this out.

Appendix 1: Units, test results, conversions and exceedances

A1.1 Basis for units

The DWSNZ use the International System of Units (SI).

The SI unit of volume is the litre (L), weight is the kilogram (kg) and length is the metre (m).

1 litre equals 1,000 millilitres (mL); 1 cubic metre equals 1,000 litres.

1 kilogram equals 1,000 grams (g); 1 gram equals 1,000 milligrams (mg); 1 milligram equals 1,000 micrograms (µg).

A1.2 Comparing a test result against a MAV or operational requirement

A1.2.1 Bacterial results

To establish whether a transgression has occurred, the test result (measurement) must be compared with the MAV.

A1.2.2 Chemical results

The *General Requirements for the Competence of Testing and Calibration Laboratories* (NZS ISO/IEC 17025) (IANZ 2005) requires laboratories to calculate their uncertainty of measurement; see International Accreditation New Zealand's Technical Guide TG5 (IANZ 2004) and section 17.6 of the Guidelines.

When testing drinking-water for chemical compliance, laboratories must report their uncertainty of measurement (U) with the test result (T).

A MAV is exceeded when the test result (T) is higher than the MAV. Ideally, the limit of detection should be less than one-fifth of the MAV.

A1.2.3 Operational requirements

Operational requirements include online or manual compliance testing of pH, turbidity, temperature, free available chlorine (FAC), pressure differential, chlorine dioxide, ozone, ultraviolet light (UV) irradiance (sensor reading), UV transmittance and direct integrity (as used in microfiltration plants).

Equipment used to demonstrate compliance must be suitable for that purpose (see Appendix A2.4–A2.9).

A1.3 Units and conversion

A1.3.1 Microbial

Total coliforms and *E. coli*) by multiple tube methods: most probable number per 100 millilitres (MPN/100 mL). For other test methods: number per 100 mL.

Plate counts: colony-forming units per millilitre (cfu/mL).

Organism size: 1 μm = 1 micrometre = 1 micron = 0.001 mm or 10^{-3} millimetres.

A1.3.2 General 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	μg/L or μgL^{-1}	parts per billion, ppb = 10^{-3} ppm	milligrams per cubic metre, mg/m^3 or $mg.m^{-3}$
		nanograms per litre	ng/L or ngL^{-1}	parts per trillion, ppt = 10^{-3} ppb	

Notes:

1 mg/L = 1,000 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.

A1.3.3 Contact time (C.t value)

C.t equals the concentration of the disinfectant in milligrams per litre (mg/L) multiplied by exposure or contact time in minutes (the C.t unit is min.mg/L) (see Guidelines, section 15.2.9).

A1.3.4 Colour

Hazen colour units (HU) are sometimes referred to as true colour units (TCU). 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.

A1.3.5 Conductivity

millisiemens per metre (mS/m or $mS.m^{-1}$)

1 mS/m = 10 μmhos/cm; 1 μS/cm = 1 μmhos/cm

Conductivity is influenced by the temperature of the sample being tested. Normal practice is to measure the conductivity at 25°C or to convert it to 25°C, including the temperature in the report.

A1.3.6 pH

pH is the negative log of the hydrogen ion activity = – log aH^+.
Approximated to indicate – log (hydrogen ion concentration) = – log $[H^+]$.

A1.3.7 Temperature

Degrees Celsius (°C) or centigrade.

A1.3.8 Turbidity

Nephelometric turbidity unit (NTU), comparable to the previously used formazin turbidity unit (FTU) and Jackson turbidity unit (JTU). (See A2.4, and Guidelines, section 8.6.2.1 and the datasheet.)

A1.3.9 Log removal

Log removal is a method for expressing the removal or inactivation of organisms (see Guidelines, section 8.3.1). The calculation for converting from percentage removal is:

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

Log removal	Percentage removal (%)
1.0	90
2.0	99
2.5	99.7
3.0	99.9
3.3	99.95
3.5	99.97
4.0	99.99
5.0	99.999

A1.3.10 UV absorbance and transmittance[8]

Note: 'The spectral attenuation (absorbance) of the water must be lower' is synonymous with 'the UV transmittance (UVT) of the water must be higher'.

Absorbance (A) = $-\log_{10}$(transmittance), or A = – log T. An example of the conversion follows:

Say T = 83% or 0.83
A = – log 0.83
= – (log 8.3×10^{-1})
= – (0.919 – 1)
= 0.081
Conversely, $\%T = 100 \times 10^{-A}$

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.

Some UV appliance manufacturers use SSK; (see Guidelines, section 8.4.4.3).

[8] Sometimes colloquially called absorption and transmission.

A1.3.11 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.

A1.3.12 Conversion of FAC to FACE

See section 6.3.7 of the Guidelines for a formula for converting FAC to FACE at different pHs. Sections 15.5.1.1 and 17.4.1 of the Guidelines provide further information.

A1.3.13 Aluminium

A dose of 11 ppm commercial grade alum is equivalent to approximately 1 mg/L aluminium as Al.

A1.3.14 Asbestos

Million fibres per litre (MF/L).

A1.3.15 Ammonium

Ammonium nitrogen x 18/14 = ammonium ion (ie, NH_4-N x 18/14 = NH_4^+).

A1.3.16 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.

A1.3.17 Nitrate

Nitrate nitrogen x 62/14 = nitrate (ie, NO_3–N x 62/14 = NO_3).

A1.3.18 Nitrite

Nitrite nitrogen x 46/14 = nitrite (ie, NO_2–N x 46/14 = NO_2).

A1.3.19 Radioactivity

Activity of radionuclide: becquerel per litre (Bq/L). A becquerel is one nuclear transformation per second.

A1.4 Permitted exceedances

The following table A1.1 lists the number of exceedances that can be tolerated for 95 percent confidence that a benchmark is not being exceeded more than 5 percent of the time.

The table refers to the number of samples, irrespective of the frequency of sampling. Thus, the number of permissible transgressions in 250 samples is the same (seven) whether all 250 samples were collected in one day or taken over the course of a year. (See Guidelines, Appendix 2).

Table A1.1: Allowable exceedances (for 95 percent confidence that the MAV is exceeded for no more than 5 percent of the time)

e	*n*	*e*	*n*	*e*	*n*	*e*	*n*
0	38–76	40	1025–1046	80	1908–1929	120	2773–2793
1	77–108	41	1047–1069	81	1930–1951	121	2794–2815
2	109–138	42	1070–1091	82	1952–1973	122	2816–2836
3	139–166	43	1092–1113	83	1974–1994	123	2837–2858
4	167–193	44	1114–1136	84	1995–2016	124	2859–2879
5	194–220	45	1137–1158	85	2017–2038	125	2880–2900
6	221–246	46	1159–1181	86	2039–2060	126	2901–2922
7	247–272	47	1182–1203	87	2061–2081	127	2923–2943
8	273–298	48	1204–1225	88	2082–2103	128	2944–2965
9	299–323	49	1226–1247	89	2104–2125	129	2966–2986
10	324–348	50	1248–1270	90	2126–2146	130	2987–3007
11	349–372	51	1271–1292	91	2147–2168	131	3008–3029
12	373–397	52	1293–1314	92	2169–2190	132	3030–3050
13	398–421	53	1315–1336	93	2191–2211	133	3051–3072
14	422–445	54	1337–1358	94	2212–2233	134	3073–3093
15	446–469	55	1359–1381	95	2234–2255	135	3094–3114
16	470–493	56	1382–1403	96	2256–2276	136	3115–3136
17	494–517	57	1404–1425	97	2277–2298	137	3137–3157
18	518–541	58	1426–1447	98	2299–2320	138	3158–3178
19	542–564	59	1448–1469	99	2321–2341	139	3179–3200
20	565–588	60	1470–1491	100	2342–2363	140	3201–3221
21	589–611	61	1492–1513	101	2364–2384	141	3222–3243
22	612–635	62	1514–1535	102	2385–2406	142	3244–3264
23	636–658	63	1536–1557	103	2407–2427	143	3265–3285
24	659–681	64	1558–1579	104	2428–2449	144	3286–3307
25	682–704	65	1580–1601	105	2450–2471	145	3308–3328
26	705–727	66	1602–1623	106	2472–2492	146	3329–3349
27	728–751	67	1624–1645	107	2493–2514	147	3350–3371
28	752–774	68	1646–1667	108	2515–2535	148	3372–3392
29	775–796	69	1668–1689	109	2536–2557	149	3393–3413

e	*n*	*e*	*n*	*e*	*n*	*e*	*n*
30	797–819	70	1690–1711	110	2558–2578	150	3414–3434
31	820–842	71	1712–1733	111	2579–2600	151	3435–3456
32	843–865	72	1734–1755	112	2601–2621	152	3457–3477
33	866–888	73	1756–1776	113	2622–2643	153	3478–3498
34	889–910	74	1777–1798	114	2644–2664	154	3499–3520
35	911–933	75	1799–1820	115	2665–2686	155	3521–3541
36	934–956	76	1821–1842	116	2687–2707	156	3542–3562
37	957–978	77	1843–1864	117	2708–2729	157	3563–3583
38	979–1001	78	1865–1886	118	2730–2750	158	3584–3605
39	1002–1024	79	1887–1907	119	2751–2772	159	3606–3626

Note: ‘e’ is the maximum permissible number of exceedances of a 95 percentile limit for the stated range of samples ‘n’. Calculations have been made using the theory stated in McBride and Ellis (2001), using ‘Jeffreys’ prior’. (See also McBride 2005, section 8.4.)

Appendix 2: Referee methods and monitoring requirements

A2.1 Introduction

Laboratories conducting tests for drinking-water compliance are either accredited by International Accreditation New Zealand (IANZ) or are Ministry of Health-recognised laboratories. Laboratories may use the test methods for which IANZ has assessed them and found them to be competent to perform, for chemical and protozoa compliance testing.

Accredited or recognised laboratories must standardise any online instrumentation used for compliance testing of water in the treatment plant or distribution system. If the instrumentation is standardised using a field test method, an accredited or recognised laboratory must calibrate the field test method at least once every six months (see section 3.1.1).

When standardising online instruments (other than turbidimeters) used for compliance testing, the water supplier must check the value of the determinand recorded at a specified time against that obtained from a grab sample taken at the same time from the designated sampling point for that determinand, and must analyse it by the referee method (or an alternative method that has been calibrated against the referee method).

The water supplier must record the result, together with any adjustments that are made to the instrument, and the identity of the operator(s). 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. For further information, see Guidelines, sections 17.3.3, 17.4 and 17.5.

A2.2 *Escherichia coli*, faecal coliforms and total or presumptive coliforms

A2.2.1 *Escherichia coli* referee method

The *Escherichia coli* (*E. coli*) referee method is:

> APHA 9223 B – Enzyme Substrate Coliform Test:
> Multi-well MPN (Quantitray); MPN (multiple-tube technique).

A2.2.2 Faecal coliform referee method

The faecal coliform referee method is:

> APHA 9221 E – Multiple Tube Fermentation (MPN) Technique (EC Medium)

A2.2.3 Total or presumptive coliform referee method

The total or presumptive coliform referee method is:

> APHA 9221 B – Multiple Tube Fermentation (MPN) Technique (Lauryl Tryptose Broth)

For a discussion on the use of MPN tables and calculations, see the Guidelines, section 6.4.2.

A2.3 Turbidimeters

Online and manual (bench-top or portable) turbidimeters that are used as instruments for compliance monitoring must comply with the requirements of ISO 7027, or USEPA Method 180.1, or USEPA Method 10133, or GLI Method 2 (USEPA 1999), or have been approved by the USEPA for drinking-water compliance monitoring.

Section 3.1.1 discusses field tests. Section 8.6.2.1 of the Guidelines further discusses turbidity and its measurement.

A2.3.1 Bench-top turbidimeters

Bench-top turbidimeters may be used for compliance testing of manual samples, either:

1. in laboratories recognised by the Ministry of Health: the turbidimeter must be standardised and used according to the conditions of accreditation; or
2. at, or near, the water treatment plant (ie, in a field test). Standardisation must be undertaken by personnel approved to do so by the DWA, and in accordance with the instrument manufacturer's specified procedures and frequency or three-monthly; whichever is more frequent. Bench-top turbidimeters are usually standardised with formazin. The DWA must approve quality assurance procedures associated with standardisation and turbidity measurement.

A2.3.2 Portable turbidimeters

Standardisation and quality assurance procedures must be undertaken by personnel approved to do so by the DWA, and in accordance with the instrument manufacturer's specified procedures and frequency or three-monthly; whichever is more frequent.

Standardisation must be performed using StablCal (Hach) or PrimeTime (HF Scientific) (or other Ministry of Health-approved stabilised formazin preparation); or AMCO-AEPA-1 styrene divinylbenzene microsphere suspensions (Advanced Polymer Systems).

Alternatively, user-diluted formazin preparations may be used, provided the:

- 4,000 nephelometric turbidity unit (NTU) formazin preparation is obtained from a quality certified manufacturer or appropriately accredited laboratory
- standardisation point is 20 NTU or greater
- dilution is done immediately before use for standardisation.

Water suppliers must verify that the performance of the instrument has not changed since standardisation daily, or each time the instrument is switched on. Suppliers can use the manufacturer's secondary standards for this purpose. If the instrument reading is outside the limits specified for the secondary standard, then the supplier must restandardise that instrument.

A2.3.3 Online turbidimeters

When using online turbidimetry (a field test):

- the signal averaging time must be one minute or less
- where discrete readings are recorded, the interval between readings must not be more than one minute.

Standardisation and quality assurance procedures must be undertaken by personnel approved to do so by the DWA, and in accordance with the instrument manufacturer's specified procedures and frequency or three-monthly; whichever is more frequent.

Water suppliers must carry out verification that the performance of the instrument has not changed since standardisation at least weekly or after any interruption to continuous reading.

A2.4 pH

Water suppliers must standardise the pH meter before they make each set of manual measurements, and follow the manufacturer's instructions for storage of the electrode when not in use. The buffer solutions used must be prepared by an analytical laboratory using the formulations given in the APHA 4500-H^+, or purchased from a chemical manufacturing company as a certified solution.

Suppliers must use two buffers (about 7, then about 4) to standardise and set the slope of the pH meter. Finally, suppliers must use a pH 9 to 10 buffer to check the standardisation holds over the whole range.

Many New Zealand potable waters are weakly buffered, which can present difficulties in pH measurement. Meters being used for potable water require special thin glass electrodes to work properly on unbuffered waters. Robust electrodes are not suitable.

For further information, see Guidelines, section 10.5.1.

A2.5 Free available chlorine

Water suppliers must use the ferrous ammonium sulphate titration, APHA 4500-Cl F, to standardise online instrumentation, laboratory or field equipment (see also section A2.1).

A2.6 Chlorine dioxide

Most online instrumental methods used for measuring chlorine dioxide incorporate an amperometric cell. Chlorine dioxide test methods become complex in the presence of free available chlorine, requiring a high level of skill (for further information see Guidelines, section 15.5.3).

The chlorine dioxide datasheet in the Guidelines sets out suitable standardisation techniques. See also section A2.1.

A2.7 Ozone

Water suppliers must follow the ozone analyser manufacturer's instructions. APHA 4500-O_3 B, indigo colorimetric method, is useful for standardising online analysers. For discussion on potential difficulties with this analysis, see Guidelines, section 15.5.4.3.

A2.8 Temperature

Water suppliers must use a thermometer that has been standardised according to the International Accreditation New Zealand's Technical Guide 3, *Working Thermometers: Calibration Procedures* (IANZ 2008). Suppliers must make checks against another similarly standardised thermometer at least once every six months. If the readings diverge by more than 0.5°C, suppliers must restandardise both thermometers.

A2.9 Other determinands

Sections A2.1–A2.8 relate to Priority 1 testing.

Section 8.3 and the appendix to Chapter 8 of the Guidelines cover sampling sites for Priority 2 determinands.

Where not already specified, the laboratory should provide sampling containers and procedures.

Definitions

absorbance — The loss of light, usually at a specified wavelength, as it passes through water. Sometimes called absorption. See Appendix A1.3.11 and Guidelines, section 8.4.4.3, 8.5.6 and datasheet.

abstraction point — The point at which water that is intended for drinking comes under the control of the drinking-water supplier. See Guidelines, section 3.4.2.

accreditation — Formal recognition that an organisation is meeting internationally accepted standards of quality, performance, technical expertise and competence; an independent endorsement of a commitment to these standards (IANZ 2007).

accuracy — The combination of bias and precision of an analytical procedure that reflects the closeness of a measured value to a true value. See Guidelines, section 17.5.

aesthetic determinand — A constituent or property of water that can adversely affect its taste, odour, colour, clarity or general appearance. See Guidelines, Chapter 18, and datasheets.

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.

algae — Also called plankton. Unicellular and multicellular plants that occur in fresh water, marine water and damp terrestrial environments. They may contribute to taste and odour problems in water. See Guidelines, section 4.2 and Chapter 18.

alkalinity — A measure of buffering capacity. The principle cause of alkalinity in most drinking-waters includes at least one of bicarbonate, carbonate or hydroxide.

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. Compliance 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 groundwater to bores or springs. An aquifer contains pores or open spaces filled with water. See Guidelines, section 3.2.

aquitard — A low-permeability layer that restricts the flow of groundwater from one aquifer to another; for example, fine silt or clay. The rate at which water can be abstracted from these layers is usually too low for the formation to be used as a source. See Guidelines, section 3.2.

bacteria — The simplest form of life; 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 filtration	A pressure-driven separation process that removes particulate matter larger than 1 μm, using an engineered porous filtration media by surface filtration. See Guidelines, section 8.4.3.3, 14.6.
bank filtration	A treatment process that uses one or more pumping wells to induce or enhance natural surface water infiltration and to recover that surface water from the subsurface after passage through a river bed or bank(s). See Guidelines, sections 8.4.1.1 and 12.3.1.
beta-emitting radionuclide	A radionuclide that disintegrates by emitting a negative (or positive) electron (beta particle). See Guidelines, Chapter 11.
bore	A piped (cased) hole constructed to access groundwater for supply purposes. See also well.
bore field	More than one bore from the same aquifer connected to a single water supply. See Guidelines, section 3.2.
bore head	The physical structure, facility or device at the land surface from which groundwater is abstracted from subsurface water-bearing formations. See Guidelines, section 3.2.
bore head protection	A bore head that effectively prevents contamination of the supply from the ground surface and complies with Environmental Standard for Drilling of Soil and Rock NZS 4411 (Standards New Zealand 2001). See Guidelines, section 3.2.4.3.
bore water	Groundwater that has been extracted from the aquifer through a bore. See also secure bore water.
calibration against a referee method	Demonstrating that an alternative method will reliably give the same result to an acceptable strength-of-agreement (NIWA 2007) as the referee method, under the same range of circumstances, within a known uncertainty considered acceptable by independent peer review, thus demonstrating that the alternative method is fit for purpose. See Guidelines, section 17.5.7.
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. See Guidelines, section 8.4.3.4, 8.5.4, 8.6.2.4 and 14.5.
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 to be evaluated. See Guidelines, section 3.5, 4.1, 4.3.1 and 8.2.3.
certification	Issuing a certificate of satisfactory performance. Section 8.4.3 of the Guidelines discusses certification of treatment processes used for protozoa removal or inactivation.
challenge test	A test of a treatment process to establish its performance parameters. See Guidelines, section 8.5.
chemical coagulation	The use of metallic salts or organic polyelectrolytes to aggregate fine suspended or colloidal particles, causing them to clump together into larger particles (floc). See Guidelines, sections 13.2–13.5.

coagulation See chemical coagulation.

coliform bacteria The bacteria used as indicators that organic, possibly faecal, contamination of the water may have occurred. Sometimes referred to as total or presumptive coliforms; include *Escherichia coli.* See Guidelines, section 5.3.2 and specific datasheets.

compliance Compliance with the DWSNZ. A drinking-water supply is in compliance when it has met all the compliance criteria requirements.

compliance criteria Requirements that must be satisfied to achieve compliance.

compliance monitoring The monitoring specified in the compliance criteria. See Guidelines, Chapter 17.

compliance monitoring period The period during which a MAV or operational requirement is monitored to check that it does not move outside its limit for more than the allowed frequency or duration.

confined aquifer See unconfined aquifer.

contact time The hydraulic residence time, determined by a tracer test or by a recognised calculation procedure, from the dosage point or point of entry to the disinfectant contact device to the point of exit. See Guidelines, section 15.2.9.

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 limit or operational requirement. The water safety plan records the control limit, along with the preventive actions considered to be necessary when the control limit is reached. See Guidelines, section 17.4.3.

conventional treatment A series of processes including coagulation, flocculation, sedimentation and filtration.

Cryptosporidium A member of the protozoa. During its complex life cycle, it forms thick-walled oocysts are formed that are 4–6 μm in diameter. See datasheet in Guidelines.

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 of a micro-organism. It has the unit min.mg/L. See Guidelines, section 15.2.9.

cyanobacteria A major group of bacteria (often able to photosynthesise), sometimes called blue-green algae. Some species produce toxins. See Guidelines, Chapter 9.

cyanotoxin A toxin secreted by certain cyanobacteria. See datasheets in Guidelines.

cyst The non-motile dormant form of *Giardia* that serves to transfer the organism to new hosts. See also oocyst and (oo)cyst.

datasheets Comprise Volume 3 of the Guidelines, which lists the sources, occurrence, removal process, analysis, health effects and derivation of MAVs of determinands.

DBP See disinfection by-product.

determinand	A constituent or property of a sample of water that is determined or estimated.
diatomaceous earth filtration	Filtration that uses diatomaceous earth (DE) as the medium, typically 0.01–0.2 mm diameter. See Guidelines, section 8.4.3.1 and 14.2.
direct filtration	A water treatment process using chemical coagulation without a clarification step upstream of the filter(s). See Guidelines, sections 8.4.2.2 and 13.2.
direct integrity test	See integrity test.
disinfection	The process used to inactivate micro-organisms. See Guidelines, Chapter 15.
disinfection by-product (DBP)	A contaminant produced as a by-product of the disinfection process. See Guidelines, section 15.4.
disinfection residual	The amount of disinfectant present in the water at any time.
dissolved air flotation	A clarification process in which the flocs formed during coagulation and flocculation are floated to the surface for removal by air bubbles. See Guidelines, section 13.5.2.
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 also network reticulation. See Guidelines, Chapter 16.
distribution zone	An identifiable part of the water supply network. See Guidelines, section 16.1.
drinking-water	Water intended to be used for human consumption, food preparation, utensil washing, oral hygiene or personal hygiene.
drinking-water assessor	An officer appointed under section 69ZK of the Health Act 1956.
Drinking-water Standards for New Zealand	A set of standards that defines the MAVs of health significant determinands and specifies the methods for determining whether a drinking-water supply complies with the standards.
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).
DWA	See drinking-water assessor.
DWSNZ	See *Drinking-water Standards for New Zealand*.
E. coli	See *Escherichia coli*.
***Escherichia coli* (*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. See datasheet in the Guidelines.
exceedance	The occurrence of a determinand in a sample at a concentration greater than the MAV.
FAC	See free available chlorine.
FACE	See free available chlorine equivalent.

faecal coliform — See thermotolerant coliforms, *Escherichia coli*, presumptive coliforms and total coliforms. See datasheet in the Guidelines.

filtrate — Water, other than wash water, leaving a filter.

filtration — A treatment process that physically 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. See Guidelines, section 3.4.

free available chlorine — The chlorine present in chlorinated water in the form of hypochlorous acid and hypochlorite ion. See Guidelines, sections 6.3.7 and 15.5.1.

free available chlorine equivalent — The free available chlorine concentration that would have the same disinfecting power as the chlorine solution would have when adjusted to a pH of 8. See Guidelines, sections 6.3.7 and 15.5.1.

Giardia — A flagelated member of the protozoa that can infect the gastrointestinal tract of humans and certain animals. Cysts are the infectious form of the organism excreted by the host; they are ovoid in shape, 8–12 μm. See datasheet in the Guidelines.

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. See also bore water. See Guidelines, Chapter 3.

guideline value (GV) — The value for an aesthetic determinand that, if exceeded, may render the water unattractive to consumers. See Guidelines, Chapter 18.

housing — The pressure vessel that is used to contain a cartridge or bag filter. See Guidelines, sections 8.4.3, 14.5 and 14.6.

inactivation — Rendering organisms (usually micro-organisms) incapable of infection. Usually achieved by disinfection or high temperatures. See Guidelines, sections 8.4.3, 14.5 and 15.2.

indicator organism — A determinand that is monitored to indicate the probable presence of faecal contamination. See Guidelines, section 5.3.

indirect integrity test — See integrity test.

infectious — Liable to transmit a disease to or cause a disease in humans.

infiltration gallery — An artificial conduit, or series of conduits for collecting water, situated next to, or in, streams under layers of sands and gravel to provide a degree of prefiltration. Also referred to as river galleries, but not the same as bank filtration. See Guidelines, sections 8.4.1 and 12.3.1.

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. See also membrane filtration. See Guidelines, section 8.4.3.5.

Indirect integrity test
A test that involves monitoring some aspect of filtrate water quality that is indicative of the removal of particulate matter. See Guidelines, section 8.6.2.4.

interim bore water security	See secure bore water.
limit of detection	The lowest quantity of a substance that can be distinguished from the absence of that substance (a blank) with a stated confidence level (generally 99%). See Guidelines, section 17.5.
MAV	See maximum acceptable value.
maximum acceptable value	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, see Guidelines, sections 10.1.1 and 10.2.5.
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. Includes microfiltration (MF), ultrafiltration (UF), nanofiltration (NF) and reverse osmosis (RO). See module and membrane unit. See Guidelines, sections 8.4.3 and 14.4.
membrane unit	A group of membrane modules sharing common valving that allows the unit to be isolated from the rest of the system for testing or maintenance. See Guidelines, sections 8.4.3 and 14.4.
MF	See microfiltration.
microfiltration (MF)	A 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, ultrafiltration (UF), nanofiltration (NF) and reverse osmosis (RO). See Guidelines, sections 8.4.3 and 14.4.
micro-organism	A very small (microscopic) organism, including bacteria, viruses, protozoa, algae and helminths (worms).
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. See Guidelines, sections 8.4.3 and 14.4.
monitoring	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. See Guidelines, Chapter 17.
nanofiltration (NF)	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 200–1,000 daltons. See membrane filtration, microfiltration (MF), ultrafiltration (UF), and reverse osmosis (RO). See Guidelines, sections 8.4.3 and 14.4.

neighbourhood drinking-water supply

See section 69G of the Health Act 1956. A drinking-water supply that is used to supply drinking-water to:

a. 25–100 people for at least 60 days each year, or

b. any number of people for at least 60 days each year if the number of those people when multiplied by the number of days per year during which they receive water from that supply is 6,000 or greater, but is not greater than 100 on 60 or more days in any year.

nephelometric turbidity unit

A measure of the clarity of water (turbidity). See Appendix A1.3.9. See Guidelines, section 8.6.2.1 and 18.2.1 and datasheet.

NTU

See nephelometric turbidity unit.

online monitoring

The process of measuring and recording a defined chemical or physical property by taking frequent measurements. See section 3.2 and Appendices 1 and 2 and Guidelines, sections 17.3 and 17.4.

(oo)cyst

Collective term for oocysts and cysts.

oocyst

A thick-walled structure within which *Cryptosporidium* zygotes develop and that serves to transfer the organism to new hosts. See also cyst and (oo)cyst.

operational requirement

A performance specification necessary to ensure that an appliance or treatment process complies with its specifications. See Guidelines, sections 8.1 and 8.6.2.1.

ozonation

Treatment of water by dissolved ozone, primarily for disinfection but also for the oxidation of chemical determinands. See Guidelines, sections 8.4.4.2 and 15.5.4.

pathogen

An organism capable of inducing illness.

pesticide

A substance or mixture of substances used for the control of any pest; includes behavioral and developmental modifiers: plant growth regulators, desiccants or defoliants, not fertilisers or animal remedies. See Guidelines, section 10.2.3 and individual datasheets.

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. See Guidelines, section 18.2.1 and datasheet.

plant inlet water

Water taken into a treatment plant for treatment, including raw water and any recycled or backwash water. See Guidelines, section 8.2.4.

plumbosolvent water

Water able to dissolve lead and that causes metals of health concern from fittings or plumbing to appear in consumers' drinking-water. See Guidelines, sections 10.2.2, 10.2.6, 10.3.3 and 10.4.2.

potable water

Drinking-water that does not contain or exhibit any determinand to any extent that exceeds the MAVs. See also wholesome drinking-water.

presumptive coliforms	Bacteria whose identification in the early stages of bacterial examination highlight a need for further identification of coliform bacteria. See also *Escherichia coli*, faecal coliform and total coliform. See Guidelines, section 5.3 and datasheets.
priority class	One of three classes of determinand defined in the DWSNZ. Priority classes are ranked according to the determinand's potential impact on public health if present in excess of its MAV in drinking-water and the quantity of the determinand present in the water supply. See section 3.3 and Guidelines, section 1.6.10.
protozoa	Free-living, aquatic, unicellular animals, larger and more complex than bacteria, which can be differentiated into general types: ciliates, flagellates and amoebae. The Priority 1 protozoa are *Giardia* and *Cryptosporidium*. See Guidelines, sections 5.3.3 and 5.4.5.
provisional secure status	See secure bore water.
quality assurance	A means of maintaining good management of a process by systematically keeping records and checking equipment and personnel performance and procedures; for example, the quality management system standard ISO 9001:2000. See Guidelines, section 17.5.4.
radiological assessment	The determination of the radioactivity content in a water sample. See Guidelines, Chapter 11.
radiological determinands	In water quality analysis, radioactive substances, factors or elements in the drinking-water that are determinable. See Guidelines, Chapter 11.
radionuclide	A radioactive atomic nucleus.
rapid granular media filtration	The process following chemical coagulation. See Guidelines, section 13.7.
raw water	Water intended for drinking that is after the abstraction point but has not yet received treatment to make it suitable for drinking.
recognised laboratory	A laboratory recognised by the Ministry of Health for testing compliance with the DWSNZ. Section 69ZY of the Health Act 1956 defines the requirements. See Guidelines, section 1.3.10.
referee method	A method definitive for demonstrating bacterial compliance with the DWSNZ. Alternative methods may be used, but these must have been calibrated against a referee method. See Guidelines, section 17.5.
Register of Drinking Water Suppliers for New Zealand	A list of drinking-water supplies in New Zealand published by the Ministry of Health, found on the Ministry's website.
regolith	The layer of unconsolidated solid material above the bedrock.
remedial action	Action taken in the event of a transgression or breach of an operational requirement, to protect public health and to reduce the likelihood of this transgression or breach recurring.

residence time determination A process that uses tritium, chlorofluorocarbon and sulphur hexafluoride concentrations in groundwater to determine the time the water has been isolated from the atmosphere. See Guidelines, section 3.2.4.2.

reticulation The network of pipes, pumps and service reservoirs that delivers drinking-water from the water treatment plant to the consumers' boundary. See network reticulation. See Guidelines, section 16.2.

reverse osmosis (RO) The passage of water through a semi-permeable membrane under a pressure that is higher than the water's osmotic pressure. See also membrane filtration, microfiltration (MF), ultrafiltration (UF) and nanofiltration (NF). See Guidelines, section 14.4.3.

sanitary inspection of the water supply A survey and analysis of the physical components of the water supply to identify the existence and hazard posed by existing and potential sources of health hazards and environmental contamination. Procedural details appear in the water safety plan. See Guidelines, section 2.2.6.

second-stage filtration A process consisting of rapid sand, dual media, granular activated carbon, or other fine grain media in a separate stage following filtration by granular media or membrane. See Guidelines, section 8.4.2.3.

secure bore water Water that is free from surface influences and free from contamination by harmful micro-organisms. See Guidelines, section 3.2.

Interim bore water security applies for the first 12 months of operation to bores abstracting from confined aquifers, or unconfined bores greater than 30 m deep drawing from a source that hydrogeological evidence indicates is likely to be secure. See Guidelines, section 3.2.

If *E. coli* is detected in a sample of secure bore water it is reclassified as provisional secure, subject to conditions – see section 4.4.4.

sedimentation The process in which solid particles settle out of the water being treated in a clarifier or settling tank. See Guidelines, section 13.5.

service reservoir A reservoir or tank present in the network reticulation that stores water to manage water flow and pressure. See Guidelines, section 16.2.1.

setback distance In relation to bank filtration, the distance between the well and the surface water when the river/stream is in flood with a 1 percent probability of recurrence (sometimes called a 'one-in-100-year' flood). See Guidelines, sections 8.4.1.1, 12.3.1.

SI units A system of coherent metric units (Système Internationale d'Unités) that the General Conference on Weights and Measures, the international authority on units, adopted.

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. See Guidelines, sections 8.4.3.2 and 14.3.

small drinking-water supply	See section 69G of the Health Act 1956. A drinking-water supply that is used to supply drinking-water to 101–500 people for at least 60 days each year. It is not a drinking-water supply to which paragraph (a) or paragraph (b) of the definition of neighbourhood drinking-water supply applies.
spring	Groundwater moving along the upper plane of an impervious rock formation that ends at the surface, or rock fissures. This discharge is susceptible to surface contamination. See Guidelines, section 3.3.3.
standardisation	A process for enhancing analytical accuracy by use of traceable standards. See Guidelines, sections 17.3.3 and 17.5.3.
surface water	Water on the land surface. It can be running (streams and rivers) or quiescent (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 is open to the atmosphere and subject to run-off.
surrogate	A determinand used to assess the likely presence or concentration of another determinand that is more difficult to determine. 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 pathogens. See Guidelines, sections 5.2.2, 5.3.4, 8.4.1, 8.4.2, 8.4.3 and 8.5.
surveillance	The process of checking that the management of drinking-water supplies conforms to the specifications in the DWSNZ. Usually conducted by the public health agency. See Guidelines, section 1.6.9.
test result	The concentration of a determinand measured by the analyst before any correction is made for experimental or method uncertainty. See Guidelines, section 17.6.
thermotolerant coliforms	A subgroup of total coliforms that will grow on a specific selective medium when incubated at 44.5 ± 0.2°C. See also presumptive coliform. See Guidelines, section 5.3.2 and specific datasheets.
total coliforms	Genera in the family Enterobacteriaceae that will grow on a specific selective medium when incubated at 35°C ± 0.2°C. See also faecal coliform and presumptive coliform. See Guidelines, section 5.3.2 and specific datasheets.
transgression	Occurs when a determinand in the sample exceeds its MAV, or its allowable concentration specified in the compliance criteria, or when the limit of an operational requirement is exceeded.
transgression limit	The limit in the DWSNZ, MAV or operational requirement) that when exceeded defines a transgression. See also control limit.
transmittance	A measure of the amount of light, at a specified wavelength, that passes through water. Sometimes called transmission. See Appendix A1.3.11. An expression used in turbidity and UV disinfection. See Guidelines, sections 8.4.4.3 and 15.5.5.
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. See datasheet in the Guidelines.

UF	See ultrafiltration.
ultrafiltration	A method of filtration in which particles of colloidal dimensions are separated from molecular and ionic substances by drawing the colloidal suspension through a membrane whose capillaries are very small, in the order of 0.003 μm. See membrane filtration, microfiltration (MF), nanofiltration (NF) and reverse osmosis (RO). See Guidelines, sections 8.4.3 and 14.4.
ultraviolet light (UV)	Light emitted with wavelengths from 200 to 400 nm, therefore outside the range visible to the human eye. See Guidelines, section 15.5.5.
unconfined aquifer	A saturated water bearing formation that has a free water table insufficiently protected by an aquiclude from surface contamination. See Guidelines, section 3.2.
United States Environmental Protection Agency	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.
UV	See ultraviolet light.
UV absorbance	See absorbance.
UV disinfection	Disinfection using electromagnetic radiation (light) in the range of 200–400 nm. See Guidelines, sections 8.4.4.3, 8.5.6 and 15.5.5.
UV lamp	A mercury vapour lamp, including LP, LPHO and MP lamps. See Guidelines, sections 8.4.4.3 and 15.5.5.
UV transmittance (UVT)	See transmittance.
validation testing	Establishing the operating conditions whereby a process can deliver specified compliance requirements. See Guidelines, sections 8.4.3.3, 8.4.3.4, 8.4.3.5, 8.4.4.2, 8.4.4.3 and 8.5.6.
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 are enclosed in a protein coat. See Guidelines, Chapter 7 and specific datasheets.
water leaving the treatment plant	Water at the point where the drinking-water supply enters the distribution system, regardless of the treatment process, if any.
water quality standards	The MAVs specified for health significant determinands and indicator organisms in the DWSNZ.
water supplier	Any person or entity that owns, or is responsible for operating, a drinking-water supply.
water treatment plant	The place where raw water undergoes chemical, biological or physical treatment to remove particles or unwanted determinands, inactivate organisms or enhance the aesthetic quality of the water.

well	In the DWSNZ, the structure in a bank filtration process from where water is abstracted. Internationally, wells are holes in the ground from which water is abstracted by bucket or hand pump.
WHO	See World Health Organization.
wholesome drinking-water	Potable water that does not contain or exhibit any determinands that exceed the guideline values for aesthetic determinands included in the DWSNZ.
World Health Organization	An agency of the United Nations, founded in 1948.

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