EPA VICTORIA

Guide to the Environment Reference Standard

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VICTORIA State Government

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EPA acknowledges Aboriginal people as the first peoples and Traditional custodians of the land and water on which we live, work and depend. We pay respect to Aboriginal Elders, past and present.

As Victoria's environmental regulator, we pay respect to how Country has been protected and cared for by Aboriginal people over many tens of thousands of years.

We acknowledge the unique spiritual and cultural significance of land, water and all that is in the environment to Traditional Owners, and recognise their continuing connection to, and aspirations for Country.

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Terms defined in the ERS

This guide needs to be read in conjunction with the Environment Reference Standard (ERS). When used in this guide, the terms listed below have the same meaning as defined in the ERS.

Act
ADWG
ambient air environment
ambient sound environment
ANZG
Aquatic reserves
aquifer
aquifer yield
AUSRIVAS
A-weighted sound pressure level
background level (in relation to the land environment)
background water quality level
band (in relation to the water environment)
drinking water
environmental value
EPT
fish
floodplain
Food Standards Code
groundwater
high water
indicator
inland waters
L_{Aeq}
land environment
line of evidence
load
natural areas
NEPM (AAQ)
NEPM (ASC)
objective
outdoor L_{Aeq}
particles as $PM_{2.5}$
particles as PM_{10}
planning zone
potable mineral water supply
potable water supply (acceptable)
potable water supply (desirable)
ppm
primary contact recreation
receiving waters
Recreational Water Guidelines
reference sites
sanitary inspection
secondary contact recreation
segment
SIGNAL2
special water supply catchment
stormwater
surface water
TDS
TSS
Victorian Wetland Inventory
VLAKES
waste
water dependent ecosystems and species
water quality
waters
waterway
weight of evidence
$\mu g/m^3$ (in relation to air)

Other terms used in this guide

Airshed	A body of air, bounded by meteorology and topography, in which substance emissions are contained.
Ambient	Refers to surrounding environment conditions.
Duty holder	Any person or organisation that has a duty under the *Environment Protection Act 2017* (the Act).
Element of the environment	Refers, as relevant, to the ambient air environment, the ambient sound environment, the land environment and/or the water environment.
Emerging contaminant	Chemical or substance that is released into the environment where there is reason to suspect it causes harm, but either no standard exists, or the current standards are not sufficiently protective.

Free field conditions	Measurement conditions for which the sound pressure levels recorded at the microphone are not affected by the reflection of sound on surfaces other than the ground.
Frequency (in relation to the ambient sound environment)	The property of sound that measures the rate of repetition of the sound wave, in Hertz (Hz) or cycles per second.
Frequency spectrum	The distribution of the energy or the magnitude of a sound across each frequency component.
Octave band	Division of the frequency range used for the purposes of sound measurement, allowing for a more targeted assessment of the ambient sound environment as it varies with frequency.
One-third octave band	A division of the frequency range used for the purposes of sound measurement, It can be used when octave bands do not provide a sufficient resolution. Each octave band comprises three one-third octave bands.
Permission	Approval issued under the Act to undertake certain activities. There are several permission types: a development licence, an operating licence, a pilot project licence, a permit, a registration. Schedule 1 of the Regulations lists which activities require a permission and what level of permission is required.
Regulations	The Environment Protection Regulations 2021.

Abbreviations

dB	decibel
dB(A)	A-weighted decibel
DGV	Default guideline value
EIL	Ecological investigation level
EPA	Environment Protection Authority Victoria
ERS	Environment Reference Standard
ESL	Ecological screening level
GED	General environmental duty
HIL	Health Investigation Level
HSL	Health Screening Level
IEC	International Electrotechnical Commission
ISO	Internal Standard Organization
n.d.	no date
NATA	National Association of Testing Authorities, Australia
PFAS	Per- and polyfluoroalkyl substances
PSU	Practical salinity unit
SEPP	State environment protection policy
SEPP (AAQ)	State Environment Protection Policy (Ambient Air Quality)
SEPP (AQM)	State Environment Protection Policy (Air Quality Management)
SEPP (PCML)	State Environment Protection Policy (Prevention and Management of Contamination of Land)
SEPP N-1	State Environment Protection Policy (Control of Noise from Commerce, Industry and Trade) No. N-1

SEPP N-2	State Environment Protection Policy (Control of Music Noise from Public Premises) No. N-2
SEPP(Waters)	State Environment Protection Policy (Waters)
TPH	Total petroleum hydrocarbons
VCAT	Victorian Civil and Administrative Tribunal
WHO	World Health Organization
WoE	Weight of evidence
WWTP	Wastewater treatment plant

Chapter 1. About this guide

This guide needs to be read in conjunction with the Environment Reference Standard (ERS) (https://www.epa.vic.gov.au/about-epa/laws/epa-tools-and-powers/environment-reference-standard).

This guide is not a stand-alone document. It refers to specific definitions, clauses, tables and figures in the ERS.

1.1 Purpose

This guide provides information about how the ERS should be applied to support decision making, and how the environmental values, indicators and objectives for each element of the environment should be interpreted.

This guide is primarily for decision makers who need to consider the ERS. Decision makers can include Environment Protection Authority Victoria (EPA) officers, officers from other government authorities and departments, environmental auditors, and representatives from local government and planning authorities. The guide will also assist applicants of proposals for new developments, infrastructure or sites that may be assessed with reference to the ERS. It will also be of assistance to site owners, environmental managers and consultants.

1.2 Background

EPA is the state's environmental regulator. As an independent statutory authority under the *Environment Protection Act 2017* (the Act), EPA's role is to prevent and reduce harm from pollution and waste. It does this in various ways, including:

- working with the community, industry, business and other government authorities and departments to prevent and reduce the harmful impacts of pollution and waste on Victoria's environment and people
- holding polluters to account
- helping all Victorians understand their obligations under the law
- providing clear advice on the state of our environment so that people can make informed decisions about their health.

The Act and the Environment Protection Regulations 2021 (the Regulations) (https://www.epa.vic.gov.au/about-epa/laws/new-laws/subordinate-legislation) introduce a regulatory framework designed to prevent harm by eliminating or minimising risks of harm to human health and the environment. At the heart of this framework are the environmental duties – a set of obligations on duty holders.

The cornerstone of the Act is the general environmental duty (https://www.epa.vic.gov.au/for-business/new-laws-and-your-business/general-environmental-duty) (GED). The GED requires Victorians to understand and minimise their risks of harm from pollution and waste to human health and the environment.

The Act also introduced the ERS as a new type of legislative instrument (illustrated in Figure 1.1). The Act states (section 93(1)) that the ERS is to be used 'to assess and report on environmental conditions in the whole or any part of Victoria'. This guide supports the application of the ERS. It forms part of the support material associated with establishing the state of knowledge for managing risks of harm to human health and the environment from pollution or waste.

The Act and other Victorian legislation require EPA and other decision makers to consider the ERS when making certain decisions. This is discussed in Section 2.4.

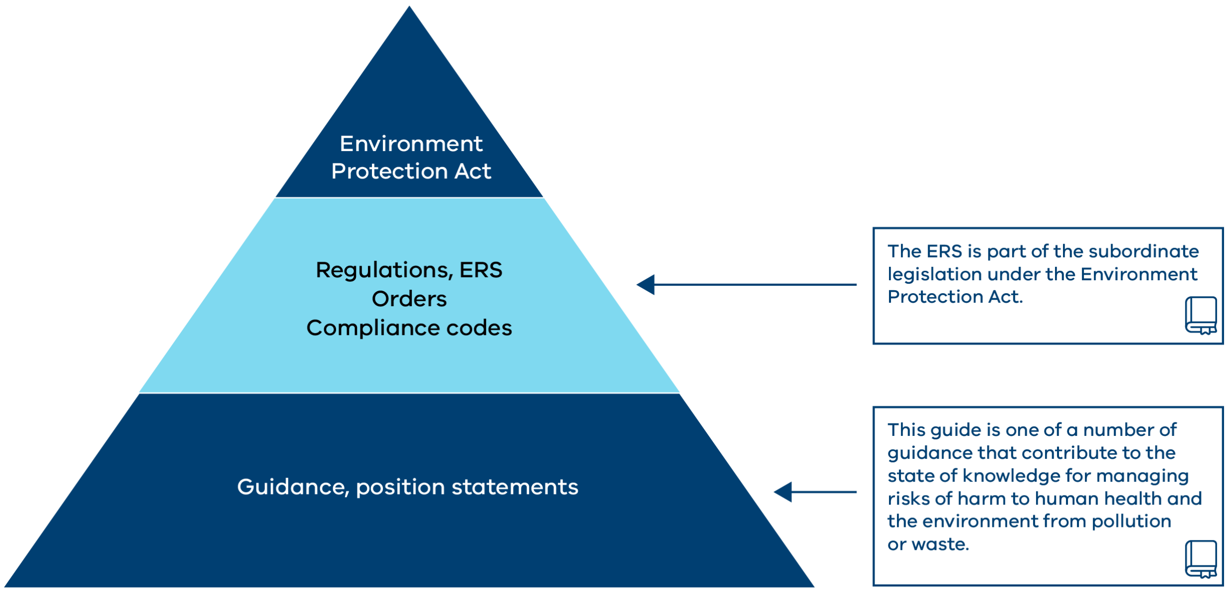

Figure 1.1. The ERS and this guide in the environment protection framework

1.3 How to use this guide

This guide is designed to be used in conjunction with the ERS. This guide is therefore not a stand-alone document. It will be reviewed and updated periodically. EPA's website should be regularly checked to ensure that the latest version of this guide is being used.

1.3.1 Structure of this guide

The structure of this guide is shown in Figure 1.2. It is recommended that the whole guide is read through to obtain a holistic understanding of the ERS. However, if guidance is sought on just one or two individual elements of the environment, specific chapters can be referred to.

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Overview of the Environment Reference Standard
Chapter 2

Applying the Environment Reference Standard
Chapter 3

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Example of application of the Environment Reference Standard
Chapter 8

Methodology for monitoring and assessing the indicators

Ambient air	Ambient sound	Land	Water
Appendix A	*Appendix B*	*Appendix C*	*Appendix D*

Figure 1.2. Structure of this guide

Chapter 2 provides the general principles of application of the ERS. This chapter outlines the role of the ERS, and the circumstances in which Victorian legislation requires consideration of the ERS. Chapter 3 describes how the ERS is applied to key regulatory decisions.

Chapters 4 to 7 introduce a framework for each element of the environment, to assess environmental conditions against the relevant parts of the ERS. These chapters are user guides and focus on the interpretation of the environmental values, and the indicators and objectives defined for each environmental element.

Each of these chapters is supported by an appendix which details how indicators can be monitored and assessed.

Chapter 8 presents a case study that describes how the ERS is used to inform a licence amendment application for the upgrade of a wastewater treatment plant.

Chapter 2. Overview of the Environment Reference Standard

2.1 Introduction

The Environment Reference Standard (ERS) is a new legislative instrument made under the *Environment Protection Act 2017* (the Act). The ERS is an environmental benchmark. It brings together a collection of environmental values, indicators and objectives that describe environmental and human health outcomes to be achieved or maintained in the whole or in parts of Victoria. These values, indicators and objectives are used to assess and report on changing environmental conditions by providing a reference point for decision makers to consider whether a proposal or activity is consistent with the environmental values identified in the ERS. The ERS also allows decision makers to evaluate potential impacts on human health and the environment that may result from a proposal or activity.

The ERS does not specify requirements that must be met by environmental managers or other duty holders.

2.2 Components of the ERS

The ERS is organised into five parts. Parts 2 to 5 are specific to four elements of Victoria's environment:

- ambient air
- ambient sound
- land
- water (surface water and groundwater).

Each of parts 2 to 5 in the ERS includes the following components:

- ***Environmental values*** are the central parts of the ERS. An environmental value is a statement about a desired outcome for human health and the environment. For example, water that supports water dependent ecosystems or an ambient sound environment that supports child development and learning. Environmental values are the uses, attributes or functions of the environment that the Victorian community wants to achieve and maintain.
- ***Indicators*** are usually defined in relation to each environmental value. The indicators are the parameters or markers used to assess whether environmental values are being achieved or maintained, or if they are threatened. For example, 'carbon monoxide (maximum concentration)' (ERS Table 2.2) is one indicator used for ambient air. Another example is 'outdoor L_{Aeq}' ('outdoor $L_{Aeq,16h}$ from 6 am to 10 pm' or 'outdoor $L_{Aeq,8h}$ from 10 pm to 6 am'), which is a key indicator used for ambient sound (ERS Table 3.3).
- ***Objectives*** are the assessment benchmarks. An objective is the character, level, load, concentration or amount of an indicator used to assess whether an environmental value (or several environmental values) is being achieved, maintained or threatened. Most objectives are scientifically derived quantitative assessment levels or a prescribed scientific basis for assessment. For example, for the ambient air indicator 'carbon monoxide (maximum concentration)', the objective is '9.0 ppm (ERS Table 2.2). A smaller number of objectives provide a descriptive (qualitative) basis for assessment. For example, the ambient sound objective for 'natural areas' is 'a sound quality that is conducive to human tranquillity and enjoyment having regard to the ambient natural soundscape' (ERS Table 3.3).
- ***Areas of application***: the ERS defines the area or areas to which the environmental values, or specific indicators and objectives, apply. For example, the environmental values, indicators and objectives for ambient air apply to the whole of Victoria. In contrast, most ambient sound indicators and objectives relate to specified land use planning zones (refer section 5.3 of this guide), while the indicators and objectives for surface water relate to geographic regions or segments (refer section 7.2.1 of this guide) for which different environmental values may be relevant.

Although the ERS is separated into different parts for each element of the environment, the different elements are not self-contained because they can impact each other. As such, interactions between different elements need to be considered holistically when making decisions.

In some cases, the ERS may reflect provisions that were in the State environment protections policies (SEPPs), which were instruments under the *Environment Protection Act 1970*. For example, the ERS adopts as environmental values some of the *beneficial uses* that were defined in the SEPPs. Refer EPA's website for information on how the content of instruments of the environment protection framework under *Environment Protection Act 1970*, such as SEPPs and waste management policies, have informed the new legislative framework.

2.2.1 Documents incorporated into the ERS

The ERS makes reference to a number of external documents. As some of the content of these external documents is too long or complex to be reproduced in the ERS, the relevant parts of the external documents have been *incorporated* into the ERS. Their content must be considered as being part of the ERS. All the external documents that have been incorporated into the ERS are listed in a *Table of applied, adopted or incorporated matter* in the endnotes section of the ERS. This table lists the full title of each document and the relevant part that is incorporated. Most of the incorporated documents are available for free online. All incorporated documents are available for inspection at EPA's head office by appointment.

Where the ERS refers to an external document, for example when stating indicators or objectives, the relevant version of the document is the latest version that is in force. Clause 4 (Definitions) of the ERS lists the external documents, with the versions *as in force from time to time*. The Table of applied, adopted or incorporated matter in the endnotes lists the version in force when the ERS was made.

2.3 Role of the ERS

2.3.1 The ERS as an assessment and reporting benchmark

The ERS provides an authoritative and transparent basis for monitoring environmental conditions to:

- assess whether environmental values are being achieved or maintained in an area
- assess changes over time
- identify and assess potential threats to the environmental values.

The ERS also sets a benchmark for reporting on environmental conditions to the public and to government.

2.3.2 The ERS as a tool within the preventative framework

The ERS is a tool that can be used to assess the impacts on human health and the environment that may result from a proposal or activity, or from existing environmental conditions on a site.

This application of the ERS must be seen within the context of preventing harm from pollution and waste as part of the broader environment protection framework under the Act. Because it is preventative in nature, this framework seeks to minimise risks of harm to human health and the environment rather than setting and authorising acceptable levels of pollution and waste. The focus on prevention allows for continual improvement in managing these risks as knowledge expands and more effective risk- reduction techniques and technologies emerge.

The ERS does not provide compliance standards; it does not set levels up to which one can pollute. Nevertheless, it is still necessary under a preventative framework to understand potential impacts on human health and the environment that may arise from an existing or proposed activity or site. The ERS provides a valuable reference for considering impacts in light of the proposed measures to minimise risks of harm to human health and the environment.

Some key functions of the ERS are described in Table 2.1. In summary, the ERS:

- supports EPA's statutory functions
- complements the environmental duties in decision making
- helps understanding impacts associated with a proposal or activity in its environmental context
- is a reference instrument.

Table 2.1. Functions of the ERS

Roles of the ERS	
The ERS supports EPA's statutory functions	The ERS supports several of EPA's statutory assessment, reporting and response functions as set out in the Act (section 358). These include to: • monitor and assess environmental quality • identify, assess and monitor risks of harm to human health and the environment • identify and respond to opportunities to improve environmental quality • provide advice and recommendations to the Minister for the Environment in relation to human health and the environment • provide information and education to the Victorian community in relation to environmental quality.
The ERS complements the environmental duties in decision making	The ERS provides a scientific basis to help identify potential risks to human health and the environment, thereby forming part of the state of knowledge that supports the environmental duties. The ERS is also valuable for considering issues that are not clearly or completely addressed through the environmental duties. For example, the ERS can help to identify highly valued or particularly sensitive environmental settings where the community expects a higher standard of environment protection to be achieved, or circumstances where collective or coordinated action may be warranted to address broad environmental threats.
The ERS helps to put a proposal in context	Impacts on environmental values are often the results of cumulative effects of pollution from many diffuse sources. When considering an individual proposal, the ERS provides a tool that helps place the proposal in its environmental context. The ERS helps to inform a decision maker about impacts that are directly attributable to the proposal, or impacts that would result from the proposal alongside other sources of pollution. This allows the decision maker to assess whether further environment protection measures may be required, and/or whether a proposal is appropriate or not.
The ERS is a reference instrument	The ERS is a reference instrument, not a compliance standard. It does not impose any environment protection obligations on duty holders, nor are the indicators and objectives compliance limits to be enforced. The ERS has no direct regulatory force.
The ERS must be considered in certain circumstances	The Act, the Regulations and other Victorian legislation require specified persons or decision makers to consider relevant environmental values, indicators and objectives in some circumstances – see Section 2.4.
The ERS may be considered in other situations	The ERS can be considered in circumstances other than those specified in legislation. For example, EPA will draw on the ERS when providing formal advice and recommendations. Other decision makers and the community can refer to the ERS wherever it usefully informs an environment protection decision.
Other tools or issues should be considered where relevant	While important, the ERS does not represent an exclusive source of reference information. Its environmental values are not a comprehensive list of concerns or issues, nor do the indicators and objectives provide an exhaustive basis for assessment. Other issues may also be considered, along with other metrics and objectives and other tools or methods for assessing impacts.

2.3.3 How the ERS interacts with the general environmental duty

In general, EPA will take the ERS into account in environment protection approval decisions, such as when:

- assessing a development or operating licence application
- providing environment protection advice to another decision maker.

In these decisions, the general environmental duty (GED) is typically a central consideration. For this reason, it is important to understand how the GED applies and how the GED and the ERS may interact for these types of decisions.

The GED requires persons undertaking activities to minimise risks of harm so far as reasonably practicable. Risks of harm must be *eliminated* where it is reasonably practicable (https://www.epa.vic.gov.au/about-epa/laws/new-laws/what-is-reasonably-practicable) to do so. Section 6(2) of the Act identifies five matters that must be considered to determine what is reasonably practicable:

- the likelihood of risks eventuating
- the potential degree of harm
- the duty holder's knowledge about the risks,
- the availability and suitability of controls
- the cost of controls.

These require a person to understand the risks of harm to human health and the environment from an activity and to identify and implement all reasonably practicable controls to eliminate or minimise those risks. *Reasonably practicable* (publication 1856) (https://www.epa.vic.gov.au/about-epa/laws/new-laws/what-is-reasonably-practicable) provides information about what is reasonably practicable.

The GED generally establishes the minimum requirements for conducting activities (except where other regulatory requirements are prescribed). The measures necessary to comply with the GED will change over time, reflecting the shift in what is reasonably practicable.

The ERS is a reference point that supports the GED. It acts as a benchmark for assessing potential impacts on human health or the environment from proposed GED compliance measures (and other factors that affect the decision). The ERS assists in evaluating the significance of these impacts.

Where assessment against the ERS suggests that potential impacts are too great, it may highlight that a further risk assessment is needed to better understand the risk profile and inform changes to the proposal. This may mean considering measures that go beyond basic compliance with the GED.

The ERS does not override the GED

- **The ERS must not be used as a proxy for attaining compliance with the GED**
  Because the expectations for GED compliance will improve over time, there is no fundamental connection between the GED and the attainment of specified objectives of environmental quality. Using objectives in this way would undermine the regulatory potential of the framework.
- **The ERS does not indicate levels up to which a person can lawfully pollute**
  To meet the GED, a duty holder must minimise risks so far as reasonably practicable, including where that would provide a level of environmental quality greater than the threshold for achieving or maintaining environmental values of the ERS.
- **Proposals should not be designed simply to meet the quantified objectives in the ERS**
  In particular, a proposal should not be 'reverse engineered' so that the measures it proposes to comply with the GED are selected on the basis that they are sufficient to meet the ERS. It is unlikely that measures developed in this way will actually comply with the GED.

2.3.4 Use of ERS when determining the GED – assessing the 'degree of harm'

When determining what is reasonably practicable, Section 6(2) of the Act requires that regard must be given to the consequences or 'degree of harm that would result if [identified]…risks eventuated'. The duty holder is expected to have reasonable knowledge of hazards that have the potential to cause harm, their potential consequences, and ways of eliminating or minimising the associated risks.

The ERS enables identification of potential harms that may occur if risks eventuate. As such, it is an important part of the state of knowledge and a tool for identifying some risks and evaluating the effectiveness of risk controls. This is particularly so where the relevant ERS objectives relate to direct cause-effect relationships between exceedance of the level of a pollutant in the environment and adverse effects on human health or the environment, such as the ambient air objectives (Chapter 4).

The ERS provides context to a proposal and may also be relevant in identifying areas that have significant environmental values or that are particularly sensitive to harm. Such areas may require additional or stricter measures to comply with the GED, which may go beyond what would be required for a similar proposal in a less sensitive area.

The ERS will not be relevant in all cases or for assessing many types of harm. For example, the ERS is not relevant to the consideration of harm associated with catastrophic failures such as the release of acutely toxic chemicals, explosions or fires. Importantly, the ERS is no substitute for the full and proper consideration of hazards and their associated risks of harm. But as a tool and part of the state of knowledge, the ERS may help clarify whether certain consequences are relevant, and what could be the potential degree of harm.

2.4 The ERS and regulatory decision making

The ERS is considered when making certain regulatory decisions. Victorian legislation prescribes situations where the ERS either ***must*** or ***may*** be taken into account, as described below.

2.4.1 Ministerial decisions

The Minister for the Environment and the Minister for Water *must* consider the ERS when making certain decisions.

Table 2.2. The ERS and Ministerial decision

Decision maker	Context
The Minister for the Environment *must* consider the ERS	The Minister for the Environment must consider the ERS when deciding whether to: • recommend the making of regulations under the Act • recommend the making of a compliance code • declare an issue to be of environmental concern. (Refer section 99 of the Act)
The Minister for Water *must* consider the ERS	The Minister for Water must consider the ERS when: • issuing certain water shares • considering an application for a bulk water entitlement • allocating an environmental entitlement under the *Water Act 1989* • addressing any environmental management plan for the marine environment made by the Minister under the *Marine and Coastal Act 2018*. (Refer *Water Act 1989*, sections 33J, 40, 48F; *Marine and Coastal Act 2018*, section 50)

2.4.2 EPA decisions and advice

Circumstances in which EPA *must* or *may* consider the ERS are described in Table 2.3.

Table 2.3. Circumstances in which EPA must *or* may *consider the ERS*

Decision maker	Context
EPA *must* consider the ERS when assessing specific types of permissions	EPA must consider the impact of the activity on human health and the environment, including the impact on environmental values when: • determining whether to issue a development licence, operating licence or pilot project licence • when reviewing an operating licence. EPA must also consider whether any environmental values are adversely affected when considering whether to grant an exemption from the requirement to hold a development or operating licence. Additionally, EPA must take any adverse effects into account when considering whether to issue a permit for the discharge or deposit of waste to aquifer. (Refer sections 69(3), 74(3), 76(4), 78(2), 80(5) and 81(3) of the Act; Regulations 24(e)(iii), 28(e))
The ERS *may* also form part of EPA's formal advice	The ERS may also form part of EPA's formal advice on projects that may have significant human health or environmental impacts. This includes when: • providing advice about a major project in line with requirements of the *Environment Effects Act 1978* or *Major Transport Projects Facilitation Act 2009* • expressing views about a proposed planning scheme review or amendment under the *Planning and Environment Act 1987*, in line with Ministerial Direction No.19 (Minister for Planning, 2018) • providing advice on a planning permit application as a recommending or determining referral authority, or when given notice under the *Planning and Environment Act 1987* • providing advice as a referral agency under the *Mineral Resources (Sustainable Development) Act 1990*.

2.4.3 Other decision makers

Table 2.4 details specific circumstances in which other organisations, including environmental auditors, councils, planning authorities and the Victorian Civil and Administrative Tribunal (VCAT) *must* or *may* consider the ERS in specific circumstances.

*Table 2.4. Other circumstances where the ERS informs decision making**

Decision maker	Context
Environmental auditors *must* consider the ERS	When carrying out the functions of an environmental auditor under the Act or any other act, an environmental auditor must have regard to the ERS, where relevant, along with any guidelines issued by the EPA. (Refer section 190(2) of the Act)
Council *must* consider the ERS when deciding on permit exemptions for an on-site waste-water management system	A council *must* consider whether granting an exemption may adversely affect the environmental values defined in the ERS when determining whether to grant a permit exemption to construct, install or alter an on-site wastewater management system. (Refer section 83(4) of the Act, Regulation 32(3))
Major transport project proponents *must* consider the ERS	Project proponents must set out how the ERS will be considered when preparing an impact management plan or a comprehensive impact statement for a declared project under the *Major Transport Projects Facilitation Act 2009* (Refer *Major Transport Projects Facilitation Act 2009*, sections 27, 39)
VCAT *must* consider the ERS when reviewing decisions	VCAT must consider the ERS, where relevant, when reviewing specified reviewable decisions under the Act, *Planning and Environment Act 1987*, *Water Act 1989*, *Catchment and Land Protection Act 1994*, *Flora and Fauna Guarantee Act 1988*, and *Subdivision Act 1988.*
The ERS *may* be considered in planning permit applications	When considering an application for a planning permit, the responsible authority under the *Planning and Environment Act 1987* (in most cases a local government) may consider the ERS, where relevant, 'if the circumstances appear to so require it.' The responsible authority must determine whether the circumstances of the application would require the ERS to be considered. Where they do, relevant environmental values, indicators and objectives should be considered. (Refer *Planning and Environment Act 1987*, section 60(1A))

Chapter 3. Applying the Environment Reference Standard

3.1 Principles of application of the ERS

As a benchmark, the application of the Environment Reference Standard (ERS) will differ according to the type of regulatory decision being made. For example, EPA's use of the ERS when assessing a permission application differs from how a responsible authority considers it when determining a planning permit application or how an environmental auditor considers it undertaking their duties. In each case, the ERS will be applied in a way that meets the needs, and supports the functions, of the decision.

While the use of the ERS will vary, Table 3.1 below sets out some key principles for application of the ERS.

Interpretation and application of the environmental values, indicators and objectives should be relevant to the situation or proposal being assessed or the decision being made.

Table 3.1. Principles of application of the ERS in regulatory decisions

Principle	Context
The ERS is used to assess impacts – it does not represent design criteria	The ERS is used to consider potential direct or cumulative impacts on human health and the environment that may result from a proposal, activity or site. The ERS does not provide criteria that a proposal should be expressly designed to meet.
Direct regulation takes precedence over the ERS	Indicators and objectives within the ERS are generally not relevant considerations where they relate to an aspect of the environment that is the subject of prescriptive regulation. For example, the ambient sound indicators and objectives will not be relevant when considering noise in relation to commercial, industrial and trade premises, nor entertainment venues when impacting on noise sensitive areas, as defined in the Environment Protection Regulations 2021 (the Regulations). This is because noise in these circumstances is regulated by specific provisions and noise limits in the Regulations and the associated *Noise limit and assessment protocol for the control of noise from commercial, industrial and trade premises and entertainment venue* (publication 1826).
Assessment should be proportionate	Assessments should be proportionate to the scale of the proposal and the magnitude of potential harms.
The decision maker exercises judgement when evaluating impacts	As the ERS is not a compliance standard, a decision maker needs to evaluate whether the identified potential impacts on environmental values are acceptable or not. Impacts on some environmental values (or objectives) may be more significant than on others. They may also be more relevant to some decisions than to others.

3.2 Applying the environmental values, indicators and objectives

Regardless of the specific elements of the environment being considered, there are three broad steps to follow when using the ERS, as shown in Figure 3.1:

- identify the environmental values and where they apply
- identify and measure the relevant indicators for assessment against the objectives
- assess the risk to the environmental values to inform reporting and decision making.

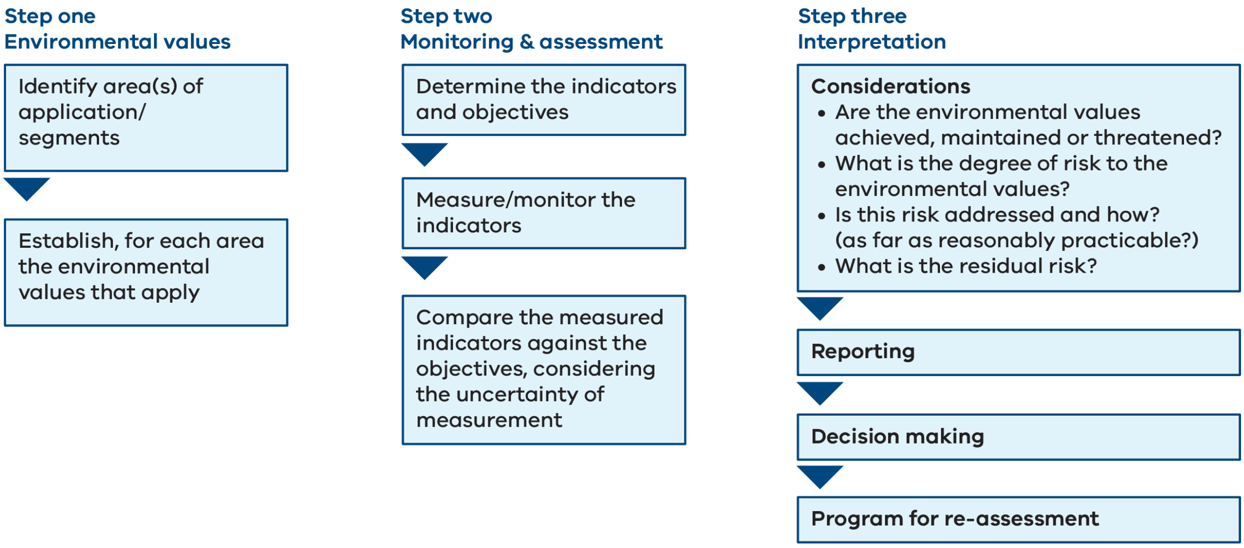


Figure 3.1. General steps to follow when considering the ERS

3.2.1 Relevant environmental values should be considered

In general, the first step when considering the ERS is to identify which environmental values are relevant, depending on the proposal, activity or site, and the potential effects on human health or the environment (or in some cases, such as land use planning decisions, the effects of the existing environment on the proposed activity or use).

Detailed assessment is unlikely to be necessary where a preliminary assessment clearly shows that there will be no effect on the environmental values that apply to the area investigated. For example, Part 2 – Ambient air of the ERS is unlikely to be relevant for a proposal that injects wastewater into an aquifer. A proposal to inject wastewater into an aquifer is also unlikely to require further consideration of the environmental value of water ‘geothermal properties’ when a desktop assessment shows that the groundwater does not have natural geothermal properties, or that its natural thermal capacity is unaffected by the proposed activity.

3.2.2 Indicators and objectives are interpreted in various ways

The ERS has many types of indicators and objectives. These were selected or derived in different ways for different applications or purposes. For example:

- **ambient air objectives** mostly identify levels of ambient air quality that correspond to an assessed level of human health burden, based on a cost-benefit analysis (see section 4.3.3 of this guide)
- **ambient sound objectives** mostly identify cumulative sound levels for all sources of environmental sound or noise, above which the risk to the environmental values increases (see section 5.4)
- **land objectives** are primarily investigation levels for considering whether further assessment or risk assessment of contaminated land is required (see section 6.4)
- **water objectives** describe concentrations, levels, or biological states or conditions that do not cause harm or pose a significant risk to the environmental value (but if not met, indicate a potential risk to the environmental value) (see section 7.2).

The relationship between the exceedance of an objective and risk of harm depends on how an objective was derived. This relationship must be understood, and the objectives interpreted in accordance with their derivation and intended application. Often this process will require the person considering the ERS to refer to the original source guidelines.

Chapter 4. Guide to Part 2 - Ambient air

This chapter should be read in conjunction with Part 2 of the Environment Reference Standard (ERS).

To understand and use the information in this chapter, refer to the definitions in the ERS and the specific clauses and tables in Part 2 - Ambient air.

4.1 Introduction

This chapter provides guidance on how to identify the environmental values, indicators and objectives that need to be considered in decision making and environmental assessments involving ambient air. A case study that describes how the ERS is used to inform a licence amendment application for an upgrade to a wastewater treatment plant is provided in Chapter 8. The application of the ERS to this scenario in terms of ambient air is discussed in section 8.4.

The environmental values, indicators and objectives for ambient air within the ERS are applicable to all air within the state of Victoria, including up to three nautical miles offshore. The definition of ambient air environment in clause 4 of the ERS excludes air that is inside buildings or structures; it is also not intended to be applied inside vehicles.

The beneficial uses for ambient air in the ERS have largely been adopted from the State Environment Protection Policy (Ambient Air Quality) (SEPP (AAQ)) as environmental values, as well as the relevant indicators and objectives. Prior to the commencement of the ERS, the SEPP(AAQ) was the Victorian implementation of the *National Environment Protection (Ambient Air Quality) Measure* (the NEPM (AAQ)). Like many other documents linked to the *Environment Protection Act 1970*, the SEPP (AAQ) now contributes to the general state of knowledge on ambient air quality in Victoria.

4.1.1 Intent of the ERS in terms of ambient air

The ambient air indicators in the ERS cover common air pollutants in Victoria. These pollutants have numerous, diffuse sources. They are widely distributed and have the potential to pose a significant public health risk at a population-wide scale. The objectives in Part 2 - Ambient air of the ERS are not intended to be concentrations one can ‘pollute up to’. Neither should they be interpreted as concentrations below which no action is required.

While the ERS is intended as a reference standard and is not a 'compliance standard' for duty holders, government decision-makers must take the ERS into account when making certain decisions.

4.1.2 Articulation with existing standards for ambient air quality

The ERS replaces SEPP (AAQ) and State Environment Protection Policy (Air Quality Management) (SEPP (AQM)). It generally adopts the objectives in the NEPM (AAQ) with some modifications, including a lower PM_{10} annual standard of 20 $\mu g/m^3$ compared with 25 $\mu g/m^3$ in the NEPM. The ERS also contains other environmental values, indicators and/or objectives that are not in the NEPM (AAQ). These include the environmental value of *useful life and aesthetic appearance of buildings, structures, property and materials* and an environmental value for climate systems.

4.1.3 How the ERS may be used

EPA may use the ERS to:

- report on air quality by comparing EPA air quality data against ERS objectives
- derive other air quality objectives that may be used during emergency incidents, or for industry, business and agriculture.

How others may use the ERS:

- Industry can refer to the ambient air environmental values, indicators and objectives to inform their air quality management practices to meet their general environmental duty (GED).
- Businesses and industry that are subject to EPA’s permission framework may have specific conditions or criteria in their licences. These will often be based on ERS indicators and objectives.
- All businesses and industry that undertake activities that have the potential to generate air emissions must ensure that air pollution is minimised or managed appropriately. This is to ensure that environmental values for air are protected.

4.2 Interpreting the environmental values for ambient air

The environmental values for ambient air (ERS table 2.1, clause 5) are largely a restatement of the beneficial uses from the SEPP (AAQ). Each environmental value is described as an expectation on the state of the ambient air environment. The environmental values include statements about protection of human health and the environment. The environmental values also include the protection of building and property, as a desirable physical characteristic of the environment. More than one indicator may be relevant to an environmental value.

The six environmental values for ambient air are:

- *life, health and well-being of humans*
- *life, health and well-being of other forms of life, including the protection of ecosystems and biodiversity*
- *local amenity and aesthetic enjoyment*
- *visibility*
- *the useful life and aesthetic appearance of buildings, structures, property and materials*
- *climate systems that are consistent with human development, the life, health and well-being of humans, and the protection of ecosystems and biodiversity.*

The environmental values of *life, health and well-being* describes air that sustains life, and is therefore low in pollutants that may cause short-term or long-term health impacts. This is why the objectives in Part 2 - Ambient air of the ERS have different measurement periods, reflecting that air pollutants can have different impacts based on the period of exposure.

Local amenity and aesthetic enjoyment are related as they describe air which can be enjoyed while undertaking outdoor activities, including non-recreational activities such as hanging laundry outside.

Some air pollutants (such as ozone) or the products of air pollution (such as acid rain) can affect the useful life and appearance of buildings. The environmental value for climate systems describes air quality that is not adversely affected by a warming and drying climate, increasing population or economic growth. These effects can include the increased risk of bushfires causing smoke and other air pollutants that can harm human health. The risk and severity of bushfires are projected to increase as the Australian climate continues to get warmer and drier. There is no specific indicator (such as an annual temperature increase) attached to this environmental value.

4.3 Interpreting the indicators and objectives

The indicators and objectives for ambient air are provided in Table 2.2, clause 6 of the ERS. Table 4.1 in this guide provides an overview of their derivation and interpretation.

Most indicators are presented as concentrations expressed in parts per millions (ppm) for gaseous pollutants or in micrograms per cubic metres (μg/m^3) for particulates (lead, PM_{10} and $PM_{2.5}$). Figure 4.1 below shows how to interpret the indicators and objectives using an example for a gaseous pollutant and an example for particulates.

Concentration objectives for ambient air are primarily health based, meaning they are set at levels designed to minimise the risk to human health from ambient air pollution at a population scale. As such, they are intended to be applied at a population level or to assess the air quality of entire airsheds. They have not been derived to assess human health risk for individuals or at a particular location. However, in the absence of more relevant standards, they may be used or adapted by EPA for this purpose.

The indicators and objectives for the environmental value of visibility also seek to ensure that the environmental values of life, health and well-being human health and amenity are not impacted. The qualitative indicator for odour also applies to these environmental values.

The quantified objectives for ambient air are not a threshold below which there will be no adverse health effects and therefore cannot be considered a ‘safe level’. As such, many of the ERS ambient air objectives do not represent a level below which air pollution concentrations present an acceptable risk to human health.

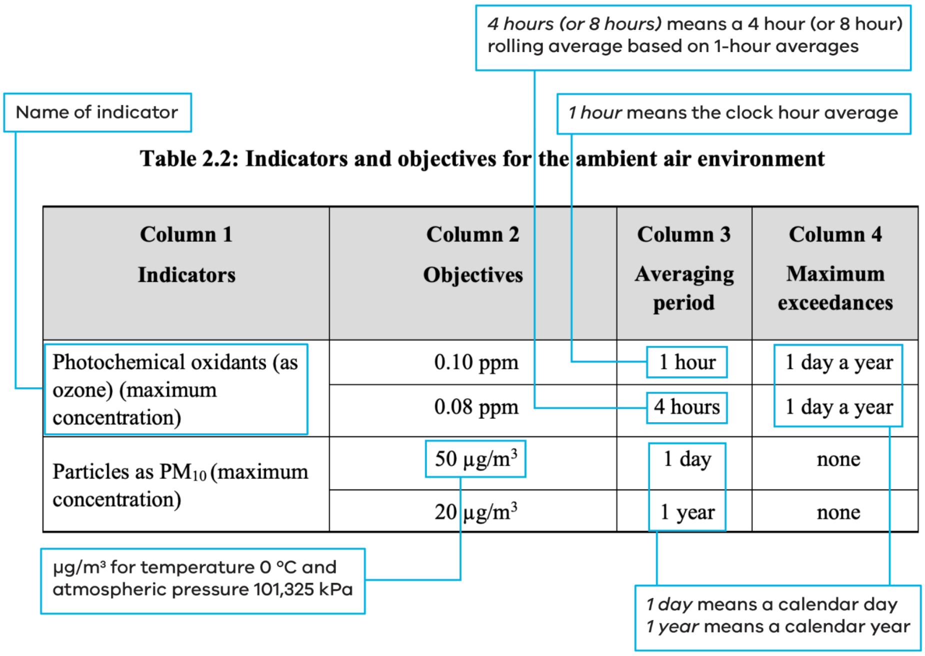


Figure 4.1. An annotated example of how to interpret the indicators and objectives for ozone and PM_{10}.

Exceeding the ambient air objectives in ERS Table 2.2 for an extended period means that ambient air quality may contribute to an increased risk of chronic disease in humans. For some pollutants, there may be natural sources which can cause ambient concentrations to periodically exceed the relevant objective. An example of this is $PM_{2.5}$ exceeding its objective over a 24-hour period during major bushfires, or high concentrations of PM_{10} for short time periods during major windblown dust storms.

The indicators and objectives for ambient air set out in the ERS address a limited set of pollutants, receptors and exposure pathways. As such, additional approaches may be necessary to fully assess and consider whether environmental values are protected or maintained, especially when emissions include indicators not included in the ERS. Where no objectives are provided for some indicators due to a lack of appropriate data, this does not mean they should be excluded from the environmental protection scheme. Rather, it is expected that a suitable indicator and objective would be derived for the site-specific situation.

4.3.1 Ambient air quality levels and background levels

Ambient air quality levels should not be confused with background levels. Background levels are generally considered to represent those levels entirely outside the influence of pollution and waste. However, ambient air quality generally includes background indicator levels and levels resulting from anthropogenic emissions. In most instances, it should not be assumed that background air quality is free of human influence, as even ‘clean’ air in an urban airshed will contain emissions from vehicles and industry.

Considering only natural sources (and disregarding human influences) will not necessarily mean that the ambient air quality will be better than the objective values. For example, major bushfires can be started by natural sources (lightning strikes), which can lead to objectives not being met.

4.3.2 Objectives and cumulative effect

The ERS objectives for ambient air are designed to consider multiple sources and other factors that can increase the risk of exposure to air pollutants.

The risks posed by ambient air pollution must always go beyond addressing a specific source of emissions in isolation. All other relevant emission sources should also be included in air quality assessments. The consideration of background concentrations of all air pollutants is, therefore, always required as a critical step in understanding the overall risk to human health or the environment. This includes considering how background concentrations vary during the year or between years due to seasonal or other temporal trends.

Depending on the nature of the specific site and type of emissions, cumulative effects on human health or the environment may need to consider the potential for additive or synergistic effects from multiple pollutants being present in the same parcel of air. Importantly, the vulnerability of the populations exposed to air pollution needs to be understood. This means that age, pre-existing medical conditions, or other contributing factors should also be considered. Therefore, the interpretation of ambient air quality data in the context of the ERS will require a holistic evaluation of all relevant cumulative effects, rather than simply a comparison to the ERS objectives.

4.3.3 Criteria air pollutants

Criteria air pollutants are compounds that are common in the urban environment. As such, they are commonly used and regulated as indicators of air quality. Criteria air pollutants include carbon monoxide, nitrogen dioxide, photochemical oxidants (ozone), sulfur dioxide, lead and particles (PM_{10} and $PM_{2.5}$). Some of these compounds, such as nitrogen dioxide and ozone, are ubiquitous in the environment. Other pollutants, such as carbon monoxide and sulfur dioxide, come from specific emission sources. These indicators are mostly classified as Class 1 substances under the Environment Protection Regulations 2021 (Schedule 4). The exception to this is $PM_{2.5}$, which is classified as a Class 2 substance.

The methods used in the NEPM (AAQ) to derive the objectives for criteria air pollutants involve a combination of health risk assessment and cost-benefit analysis. As such, they do not represent concentrations below which risks are deemed to be ‘acceptable’, and therefore they do not indicate levels for a ‘risk free’ ambient air environment. Instead, the objectives are intended to be used as benchmark concentrations to help evaluate the level of risks to health posed by ambient pollutant concentrations.

EPA uses the indicators and objectives for criteria air pollutants when reporting to the community on the state of the environment, as part of its monitoring and reporting requirements under the NEPM (AAQ). EPA uses monitoring methods that are reference or equivalent methods at air quality monitoring stations, located at sites that meet the NEPM (AAQ) requirements. The concentrations of lead decreased in Victoria to levels below concern due to the phase out of leaded petrol. As a result, EPA discontinued the measurement of ambient lead in 2004.

4.3.4 Odour

Part 2 - Ambient air of the ERS includes an odour indicator, where the absence of offensive odours demonstrates the environmental value is being met.

Odour can come from both natural and industrial sources. Some facilities generate odours due to the type of industry or operations involved. As such, an environment totally free of odour is normally not achievable. This is one of the reasons that there are separation distances/buffers between land uses, such as between industrial and residential areas (refer *Recommended separation distances for industrial residual air emissions – guideline* (publication 1518)).

Odour is subjective and varies in its perception from person to person. The consideration of harm, however, is an objective assessment and is the focus of EPA guidance and monitoring (see *Determination of odour concentration by dynamic olfactometry* (publication 1666)). Natural odours, such as rotting seaweed, are offensive to some people, but the ERS does not cover natural odour sources Table 4.1 below presents the derivation and interpretation of indicators and objectives for odour.

4.3.5 Visibility reducing particles (minimum visual distance)

Poor visibility due to air pollution reduces our enjoyment of the environment around us. The minimum visual distance indicator is one of the key ways the community can assess air quality for themselves without measurement. The objective for visibility (20 km) represents a typical distance over which the community expects to be able to see.

Measuring visibility is a common way to assess smoke from burning in the absence of $PM_{2.5}$ measurements. Smoke at low concentrations can affect people’s amenity by reducing visibility and in some situations may affect the health of sensitive members of the population. There can be significant smoke impacts due to fuel reduction burning, the burning of crop residues and other burning activities.

4.3.6 Climate systems

While the ERS includes an environmental value of *climate systems that are consistent with human development, the life, health and well-being of humans, and the protection of ecosystems and biodiversity*, there is no indicator or objective set for climate change. However, there is international agreement (the Paris Agreement) to keep global temperature rise below 2 ^{0}C. Each party to the Paris Agreement is required to develop a nationally determined contribution. Information on Victoria’s contribution to Australia achieving its nationally determined contribution can be found on the ‘Climate Change’ page (https://www.climatechange.vic.gov.au/) of the website of the Department of Environment, Land, Water and Planning (DELWP, n.d.).

Table 4.1. Derivation and interpretation of indicators and objectives for ambient air

Indicator	Indicator type	Derivation of Objective	Interpretation
Carbon monoxide Nitrogen dioxide Sulfur dioxide	Criteria air pollutants (maximum concentration)	The objectives were derived by a national process using the *Methodology for setting air quality standards in Australia* (NEPC, 2011a) The original NEPM (AAQ) was developed in 1998 and is consistent with the *National Environment Protection (Ambient Air Quality) Measure – Revised Impact Statement* (NEPC, 1998). It was comprehensively reviewed in 2011 (NEPC, 2011,b). For nitrogen dioxide and sulfur dioxide, the NEPM standards are currently under review (NEPC, n.d.)	Carbon monoxide, nitrogen dioxide and sulfur dioxide are part of a group of air pollutants referred to as criteria air pollutants. This is because they are common in the urban environment and commonly used and regulated as indicators of air quality. These indicators have been grouped together as they commonly arise from combustion and, as a result, are produced by many industries. Sulfur dioxide emissions are commonly linked to the amount of sulfur present in fuel. Sulfur content in automotive fuel in Australia is regulated by fuel standards that are being reviewed, with the aim of adopting the Euro 6 standards. The International Maritime Organization has proposed more stringent limits on the sulfur content of marine fuels under the Marpol Convention. This will potentially reduce the levels of sulfur dioxide associated with shipping and ports. In general, the ambient levels of carbon monoxide, nitrogen dioxide and sulfur dioxide in Victoria are well below the objectives in the ERS.
Lead	Criteria air pollutants (maximum concentration)	The objective was derived by a national process using the *Methodology for setting air quality standards in Australia* (NEPC, 2011a) The original NEPM (AAQ) was developed in 1998 and is consistent with the *National Environment Protection (Ambient Air Quality) Measure – Revised Impact Statement* (NEPC, 1998). It was comprehensively reviewed in 2011 (NEPC, 2011,b).	The concentrations of lead decreased in Victoria to levels below concern as a result of the phase out of leaded petrol. As a result, EPA discontinued the measurement of ambient lead in 2004.
Particles as PM_{10} and $PM_{2.5}$	Criteria air pollutants (maximum concentration)	The objectives for PM_{10} and $PM_{2.5}$ were derived by a national process based on the *Methodology for setting air quality standards in Australia* (NEPC, 2011a).	In general, the ambient concentrations of PM_{10} and $PM_{2.5}$ in Victoria are below the objectives in the ERS. However, natural sources such as bushfires and continental scale wind-blown dust events can lead to ambient concentrations above the desired objective. The NEPM (AAQ) makes allowances for

Indicator	Indicator type	Derivation of Objective	Interpretation
		For particles, the NEPM standards were reviewed in 2015 (NEPC, 2015).	these exceptional events so that the assessment of objective exceedances can focus on those caused by anthropogenic sources, where there may be more opportunity to intervene and improve air quality. With a drier and hotter climate forecast for the future, the intensity and frequency of these natural pollution events are forecast to increase.
Photochemical oxidants (as ozone)	Criteria air pollutants (maximum concentration)	The objectives for ozone in the ERS were derived by a national process based on the *Methodology for setting air quality standards in Australia* (NEPC, 2011a). For ozone, the NEPM standards are being reviewed (NEPC, n.d.).	Ozone is treated differently from carbon monoxide, nitrogen dioxide and sulfur dioxide due to the way it forms in the atmosphere. Rather than being directly emitted by combustion or other industrial processes, ozone forms from a photochemical reaction from precursor chemicals (such as volatile organic compounds) generated by combustion processes. As a result, ozone can be difficult to directly regulate, hence the focus is usually on precursors. In general, ambient concentrations of ozone are below the objectives in the ERS. However, exceedances of the objectives do occur under certain meteorological conditions. In Melbourne, ozone formation is associated with higher temperatures, so with a future hotter climate, the intensity and frequency of ozone exceedances are likely to increase.
Odour	Offensive odour	The objective for odour draws from the qualitative objective values for *local amenity and aesthetic enjoyment*. This objective describes an outdoor air environment that is free from offensive odours that supports lifestyle, recreation and leisure. The indicator is based on the odours that are not permitted from commercial, industrial, trade and domestic activities within the locations specified (residential area or in a public open space adjacent to a residential area).	An offensive odour can be detrimental to health and well-being and interferes with normal enjoyment or use of the air environment, and/or causes people to feel revolted, disgusted, upset, or annoyed. Not meeting this objective can: • interfere with home activities such as putting out the washing, barbecues, or other domestic or recreational activities • cause distress through infiltration into homes and prevent airing of homes as windows remain closed • cause health impacts through physiological or psychological triggers • aggravate asthma • cause nausea, headaches and other acute health symptoms

Indicator	Indicator type	Derivation of Objective	Interpretation
			• interfere with people's capacity to operate at workplaces • taint food and other odour sensitive products.
Visibility (reducing particles)	Amenity (minimum visual distance)	This objective was established for aesthetic purposes to protect the visual appearance of the atmosphere. Therefore, it is not designed for health protection, though it is strongly influenced by particle concentration. Although the basis of this objective is necessarily subjective, the impact of visibility-reducing particles on people's amenity is the subject of many complaints received by EPA.	Visibility is the primary means by which most people judge air quality. As such, this objective is still considered to be appropriate and relevant to air quality in Victoria. The 20-kilometre objective was developed as a Melbourne-specific standard. It was set on the ability to see the Dandenong Ranges from Camberwell, which was determined to be the centre of urban Melbourne when the objective was set in the mid-1990s.
Indicator(s) for climate change	-	There is no specific ERS indicator or objective for the environmental value for climate change.	-

Chapter 5. Guide to Part 3 - Ambient sound

This chapter should be read in conjunction with Part 3 of the Environment Reference Standard (ERS)

To understand and use the information in this chapter, refer to the definitions in the ERS and the specific clauses and tables in Part 3 - Ambient sound.

5.1 Introduction

This chapter provides guidance on the environmental values, indicators and objectives that need to be considered in decision making and environmental assessments involving sound or noise that may pose a risk to the ambient sound environment.

A case study that describes how the ERS is used to inform a licence amendment application for an upgrade to a wastewater treatment plant is provided in Chapter 8. The application of the ambient sound indicators and objectives to this scenario is discussed in section 8.5.

The ambient sound environmental values in the ERS describe ambient sound quality that supports acceptable human health and amenity outcomes and enjoyment of natural areas. The ERS also recognises the community's demand for musical entertainment.

The ambient sound environmental values in the ERS have been adopted from the beneficial uses in the State Environment Protection Policies (SEPP) for noise. These beneficial uses are sleep during the night, normal domestic and recreational activities and normal conversation, which come from:

- SEPP (Control of Noise from Commerce, Industry and Trade) No. N-1 (SEPP N-1) (Victorian Government, 1989,a)
- SEPP (Control of Music Noise from Public Premises) No. N-2 (SEPP N-2). (Victorian Government, 1989,b)

Two other environmental values were also developed during a review of the noise SEPPs (2014-18): *child learning and development*, and *human tranquillity and enjoyment outdoors in natural areas*. These have also been adopted as environmental values in the ERS.

The environmental value of *musical entertainment* was added to the ERS following consultation on the October 2019 ERS exposure draft. This environmental value retains the intent of the policy goal of SEPP N-2 to:

- protect residents from levels of music noise that may affect the beneficial uses made of noise sensitive areas while recognising the community demand for a wide range of musical entertainment.

The noise limits and obligations of SEPP N-1 and SEPP N-2 do not form part of the ERS and are not related to the ERS indicators or objectives. Instead, the Environment Protection Regulations 2021 (the Regulations) set noise limits and assessment methods for noise emitted from industry, and entertainment venues and events.

5.2 Interpreting the environmental values for ambient sound

Clause 7 of the ERS sets out the environmental values for the ambient sound environment that are to be achieved or maintained in Victoria. The ERS also sets out the indicators and objectives to support those values.

The environmental values for ambient sound are:

- *sleep during the night*
- *domestic and recreational activities*
- *normal conversation*
- *child learning and development*
- *human tranquillity and enjoyment outdoors in natural areas*
- *musical entertainment.*

ERS Table 3.1 provides a brief description of each ambient sound environmental value and intended outcome.

The environmental value of *sleep during the night* describes an ambient sound environment that supports sleep at night. It refers to people being able to fall asleep, having good quality sleep and not being awakened by noise during the night. When this environmental value is at risk, sleep disturbance can occur. Sleep disturbance includes difficulty falling asleep, awakenings, alterations of sleep stages or depth, increased body movements and cardiovascular effects. Secondary effects of sleep disturbance include perceived sleep quality being reduced, fatigue, and decreased performance and well-being.

The environmental value of *domestic and recreational activities* refers to an ambient sound environment that supports recreational and domestic activities in a residential setting. This means that ambient sounds in the environment should not interfere with the way people use their homes. This includes tasks that require concentration or sustained attention, such as reading, working from home, watching television, listening to music and resting. It also includes recreation, and entertaining, such as hosting a barbeque outdoors.

The environmental value of *normal conversation* is described as an ambient sound environment that allows for a normal conversation without the need to raise voices. It means a person can speak without having to raise their voice for the words to be heard and understood by another person.

The environmental value of *child learning and development* refers to an ambient sound environment that supports cognitive development and learning in children. Meeting this value in learning environments means that noise from outside won't interfere with children:

- learning to read and comprehending written texts
- hearing and understanding teaching instruction
- communicating with others
- concentrating and maintaining focus on tasks that require attention.

The environmental value of *human tranquillity and enjoyment outdoors in natural areas* refers to an ambient sound environment that allows for the appreciation and enjoyment of the natural environment and the restorative benefits of tranquil soundscapes in natural areas. Non-natural sounds intruding into natural areas can detract from the tranquillity and enjoyment of the environment.

The environmental value of *musical entertainment* refers to 'an ambient sound environment that recognises the community's demand for a wide range of musical entertainment'. It reflects the importance of musical entertainment to the Victorian community and economy.

5.3 Land use categories for the ambient sound environment

While the environmental values for ambient sound apply across the whole of Victoria, the indicators and objectives vary depending on different categories of land use.

The ambient sound land use categories recognise that urbanisation increases ambient sound in the environment. Five categories are defined to cover the typical land use settings that occur throughout Victoria (Table 3.2, clause 8 of the ERS).

The categories correspond to decreasing intensity of urban development, from highly dense urban settings (in category I) to rural settings (in category IV), and natural areas (in category V). This reflects the difference between urban settings where higher sound levels may be tolerated, while natural settings include sounds that are considered an integral part of the desired soundscape.

The categories are consistent with the differences in intensity or scale of development of the built environment within urban, regional and rural areas. They are based on ambient sound levels that are likely to be found in each category. Category I is typically urban with distinctive features or characteristics of taller buildings, high commercial and residential intensity and high site coverage. Melbourne's central business district is an example of a category 1 setting. Category II typically contains medium rise building form with a strong urban or commercial character with mixed land uses including activity centres and larger consolidated sites, and active public spaces. The major activity centres around metropolitan Melbourne are examples of category II settings.

The land use category descriptions are based on similar descriptions used in the Victorian planning system and are generic characterisations that reflect typical urban form outcomes within each of the categories. As such, the descriptions are not intended to be comprehensive. Instead, they capture the major differences in urban form that will be relevant in the context of ambient sound monitoring across Victoria.

The land use categories are linked to the planning land use zones, shown in ERS Table 3.2.

Some land use zones within the planning system include schedules to the zones that further identify types of developments. This is the reason why some zones (comprehensive development, priority development, special use, and public use) must be assessed on a case-by-case basis, as their specific assignment to an ERS category will depend on surrounding land uses and the intent of the planning zone specified in the schedule.

The land use categories have been developed in accordance with scientific knowledge of the sound levels that characterise the maintenance of the environmental values, and above which there is an increased risk of impact to human health and disturbance to people's everyday activities.

5.3.1 Developed areas – category I to IV

Developed areas include all areas of Victoria other than natural areas. Categories I to IV cover a range of land use densities including highly urbanised areas, mixed land uses and activity centres. They also cover suburban residential areas, small regional towns and farmland. ERS Table 3.2 describes each of the categories.

All environmental values except *human tranquillity and enjoyment outdoors in natural areas* are relevant to categories I to IV.

However, proposed developments that may impact on the ambient sound of developed areas and on *human tranquillity and enjoyment outdoors* within nearby natural areas need to be assessed to consider both aspects. This would be the case for example, if a visitor facility that generates increased vehicle traffic is developed at the boundary of a state park near residential areas.

Adjacent ambient sound categories

In most cases, the category with the lower objectives should be adopted where a decision using ERS relates to either:

- land near the interface of two categories
- near or at the boundary of land use planning zones that fall within different categories.

5.3.2 Natural areas – category V

Category V areas are described as the '*unique combinations of landscape, biodiversity and geodiversity*'. These natural areas typically provide undisturbed species habitat and enable people to see and interact with native vegetation and wildlife.

The ERS defines natural areas as national parks, state parks, state forests, nature conservation reserves and wildlife reserves. The ERS definition of 'natural areas' also includes environmentally significant areas and landscapes outside metropolitan Melbourne that are identified in a planning scheme that refers to clause 12.05 of the Victoria Planning Provisions (VPP, n.d.) (https://planning-schemes.api.delwp.vic.gov.au/schemes/vpps). This definition of natural area can also apply to any relevant local policies. Natural areas are classified as land within category V irrespective of the planning zones that apply to that land.

Human tranquillity and enjoyment outdoors in natural areas is the only environmental value that applies to category V land use.

5.4 Interpreting the indicators and objectives

For each land use category, the ERS provides indicators and objectives that are relevant to the environmental values that apply in that category. The indicators differ for developed (categories I to IV) and natural areas (category V). The objectives also vary for each land use category and corresponding indicator.

For the environmental value of musical entertainment, there is no indicator or objective. Instead, this environmental value may be applied in decision making, such as where noise emissions from a proposed development might pose a risk to musical entertainment at a particular location.

Table 5.1 of this guide describes the basis for, or derivation of, the objectives. It also provides information to interpret the risks to environmental values relevant to the land use categories.

5.4.1 Developed areas – categories I to IV

The following environmental values apply in developed areas:

- sleep during the night
- domestic and recreational activities
- normal conversation
- child learning and development

- musical entertainment.

a) Indicators

The indicators relevant to these environmental values are outdoor sound levels (L_{Aeq}) for a given time interval, as set out in Table 3.3, clause 9 of the ERS

The time intervals are:

- 16 hours during the day and evening, from 6 am to 10 pm
- 8 hours at night, from 10 pm to 6 am.

The L_{Aeq} metric is the single number indicator for measuring ambient or environmental sound (or noise) that is most widely used internationally and in other jurisdictions in Australia. It provides a representation of the quality of the ambient sound environment over a defined time period.

Environmental sound varies over time and the L_{Aeq} metric represents this by converting many instantaneous sound pressure level measurements over the defined time interval into a single number. This single number is referred to as an equivalent continuous sound pressure level (L_{Aeq}).

For the ERS, A-weighted sound pressure levels are measured. The A-weighting (denoted by 'A' in L_{Aeq}) was devised to represent the human response to sound and its variation with frequency, in the typical range of magnitude for environmental sound levels.

b) Objectives

The objective for the *outdoor* $L_{Aeq,T}$ indicator is an ambient sound level in decibels. T refers to the time interval (8 hours or 16 hours).

The objectives vary with the time interval for the relevant time of day. The lower night-time objectives compared to the day/evening objective for the same category apply to the environmental value of *sleep during the night*. For example, in category III, the objective for the $L_{Aeq,8\,hr}$ from 10 pm to 6 am is 40 dB(A), whereas for the same category the objective for the outdoor $L_{Aeq,16hr}$ during the day and evening (6 am to 10 pm) is 50 dB(A). This is sufficient to maintain the environmental value of sleep for most people during the night, even with bedroom windows open.

The ERS objectives also differ based on the land use category. The objectives for developed areas are based on the Australian standard for design sound levels within buildings AS/NZS 2107:2016. These levels were adjusted to the outdoor environment (in free-field conditions) based on the typical noise reduction provided by the building envelope within the corresponding land use setting. For example, the difference in noise level from outdoors to indoors with the window open is generally understood to be 10 dB(A). Similarly, for typical older Australian dwellings without additional noise control, a reduction of 15 dB(A) can reasonably be expected when windows are closed. Greater noise reduction, around 20 dB(A), can be achieved in contemporary constructions that include thermal efficiency measures (such as thermal double glazing for the prevention of air leakage). Even higher noise reduction can be expected where specific acoustic treatments have been incorporated.

The ERS objectives for sound in the ambient environment are designed to achieve and maintain the environmental values that relate to the intended use of buildings in specific land use categories. The differences in objectives recognise the reality of current ambient sound levels that can reasonably be expected in developed areas. In some land use settings, such as category I, some modification to living arrangements or building design is expected (such as closed windows or improved acoustic attenuation). In the more urbanised ERS land use categories (I and II), additional noise attenuation above standard contemporary energy-efficient construction may be required to achieve internal noise levels equivalent to those observed in other land use categories.

The numerical objectives apply to the cumulation of sound in the environment. This means the objectives apply to existing ambient sound level and contribution from any new sound sources introduced into the environment.

c) Applying the indicators and objectives

Where relevant, the decision maker will consider the ambient sound environmental values, indicators, and objectives to inform their decision. Importantly, the ERS is not a compliance standard. Therefore, the numerical objectives are not prescribed noise limits for a particular land use zone, nor are they noise design criteria for proposed developments. The Regulations prescribe controls and limits for noise from residences, commercial, industrial and trade premises, and entertainment venues.

The ERS is relevant for activities that are not directly regulated but may interact with the ambient sound environment. This can be either by directly emitting noise or increasing sound sources in the environment indirectly such as by increased traffic movements.

It is expected that when a decision-maker considers the ERS for a development proposal, the decision-maker would examine whether:

- the proposal would change the sound of the ambient environment
- sounds emitted from a proposal would adversely affect or pose a risk to the environmental values.

Where the ambient sound levels at a location exceed the corresponding objectives, decision makers should further consider the existing ambient sound environment and emissions associated with the proposal. These considerations will depend on the specific legislation under which the decision is being made and the details of the proposal. The environmental values, indicators and objectives for ambient sound can be used to assess the risk of harm associated with a proposal.

The cumulative effect of noise also needs to be considered during the design of new developments, so that it accounts for any additional noise associated with subsequent developments. In principle, if the first development in a given area is designed to meet the ERS objective level, contributions from later noise sources need to be at least 10 dB(A) below the objective. This is so the overall ambient sound level does not increase. If the first development designs their noise emissions to be below the objective levels, it leaves capacity for the additional noise emissions for future developments.

Table 5.1 below provides information on the risk to the environmental values when the ERS objectives are not met.

5.4.2 Natural areas – category V

a) Indicator and objective

The indicator for category V land use is qualitative. This is because numerical criteria, such as sound levels measured as L_{Aeq}, are limited in their ability to represent the values of natural areas. This is related to how the experience of natural areas is affected by the presence of non-natural sounds intruding into the natural soundscape. Rather than the loudness or quietness of a sound, it is the audibility, noticeability and whether it fits with the environment that either enhances or detracts from the experience and disrupts people's tranquillity and enjoyment.

The audibility and noticeability of introduced sounds in the presence of other ambient environment sound depends on the loudness, temporal variation and the frequency of both the existing sound and the introduced sound (or noise signal). Regardless of its decibel level, an introduced sound can be audible during quieter times, as the natural sounds vary temporally, seasonally and in frequency, such as with bird calls or leaf rustling. For this reason, the objective for category V areas is '*a sound quality that is conducive to human tranquillity and enjoyment having regard to the ambient natural soundscape*'.

b) Applying the indicator and objective

When considering the environmental value of *human tranquillity and enjoyment outdoors in natural areas,* decision-makers should consider the potential impacts on achieving the objective for category V (*a sound quality that is conducive to human tranquillity and enjoyment having regard to the ambient natural soundscape*). Decision makers should also consider any change in the sound of the ambient environment and whether sounds emitted from the proposal would support or interfere with the tranquillity and enjoyment of a natural area.

To support an assessment of the condition of the sound environment of category V land, the quality of the ambient sound environment can be described using soundscape methods to provide a characterisation. For the ERS, an assessment must include a description of the ambient sound environment, including unwanted and wanted sounds, and an evaluation of the degree to which the ambient natural soundscape is conducive to human tranquillity and enjoyment.

Even though the indicator and objective that apply to category V land are qualitative and do not require an assessment of sound levels, measurements to describe the temporal variation in sound levels may be used to support an assessment of the environmental condition. The international standards for describing, measuring, and reporting soundscape may be used, such as the International Standards series ISO 12913 (which includes ISO 12913-1, ISO 12913-2 and ISO/TS 12913-3).

When assessing risks to the environmental value of *human tranquillity and enjoyment outdoors in natural areas* from proposed developments, condition reporting using soundscape studies can be used to establish baseline ambient sound environment. In addition, an assessment of the impact of the proposal should consider:

- the preferred sound environment for the category V land (whether the sounds are to be heard or not)
- the sounds generated by the proposed development and related activities

- design response options to:
  - eliminate or control *unwanted* sounds
  - maintain, enhance, generate or introduce *wanted* sounds (including sounds that mask unwanted sounds)
- the characteristics of the sound environment if the proposed development goes ahead
- the risk (or benefit) to the ambient sound environment that consider the ERS objective for category V land.

These considerations are based on the approach to designing outdoor space proposed by Brown and Muhar (2004).

Table 5.1. Derivation and interpretation of objectives for ambient sound environmental values

Environmental value	Indicator type	Derivation	Interpretation
Sleep during the night	Decibel level as an outdoor $L_{Aeq,8\ hour}$ (in free field conditions)	Decibel level objectives are derived from standards for design of building interiors suitable for sleep (AS/NZS 2107:2016). The objectives are adapted based on expected building attenuation in the land use setting and whether the occupant is more likely to sleep with their windows opened or closed. In category I, the night-time objective is consistent with the levels suggested by enHealth (2018) as evidence-based limits outdoors and the interim target in the World Health Organization *Night noise guidelines for Europe* (WHO, 2009).	Not meeting the decibel level objectives outdoors in the ambient sound environment indicates that there is an increased risk of sleep disturbance due to noise (difficulty falling asleep, awakening, poor quality sleep). An increased potential risk of sleep disturbance can be expected when the levels are exceeded: • even if windows are closed in the more urbanised areas in categories I and II • when windows are open in categories III and IV.
Domestic and recreational activities	Decibel level as an outdoor $L_{Aeq,16\ hour}$ (in free field conditions)	Decibel level objectives for domestic and recreational activities are derived from standards for design of building interiors suitable for living areas of residential buildings in different land use settings (AS/NZS 2107:2016). The objectives are adapted, based on expected building attenuation in the land use setting and whether the occupant is more likely have windows opened or closed. In category I, the day-time objective is consistent with the level suggested by enHealth (2018) as evidence-based limits outdoors.	The objectives are set at levels above which there is an increased risk of disturbance by noise. Not meeting the decibel levels outdoors can affect domestic and recreational activities that people conduct at home and other residences. Noise can be expected to interfere with reading and other tasks that require concentration or sustained attention, such as working from home, watching television, listening, rest and recreation. An increased risk of disturbance to domestic and recreational activities can be expected when the levels are exceeded: • for categories I and II, outdoors and indoors,

Environmental value	Indicator type	Derivation	Interpretation
			even if windows are closed, • for categories III and IV, outdoors and indoors when windows are open.
Normal conversation	Decibel level as an outdoor $L_{Aeq,16\ hour}$ or an outdoor $L_{Aeq,8\ hour}$ (in free-field conditions)	Ambient sound can interfere with speech intelligibility (the ability of speech to be heard and understood). The objectives are based on evidence of speech intelligibility at different ambient sound levels.	The risk of interference to normal conversation increases when ambient sound levels exceed the day-evening objectives for categories I and II. This risk increases as the distance between the speaker and the listener increases. In category I, if sound levels increase above the level of the day-evening objective, the ability to hold a normal conversation indoors can be affected when the windows are open. In category I and II, conversations outdoors can require a higher vocal effort as sound levels increase above the level of the day-evening objective.
Child learning and development	Decibel level as $L_{Aeq,16\ hour}$ (in free- field conditions)	Decibel level objectives for child learning and development are derived from standards for design of building interiors suitable for teaching spaces and classrooms in educational buildings. (AS/NZS 2107:2016) In categories I, II and III, the objectives are based on having the classroom windows closed on the facade most exposed to the sound. The objectives do not apply to spaces inside buildings used for sleeping during daytime, as may occur in childcare centres.	Ambient sound levels exceeding the objectives pose a risk to children being able to hear and understand complicated spoken messages in classrooms and learning areas. In categories I and II, additional building attenuation may be warranted to achieve acceptable internal sound levels. For example. AS/NZS 2107:2016 recommends a range of 35 to 45 dB(A) for teaching spaces and single classrooms. Above this range, most people will be dissatisfied with the level of intruding sound.
Human tranquillity and enjoyment in natural areas	Qualitative	This objective is based the World Health Organization *Guidelines for community noise* (WHO, 1999) recommendations to protect the outdoors in parkland and conservation areas from disruption of tranquillity. WHO (1999) states	Introducing non-natural sounds into natural areas poses a potential risk to visitor experience, disruption of tranquillity and loss of enjoyment of the natural area.

Environmental value	Indicator type	Derivation	Interpretation
		‘existing quiet outdoor areas should be preserved and the ratio of intruding noise to natural background sound should be kept low’.	
Musical entertainment	None	Recognises the importance of musical entertainment to Victoria’s culture and economy. It carries over the policy goal of SEPP N-2 (Victorian Government, 1989b)	Decisions that introduce sounds into the environment where musical entertainment is performed pose a risk to this value.

Chapter 6. Guide to Part 4 - Land

This chapter should be read in conjunction with Part 4 of the Environment Reference Standard (ERS)

To understand and use the information in this chapter, refer to the definitions in the ERS and the specific clauses and tables in Part 4 - Land.

6.1 Introduction

The ERS defines 'land environment' as including soil, fill, rock, weathered rock and sand, the vapour and liquids within interstitial space in the unsaturated zone, and sub-aqueous sediment. In this context, sub-aqueous sediments are soils or sediments that are below surface or marine water, and above groundwater.

While the definition of land in section 35 of the *Environment Protection Act 2017* (the Act) (with respect to contaminated land) includes groundwater, the ERS addresses groundwater as part of the water environment. See Chapter 7 of this guide (Guide to Part 5 - Water) for information about groundwater environmental values, segments, indicators and objectives.

The environmental values of land are described in clause 10 of the ERS. The land environment indicators and objectives are described in Table 4.3, clause 12 of the ERS. The ERS has largely adopted the land environmental values (beneficial uses), indicators and objectives from the State Environment Protection Policy (Prevention and Management of Contamination of Land) (SEPP (PMCL)).

SEPP (PMCL) also included clauses related to the application of the environmental values, indicators and objectives in specific circumstances. These include circumstances such as planning decisions, licensing and remediation activities. These clauses have not been included in the ERS, but where relevant, they have been included in the Environment Protection Regulations 2021 (the Regulations) or updated in guidance documents. Refer to EPA's website for information on how the content of instruments of the environment protection framework under the *Environment Protection Act 1970*, such as SEPPs and waste management policies, have informed the new legislative framework.

SEPP (PMCL) incorporated certain parts of the National Environment Protection (Assessment of Site Contamination) Measure (NEPM (ASC)) 1999 (as amended in 2013), using the investigation levels as indicators and objectives for the protected beneficial uses (environmental values in the ERS). The ERS has also incorporated specific investigation and screening levels from the NEPM (ASC), as detailed in Table 4.3 of the ERS.

While SEPP (PMCL) is superseded by the ERS, it remains a 'state of knowledge' document for contaminated land management for the time being. The same applies to the parts of the NEPM (ASC) that are not specifically incorporated into the ERS.

The NEPM (ASC) defines investigation and screening levels as '*the concentration of a contaminant above which further appropriate investigation and evaluation will be required*.' In other words, exceedance of investigation and screening levels indicates the potential for harm in relation to the corresponding land use assumptions for those levels. If the evidence does not support a potential for harm in relation to any environmental values, including potential adverse impacts on underlying groundwater, then such land would not be regarded as contaminated for the purposes of the Act. The ERS uses the NEPM (ASC) investigation and screening levels as a proxy for indicators in the land use settings where no other published standards exist in Australia. In the ERS, the indicators and the objectives will be a guide to determine whether a potential exists for harm to human health and the environment.

As additional context, the NEPM (ASC), Schedule B1 explains the limitations of the investigation and screening levels:

> *'2.1.2 Inappropriate use of investigation levels and screening levels*
> *Investigation and screening levels are not clean-up or response levels nor are they desirable soil quality criteria. Investigation and screening levels are intended for assessing existing contamination and to trigger consideration of an appropriate site-specific risk-based approach or appropriate risk management options when they are exceeded. The use of these levels in regulating emissions and application of wastes to soil is inappropriate.*
> *The use of investigation and screening levels as default remediation criteria may result in unnecessary remediation and increased development costs, unnecessary disturbance to the site and local environment, and potential waste of valuable landfill space. Similarly, the inclusion of an investigation and screening level in this guidance should not be interpreted as condoning discharges of waste up to these levels.'*

A key difference between SEPP (PMCL) and the ERS is that the ERS places no obligations on duty holders.

Contaminated land can also include volatile contaminants that move through soil, groundwater and into the air environment as a vapour. SEPP (PMCL) did not set indicators and objectives for soil vapour. The ERS does not explicitly consider vapour in soil or the movement of vapours into the ambient air environment. However, in referring to the Health Investigation Levels (HILs) and Health Screening Levels (HSLs) in the NEPM (ASC) the ERS gives regard to vapour-based guideline levels. It is an important consideration in the assessment and investigation of contaminated land and groundwater. The duty to notify of contaminated land requires the notification of soil vapour concentrations, in accordance with section 11 of the Regulations. These thresholds are based on the HSLs, groundwater investigation levels and interim soil vapour levels in the NEPM (ASC) (discussed in Schedule B1 of the NEPM (ASC)).

A summary flow chart for use of Part 4 - Land of the ERS in decision making and environmental assessments is presented in Figure 6.1 below. Each of the decision points is discussed in the sections below.

A case study that describes how the ERS is used to inform a licence amendment application for an upgrade to a wastewater treatment plant is provided in Chapter 8. The application of the indicators and objectives for land to this scenario is discussed in section 8.3.

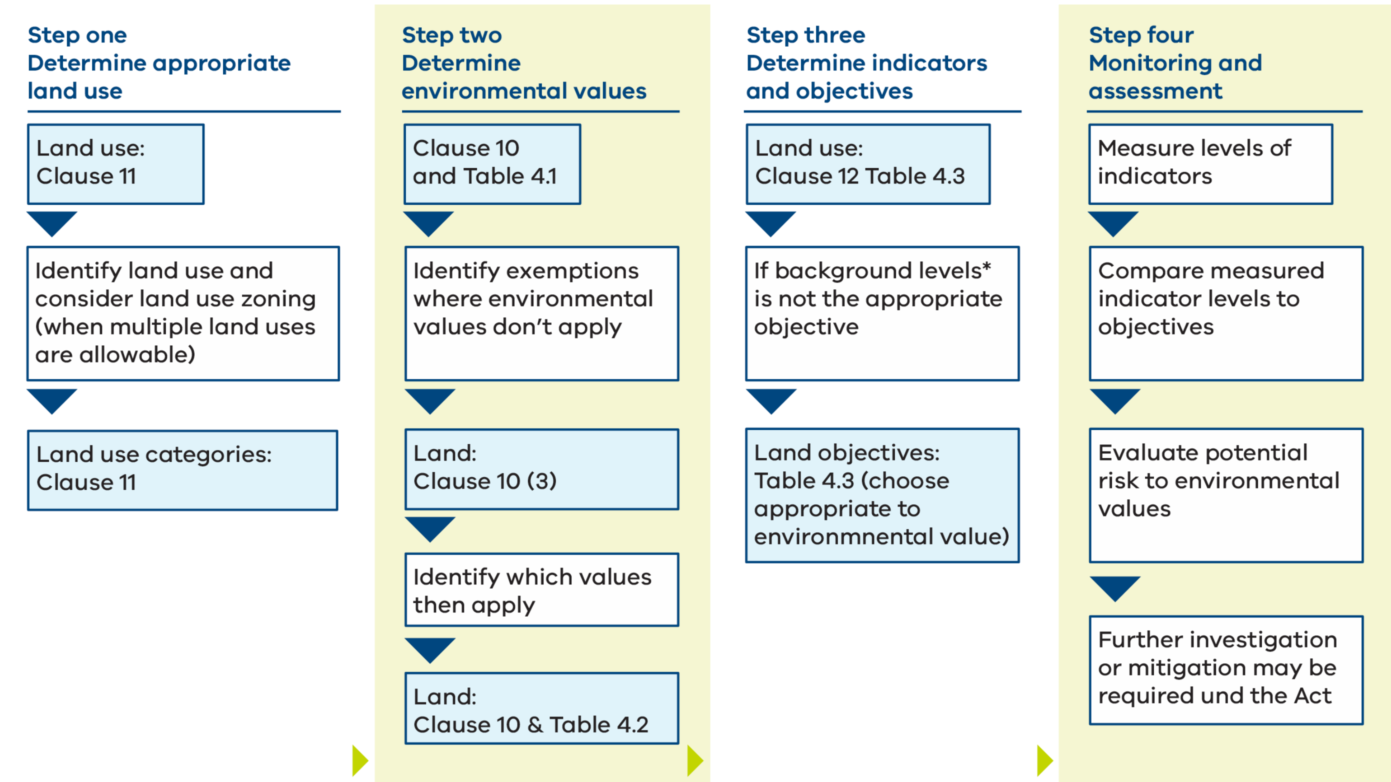


Figure 6.1. Decision tree for using Part 4 - Land of the ERS in decision making and environmental assessments
This figure refers to clauses and tables of the ERS
** 'background level' is defined in clause 4 of the ERS*

6.2 Interpretation of environmental values for land

6.2.1 Where and what are the environmental values?

The ERS includes five environmental values that apply to Victoria's land environment. These are included in column 1 of ERS Table 4.1 and briefly described in column 2 and are:

- *land dependent ecosystems and species*
- *human health*
- *buildings and structures*
- *aesthetics*
- *production of food, flora and fibre*.

Table 4.2 of the ERS describes how the environmental values apply across the various land use categories. As environmental values are intrinsically linked to land use, where a change in land use occurs, the environmental values should also change.

a) Land dependent ecosystems and species

This environmental value applies to land dependent ecosystems. An ecosystem consists of biological, chemical and physical components that affect and are affected by the state of each other. *Land dependent ecosystems and species* is an important environmental value for land that requires consideration in all types of land use environments. This environmental value recognises the need to protect soil health and the integrity and biodiversity of the ecosystem. However, recognising that different types of environments support different ecosystems, the land dependent ecosystems and species environmental value has been divided into three types: natural ecosystems, modified ecosystems and highly modified ecosystems.

Natural ecosystems occur in areas that have been relatively undisturbed by human activities. These will generally be land that has not been developed, built on, modified or contaminated by humans. Natural ecosystems are predominantly conservation areas such as parks and reserves. Species diversity is usually high and there may be many varieties of plants and animals.

Modified ecosystems occur on land that is not pristine. They include areas that have been disturbed by human activity but which still allow an altered ecosystem to exist. These usually have a lower species diversity. Examples of modified ecosystems include residential allotments, grazing, bike and walking trails. Modified ecosystems still retain many important functions and species that are of ecological, societal or economic relevance.

Examples of the types of species in modified ecosystems that may require protection include:

- significant native trees and plants that may be of importance to wildlife, transient or otherwise (ecological)
- species associated with domestic gardens (societal)
- pasture or other species of economic importance for grazing or other agricultural activities (economic).

Highly modified ecosystems occur in areas characterised by a high level of anthropogenic intervention, where the environment has been substantially altered. Examples include industrial estates, intensive agricultural areas, athletic tracks and high-density residential housing. In these areas, species diversity is low, with few valuable plants and animals. However, the species that do exist and are of value should be protected. Furthermore, soils should still support the basic soil processes and should be able to recover if land use changes. Maintaining land dependent ecosystems and species should be based on:

- identifying the ecological values to be protected for a given land use in a particular area
- identifying the ecosystems relevant to an area
- ensuring that the plants and animals of value to that ecosystem are protected from the effects of land contamination.

b) Human health

The environmental value of *human health* relates to the need for people to be able to make use of land without experiencing adverse exposure or harm to their health. Different types of exposure pathways and potential levels of exposure are associated with different uses of land. Protection of human health is of primary importance and this environmental value is therefore designated as being protected in all of the land use scenarios.

In determining whether the environmental value of *human health* is protected, consideration should be given to both the primary occupants of the site (for example, residents) and others who visit a site periodically. This is especially the case for people whose activity is more likely to bring them in contact with the land (for example, gardeners or utilities maintenance workers).

In addition, the NEPM (ASC) health investigation levels (HILs) assume common exposure pathways for typical land use scenarios. However, they may not include all exposure scenarios that are relevant for a given contaminant or land use setting. Hence, the assessment of this environmental value should not be limited where there is evidence of other exposure pathways.

c) Building and structures

Land may interact with buildings, footings and structures, such as support piers and underground service pipes. Land that is affected by acidic or corrosive substances can degrade concrete structures, which can lead to replacement and/or other costs associated with structure collapse. Buildings and structures are therefore designated as a protected environmental value for all land uses. The ERS aims to meet community demands with respect to the safety and durability of structural developments, helping to prevent costs associated with degradation of infrastructure.

Land that is contaminated with other substances that can adversely affect buildings and structures should also be considered. These substances may occur in vapour intrusion and permeation of water supply pipes (for example, benzene permeation through PVC water pipes).

d) Aesthetics

Aesthetics refers to the five senses of humans but is primarily considered through visual and odour components of land, as touch, taste and sound are less likely to be impacted. Aesthetics are considered in the parks and reserves, agriculture, residential, recreation and open space, and commercial land use types. This environmental value helps to ensure the community lives in an aesthetically pleasing environment that is not degraded by the effects of land contamination.

e) Production of food, flora and fibre

The use of land for the production of crops (including food, timber and flowers) and pastures for the farming of animal produce is extensive in Victoria. However, the production of food, flora and fibre is not limited to an agricultural environment. While food, flora and fibre may not be ‘farmed’ in other land use environments, parks, reserves and the sensitive land use environments (including residential land) support this environmental value to a greater or lesser extent (for example, home vegetable production, backyard chickens). In addition, food production on land under water, such as flood irrigation for growing rice, is also recognised.

6.2.2 How do environmental values applying to land vary?

The ERS applies as a reference standard for the state of the land at a particular time. Undertaking activities on land may affect the environmental values, as well as other elements of the environment (such as surface water and groundwater). The Act requires that activities must be undertaken, and land must be managed, in a way that minimises the risks of harm to human health and the environment. As part of minimising such risks of harm, decision makers and duty holders may need to consider the impacts an activity or management action has on achieving or maintaining any environmental value in any element of the environment.

The environmental values provided in Part 4 of the ERS are specific to the land use category and are presented in Section 6.3 below. In other words, the use of the land and the land use zoning determine which environmental values are protected. In most cases, users of the ERS will consider the land use setting to decide which environmental values need to be considered, and therefore what indicators and objective apply.

The ERS signals that land quality is to be suitable to protect soil health. Soil health is defined by Doran and Zeiss (2000) as *‘...the capacity of soil to function as a vital living system, within ecosystem and land use boundaries, to sustain plant and animal productivity, maintain or enhance water and air quality, and promote plant and animal health*’. Soil health is commonly measured using indicators of soil quality, which integrate physical, chemical and biological properties. Such properties can be adversely affected by pollution, impairing the ability of a soil to function and provide ecosystem services. Methods for measuring soil health include assessment of soil enzyme activity, soil macrofauna and soil microbiome. While the ERS has not adopted any direct measures relating to objectives and indicators for soil health, future updates of the ERS may encompass them.

6.2.3 When does an environmental value of the land environment not apply?

The complexity of the environment means that the environmental values for land are, by necessity, general in nature. ERS clause 10(3) describes circumstances where an environmental value may not apply to the land environment. It is important to note that an environmental value of the land environment may not apply to a site if either:

- the background level of an indicator is greater than the relevant objective
- the achievement or maintenance of the environmental value is impracticable due to characteristics of the site.

For example, during an environmental assessment for a residential development, soil sampling and analysis may report concentrations of zinc that pose a risk via the consumption of vegetables. However, a review of the geological conditions, surrounding soil concentrations at offsite areas and the site history indicate that the concentrations onsite are background levels. On this basis, the environmental value production of *food, flora and fibre* would not apply due to the natural conditions.

Environmental values of land may also not apply in instances where protections under other legislation prevent the land being used for an environmental value. Regardless of the natural conditions or background levels, if the land is to be used for a purpose that may result in human exposure, it should be assessed as to whether it is suitable for this use.

6.2.4 Examples of the use of environmental values

The ERS identifies environmental values that are associated with each land use by summarising the information in table form (ERS Table 4.2). The table and description of land use primarily serve to:

- clarify matters relevant to planning authorities when evaluating planning scheme amendments and planning applications
- clarify the environmental values which an Environmental Auditor (Contaminated Land) must consider when issuing an environmental audit statement under the Act
- encourage planning authorities to consider regional or local constraints and opportunities and set appropriate targets for the maintenance or achievement of environmental values of all land (both developed and undeveloped) within their jurisdiction.

As ERS Table 4.2 correlates the environmental values and land use categories, it also serves as a guide to managing existing contamination and ensuring that a site is suitable for its existing or future use.

As previously described, one of the key benefits and objectives of the ERS is providing clarity in identifying environmental values to be maintained or achieved in different circumstances. Although the ERS identifies environmental values that are associated with a particular land use environment, contamination must be prevented or minimised so that all future environmental values – not just those for the current land use – are maintained or achieved. In practice this is sensible, as allowing contamination to continue to occur simply because it is industrial land may represent a barrier to a future land use of, and a cost to, both the occupier and the community.

6.3 Land use categories

Clause 11 of the ERS identifies six types of land uses: parks and reserves, agriculture, sensitive use, recreation / open space, commercial and industrial. These land use types are broadly consistent with the planning zones specified in the Victoria Planning Provisions (VPP, n.d.) (https://planning-schemes.api.delwp.vic.gov.au/schemes/vpps). Table 4.2 of the ERS describes the environmental values that apply to the land use categories. The categories include the most common types of land use and are based on those provided in the NEPM (ASC). The categories do not, however, include all the different types of land uses. Where there does not appear to be an applicable land use in the ERS, further consideration and assessment will be required to determine the most appropriate land use setting and applicable environmental values.

Land use is the primary determinant of the environmental value to be considered when applying the ERS. As such, community expectations regarding the protection of the environmental values of the land environment should be reasonably considered. Community expectations will vary, depending on the land use. For example, the level of protection required for ecosystems may be different, depending on whether the site is used as a park or an industrial site.

Parks and reserves include national parks, state parks, state forests, nature conservation reserves and wildlife reserves. These are defined or gazetted under relevant Acts or statutory documents and may include other parks and reserve areas (as designated by EPA Victoria or the Department of Environment Land Water and Planning, including those on both public and private land, and marine and freshwater reserve areas).

Agriculture land use includes any areas used for the purposes of agriculture or horticulture, including areas of land under water used for aquaculture and urban farming. Consideration of the water environmental values may also be required for aquaculture.

Sensitive use is defined by the ERS to include land used for a:

- residential purpose
- childcare centre
- pre-school centre or primary school.

Playgrounds and secondary schools are also considered to be sensitive uses.

Ministerial Direction No.1 under section 12 (2)(a) of the *Planning and Environment Act 1987* (Minister for Planning, 2001) defines a sensitive use as land used for a residential use, childcare centre, kindergarten, pre-school centre, primary school, even if ancillary to another use. This definition is consistent with the definition provided in the ERS.

Some environmental values require access to soil for them to be realised. Accordingly, sensitive use is divided into two main categories – *high density* and *other (lower density)*. This is in recognition that some developments make maximum use of the land area, resulting in minimum access to soil, whereas other developments result in substantial access to soil. For example, there are childcare centres in high-density suburbs with limited access to soil, and others in outer suburbs where the children have ready access to soil. Similarly, a sensitive use in an inner-city area may have different indicators when compared to a sensitive use in an outer suburban area. For example, a key pathway of exposure to contamination for sensitive land use is through food production, such as home-grown vegetables or urban farming. In inner city areas, food will likely be grown in above ground containers or in restricted areas due to limited access to the underlying soil, so the potential exposure to contamination at a specific site is often low. However, in the outer suburbs (or in inner suburban sites with sufficient space), plants may have substantial access to the underlying soil, meaning the potential for exposure to contaminated soil is higher. Therefore, a sensitive land use type may occur in a high-density development area where access to underlying soil is minimal, or in an area where the access to the underlying soil is greater.

Recreation / open space includes areas such as sports complexes, bike tracks, walking trails and golf courses, green-belt /green wedge areas, local parklands and any other general open space areas and public recreation areas.

Commercial refers to sites undertaking light commercial, or business activities (for example, sites with office workers who spend up to an hour daily outside). The commercial category excludes uses defined as industrial.

Industrial refers to a site used for utilities or undertaking light to heavy industrial activities.

The NEPM (ASC) HILs were developed for four generic land use settings. These are intentionally conservative and are based on a reasonable worst-case scenario (NEPM (ASC), Schedule B1, Section 2.2):

- HIL A – residential with garden/accessible soil (home grown produce representing less than 10% of fruit and vegetable intake, no poultry); includes day care centres, preschools and primary schools
- HIL B – residential with minimal opportunities for soil access; includes dwellings with fully and permanently paved yard space such as high-rise buildings and flats
- HIL C – public open space such as parks, playgrounds, playing fields including ovals, secondary schools and footpaths. It does not include undeveloped public open space (such as urban bushland and reserves) which should be subject to a site-specific assessment.
- HIL D – commercial/industrial such as shops, offices, factories and industrial sites.

The HSLs were developed for selected petroleum compounds and fractions of total petroleum hydrocarbons (TPH), and for the same four generic land uses as the HILs. However, levels vary depending on the depth of the soil sample (NEPM (ASC), Schedule B1, Section 2.4).

The NEPM (ASC) ecological investigation levels (EILs) were developed for common contaminants in soil and for three generic land use settings (NEPM (ASC), Schedule B1, Section 2.5.3):

- areas of ecological significance
- urban residential areas and public open space
- commercial and industrial land uses.

The ecological screening levels (ESLs) were developed for selected petroleum compounds and fractions of TPH, and for the same three generic land uses as the EILs. However, levels vary depending on the fractions of TPH (NEPM (ASC), Schedule B1, Section 2.6).

The NEPM (ASC) does not include investigation levels for agriculture. In this case, site-specific assessment is necessary.

6.4 Land indicators and objectives

Table 4.3 of the ERS outlines the indicators and objectives for the land environment, which is reproduced in columns 2 and 3 of Table 6.1 of this guide. The primary objective is to maintain background levels. Background levels are discussed further in section 6.4.2 below.

Where background levels have not been maintained, the potential for harm to the environmental values can be assessed using the ERS indicators and objectives, the HILs/HSLs and EILs/ESLs (as appropriate) and then published guidance, such as the protocols set out in the NEPM (ASC).

Indicators exceeding the levels reported in the NEPM (ASC), or other guidance adopted under the NEPM (ASC) protocols, do not necessarily mean that harm has occurred or is imminent. Rather, exceedances infer that further investigation of potential harm is warranted. Regardless of whether an objective is met or not, it is potentially unlawful to pollute up to a published guidance value. This is because under the general environmental duty (GED) in the Act, any risk of harm must be eliminated or otherwise reduced so far as reasonably practicable. Moreover, the indicators and objectives set out in the ERS address a limited set of contaminants, receptors and exposure pathways. As such, additional approaches may be necessary to fully assess and consider whether environmental values are protected or maintained. Examples of when further assessment may be warranted include:

- acute and physical risks from pollution and waste to human health and the environment
- pathogenic materials and waste, radioactive substances, unexploded ordinance and explosive gas mixtures on and under land
- the potential for land contamination to impact water quality objectives
- agriculture
- accumulation of chemicals into food for the general population.

While the ERS indicators and objectives are useful in characterising certain land uses at particular points in time, this does not mean the objectives in the ERS can be used to justify the ongoing presence of contamination of land. This may particularly be the case where that land may better serve the community by accommodating more sensitive uses in the future or where offsite impacts threaten the environmental values of adjacent land.

6.4.1 Derivation and interpretation of specific indicators and objectives

The ERS has incorporated existing policy and guidance from the SEPP (PMCL) and NEPM (ASC). The NEPM (ASC) does not specify values that *confirm* risk of harm to the environment or human health, but rather provides values that should trigger further investigation and risk assessment. Each investigation and screening level in the NEPM (ASC) is documented and has been derived under specific circumstances. Schedule B4, for example, presents the health risk assessment methodology that forms the basis for calculation of HILs. The derivation process has not been included in this guide, but Table 6.1 below includes references to the detailed description in the NEPM (ASC).

The objectives for each of the environmental values represent levels in soil that, when not met, indicate there is a potential harm to that environmental value from pollution and/or waste. Because there are various reasons that objectives may not be met, including natural processes unrelated to the impacts of pollution and waste, further investigation may be required to identify risk to environmental values. The investigation required should be proportionate to the predicted risk to environmental values. More detailed guidance on appropriate approaches for further investigation when objectives are exceeded is presented in the NEPM (ASC) (Schedule B1, section 3.2.2).

Each of the levels provided in the NEPM (ASC) and incorporated into the ERS are based on a different derivation methodology:

- HILs – '*The health risk assessment methodology that forms the basis for calculation of HILs is provided in Schedule B4. The derivation of the HILs is presented in Schedule B7 (and appendices) and uses the Australian exposure factor guidance (enHealth 2012*[a]*).'* (NEPM (ASC), Schedule B1, Section 2.2)
- HSLs – '*Health Screening Levels (HSLs for various petroleum hydrocarbon compounds were developed by the Cooperative Research Centre for Contamination Assessment and Remediation of the Environment (CRC CARE). The principal reference for the HSL methodology is Friebel and Nadebaum (2011a). In addition to the documentation of the methodology, a detailed application report (Friebel and Nadebaum 2011b) and a sensitivity analysis of the main parameter inputs (Friebel and Nadebaum 2011c) are available.'* (NEPM (ASC), Schedule B1, Section 2.4.1)
- EILs – derived for common contaminants in soil based on a species distribution model developed for Australian conditions (NEPM (ASC), Schedule B5a, Schedule B5b and Schedule B5c)
- ESLs - are presented based on a review of Canadian guidance for petroleum hydrocarbons in soil and application of the Australian methodology (NEPM (ASC) Schedule B1, Section 2.6.2, and Schedule B5b).

6.4.2 Background level for the land environment

For the land environment, background levels of an indicator refer to those found outside the influence of waste and pollution. These are essentially natural levels found in soil free of human influence. In some instances, these may include background levels influenced by some large- scale drivers of land quality, such as climate change, that may be attributed to human actions (and therefore may not be considered 'natural' by everyone) but are levels not attributable to a source of pollution or waste to land.

In the ERS, the land background level for an individual indicator is the level in the environment outside the influence of any waste or contaminant containing a measurable level of that indicator. This is because there may be land that has experienced some impacts of pollution and waste but background levels of a specific indicator can still be determined because the pollution does not contain that indicator. For example, land may have been polluted with nutrients in the past, but if the indicator of interest is a heavy metal that has not been a previous contaminant, then background levels can still be determined for the heavy metal.

Land background levels are referred to in clause 10(3) of the ERS and the objectives in ERS Table 4.3.

In general, background levels are preferred over the default objectives defined in ERS Table 4.3, as they will be the most appropriate for many land use scenarios. This is particularly the case where there has been little to no influence of pollution or waste. Adopting background levels is appropriate for open space land use such as reserves, national parks and state parks, where human impacts are minimal or have been greatly reduced to preserve the natural character of these environments. There will be circumstances where background levels can be determined in modified land environments for specific indicators that are not a common or widespread pollutant.

However, it is often not practicable to determine land background levels for particular indicators if there has been a legacy of diffuse and point source pollution. Where it is not feasible to adopt background levels as objectives, the default objectives in ERS Table 4.3 should be used. This approach ensures that protective objectives are adopted and is broadly consistent with the principles of the NEPM (ASC).

Background levels should not be confused with ‘ambient’ levels. Background levels represent those levels entirely outside of the influence of pollution and waste, whereas ambient levels include background levels and levels introduced by waste or contaminants due to general anthropogenic activity from diffuse and non-point sources. Ambient level is not a term used in the ERS, but it is used in other EPA publications and the NEPM (ASC). Additionally, ‘ambient’ is at times referred to as ‘background’ levels when assessing impacts such as from a future licensed discharge or pollution event for other elements of the environment (such as ambient air and water).

6.4.3 Where no specific objectives are in the ERS

In some circumstances, lack of appropriate data means that no specific objectives are provided for some indicators. This does not mean they are excluded from the environment protection scheme. Rather, it is expected that where the level of the indicator is greater than background levels and has the potential to cause harm to human health or the environment, that a suitable objective will be derived for the site- specific situation. For example, section 2.5.1 of Schedule B1 of NEPM (ASC) explains that EILs have only been derived for specific compounds, and that Schedule B5a provides a framework to derive site-specific or ecological specific risk assessments. The NEPM (ASC) also provides a framework and spreadsheet for deriving site-specific HILs.

Where no specific objectives are set in the ERS, any decision making relating to the indicator will require the development of suitable objectives through monitoring or synthesis of available data.

6.4.4 Where multiple objectives are specified

In some cases, the ERS specifies multiple objectives for the same indicator in the land environment. Multiple environmental values commonly co-exist for land, meaning different objectives for the same indicators could be applicable in one location. There are many commonalities in indicators for human and ecological health, but objective levels can be quite different, reflecting the different sensitivities to chemicals or different organisms.

For example, in an open space or parkland land use setting, there may be human health objectives and ecological objectives that need to be considered for the one indicator. In this example, it could be that the concentration of lead in soil that is acceptable for human health protection is not acceptable for ecological protection.

All relevant objectives should be assessed in order to understand the risk profile and identify the most relevant proportionate risk management strategy. Any decision to reduce the level of protection to below that associated with the most sensitive objective will require justification.

Table 6.1. Derivation and interpretation of indicators and objectives for land environmental values

Environmental value	Indicators	Objectives	Interpretation	Reference to Derivation in relevant standard/guideline
Land dependent ecosystems and species	Inorganic and organic contaminants listed in Appendix A of Schedule B2 of the NEPM (ASC) and any other contaminants present at the site as determined by the current use or site history assessed in accordance with the NEPM (ASC).	The objective for each indicator is the ecological investigation level or ecological screening level for each indicator, unless: (a) there is no ecological investigation level or ecological screening level; or (b) due to site specific characteristics the more appropriate objective is: (i) the level derived using the risk assessment methodology described in the NEPM (ASC); or (ii) the background level determined in accordance with section 36 of the Act, in which case the objective for the indicator is (i) or (ii) as applicable.	In practice, background levels should be considered and applied in the first instance. Site specific characteristics in soil may include the chemical, biological or physical properties of a soil. For example, soils that have low permeability and moderate salt levels would be likely to accumulate salt if that was a pollution source. This would result in degradation to soil physical and chemical properties and plant health decline due to the salinisation of the soil.	Relevant guideline is NEPM (ASC) Summary of EIL derivation: Schedule B1, section 2.5 Framework for ecological risk assessment: Schedule B5a EIL methodology: Schedule B5b Specific EIL derivations: Schedule B5c Summary of ESL derivation: Schedule B1, section 2.6
Human health	Inorganic and organic contaminants listed in Appendix A of Schedule B2 of the NEPM (ASC) and any other contaminants present at the site as determined by the current use or site history assessed in accordance with the NEPM (ASC).	The objective for each indicator is the investigation or screening level specified for human health in the NEPM (ASC) for each indicator, unless: (a) there is no investigation level specified for human health in the NEPM (ASC); or (b) due to site specific characteristics the more appropriate objective is: (i) the level derived using the risk assessment methodology described in the NEPM (ASC); or (ii) the background level determined in accordance with section 36 of the Act,	The objectives for human health align with the processes set out in the NEPM (ASC) for each indicator. However, it's important to recognise that in certain instances either the contaminant, site setting, exposure pathway or receptor may not be adequately addressed by the default HILs / HSLs.	Relevant guidelines are NEPM (ASC) and eHealth (2012,a,b) Summary of HIL derivation: NEPM (ASC) Schedule B1, section 2.2 Health risk assessment methodology for HILs: NEPM (ASC) Schedule B4 HIL derivation: NEPM (ASC) Schedule B7, *Australian exposure factor guidance* (enHealth 2012a) and *Environmental Health Risk Assessment: Guidelines for assessing human health risks*

Environmental value	Indicators	Objectives	Interpretation	Reference to Derivation in relevant standard/guideline
		in which case the objective for the indicator is (i) or (ii) as applicable.		*from environmental hazards* (enHealth 2012b) Interim HILs for volatile organic chlorinated compounds (VOCCs): Schedule B7 & Appendix A6 Summary of HSL derivation – Schedule B1, section 2.4
Buildings and structures	pH, sulfate, chloride, redox potential, salinity or any chemical substance or waste that may have a detrimental impact on the structural integrity of buildings or other structures.	Land that is not corrosive to, or otherwise adversely affecting, the integrity of structures or building materials.	Care needs to be taken to ensure that the criteria used for assessing this objective are fit for purpose (e.g., criteria that are designed to inform building material choices should not be used to indicate that the environmental value is not achieved, without justification). Consideration should also be given to conditions that may lead to chemical permeation into services, such as drinking supply lines.	Australian Standard AS 2159, 2009: Piling-Design and Installation
Aesthetics	Any chemical substance or waste that may be offensive to the senses.	Land that is not offensive to the senses of human beings.	Aesthetics is subjective and setting objectives can be challenging. Typically, land should not appear to be stained or have starkly contrasting surface colours. It should not be odorous in ways considered to be non-natural and should not have non-natural features that	Discussion of aesthetic considerations: NEPM (ASC) Schedule B1, section 3.6

Environmental value	Indicators	Objectives	Interpretation	Reference to Derivation in relevant standard/guideline
			cause undue noise or sounds.	
Production of food and flora and fibre	Inorganic and organic contaminants listed in Appendix A of Schedule B2 of the NEPM (ASC), and any other contaminants present at the site as determined by the site history assessed in accordance with the NEPM (ASC).	The levels specified in the Food Standards Code (FSNAZ, n.d.) detected in any food, flora or fibre produced at the site. Levels that do not adversely affect produce quality or yield.	Frequently it is not possible to measure food, flora or fibre directly, or the Food Standards Code (FSNAZ, n.d.) may not include the contaminant of interest. In such instances, risk assessment paradigms established under the environmental values of *human health* and *land dependent ecosystems and species* may be appropriate.	Australia New Zealand Food Standards Code (FSNAZ, n.d.)

Chapter 7. Guide to Part 5 - Water

This chapter should be read in conjunction with Part 5 of the Environment Reference Standard (ERS)

To understand and use the information in this chapter, refer to the definitions in the ERS and the specific clauses and tables in Part 5 - Water.

7.1 Introduction

Part 5 - Water of the ERS lists the environmental values of water environments in Victoria and describes the environmental quality that is needed to achieve and maintain these values. To do this, Part 5 includes three key components:

- **Segments:** areas or features of water environments that have common environmental conditions and natural characteristics. Segments share common environmental values, indicators and objectives.
- **Environmental values:** the values or uses of water environments that Victorians value and want to protect from pollution and waste. Environmental values depend on suitable quality water.
- **Indicators and objectives:** physical, chemical and biological conditions that are characteristic of healthy water environments. These conditions can be used to determine or assess whether environmental values are being achieved, maintained or threatened.

This chapter provides guidance on how to interpret and use Part 5 of the ERS. Specifically, it shows how to identify the environmental values, segments, indicators and objectives that need to be considered in decision making and environmental assessments. There is additional information to support the interpretation of clauses and tables in Part 5 of the ERS.

Figure 7.1 below provides an overview of how to navigate Part 5 of the ERS to identify relevant segments, environmental values, indicators and objectives. The structure of this chapter follows the same order and structure.

A case study that describes how the ERS is used to inform a licence amendment application for an upgrade to a wastewater treatment plant is provided in Chapter 8. The application of the objectives for surface water is discussed in section 8.2. The application of the objectives for groundwater is discussed in section 8.3.

7.1.1 How Part 5 - Water of the ERS is different from the State Environment Protection Policy (Waters)

Part 5 of the ERS has largely adopted the segments, environmental values (beneficial uses), indicators and objectives from the State Environment Protection Policy (Waters) (SEPP (Waters)). SEPP (Waters) was developed based on an extensive scientific review of indicators, objectives and segments, as detailed in *Development of indicators and objectives for SEPP (Waters)* (publication 1733). Under the *Environment Protection Act 2017* (the Act), SEPP (Waters) is no longer subordinate legislation and has been replaced by the ERS and the Environment Protection Regulations 2021(the Regulations). Some parts of SEPP (Waters) that have not been translated into the ERS, Regulations or guidance will still provide relevant knowledge under the new environment protection framework. Refer EPA’s website for information on how the content of instruments of the environment protection framework under *Environment Protection Act 1970*, such as SEPPs and waste management policies, have informed the new legislative framework.

A key difference between SEPP (Waters) and the ERS is that the ERS places no obligations on duty holders. This means that some objectives, such as those for loads in marine bays and water-based recreation, are slightly different. In SEPP (Waters), some of the provisions of these objectives established timeframes. For example, pollutant load objectives (known as ‘targets’ in SEPP (Waters)), were indicators with an associated load objective. This target had to be achieved by a specified date and included obligatory actions for waterway managers to achieve that target. Because the ERS imposes no obligations, load objectives now consist only of the indicator and associated load objective.

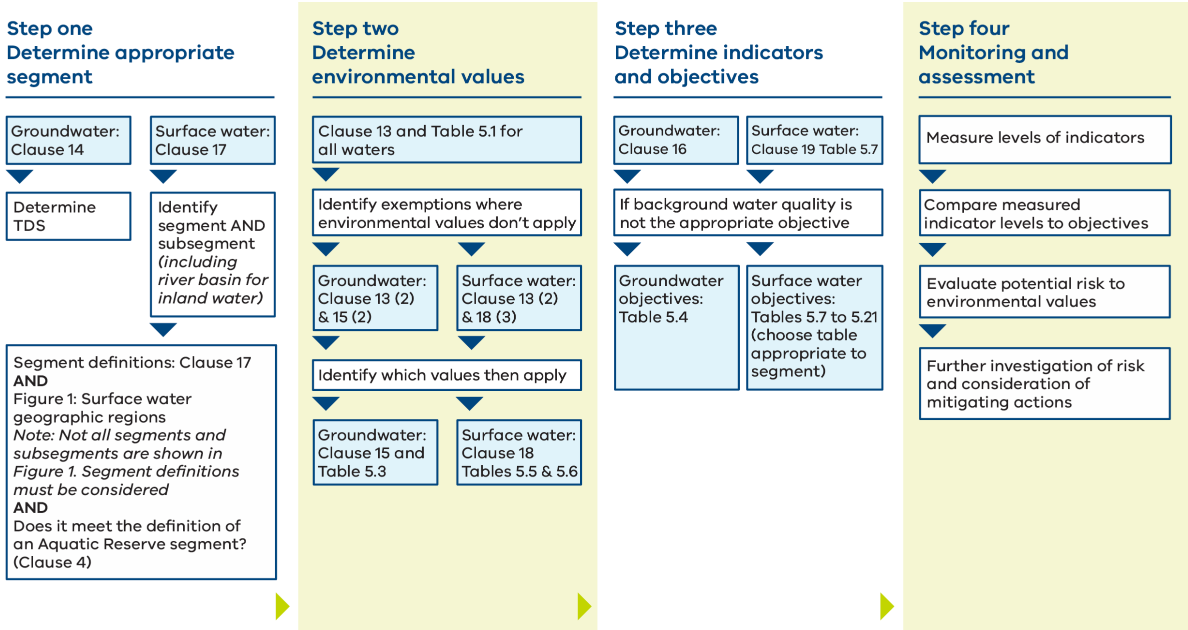


Figure 7.1. Decision tree for using Part 5 - Water of the ERS in decision making and environmental assessments
This figure refers to clauses, tables and figures of the ERS.

7.2 Interpreting Part 5 - Water of the ERS

7.2.1 Step 1: Determining segments

The ERS divides water environments into two categories: groundwater and surface waters. Definitions for groundwater and surface waters are included in clause 4 of the ERS. Groundwaters are waters occurring in or obtained from an aquifer, including any dissolved or suspended matter (*Water Act 1989*).

Surface waters are waters other than groundwater and encompass all types of waters found above ground. Surface waters include rivers, streams, wetlands, estuaries and marine waters, such as bays and the open coast. Surface waters also encompass the full depth range of these water bodies, from the surface layers to the bottom of deep-water bodies such as lakes, bays and oceans.

Groundwater and surface waters are divided into specific segments described in ERS clauses 14 and 17 respectively. Surface water segments are also further divided into subsegments. Surface water segments and subsegments define geographic areas that have broad differences in their natural characteristics, baseline water quality and environmental values to be achieved and maintained. Figure 7.2 below shows the relationships between water types, segments and subsegments.

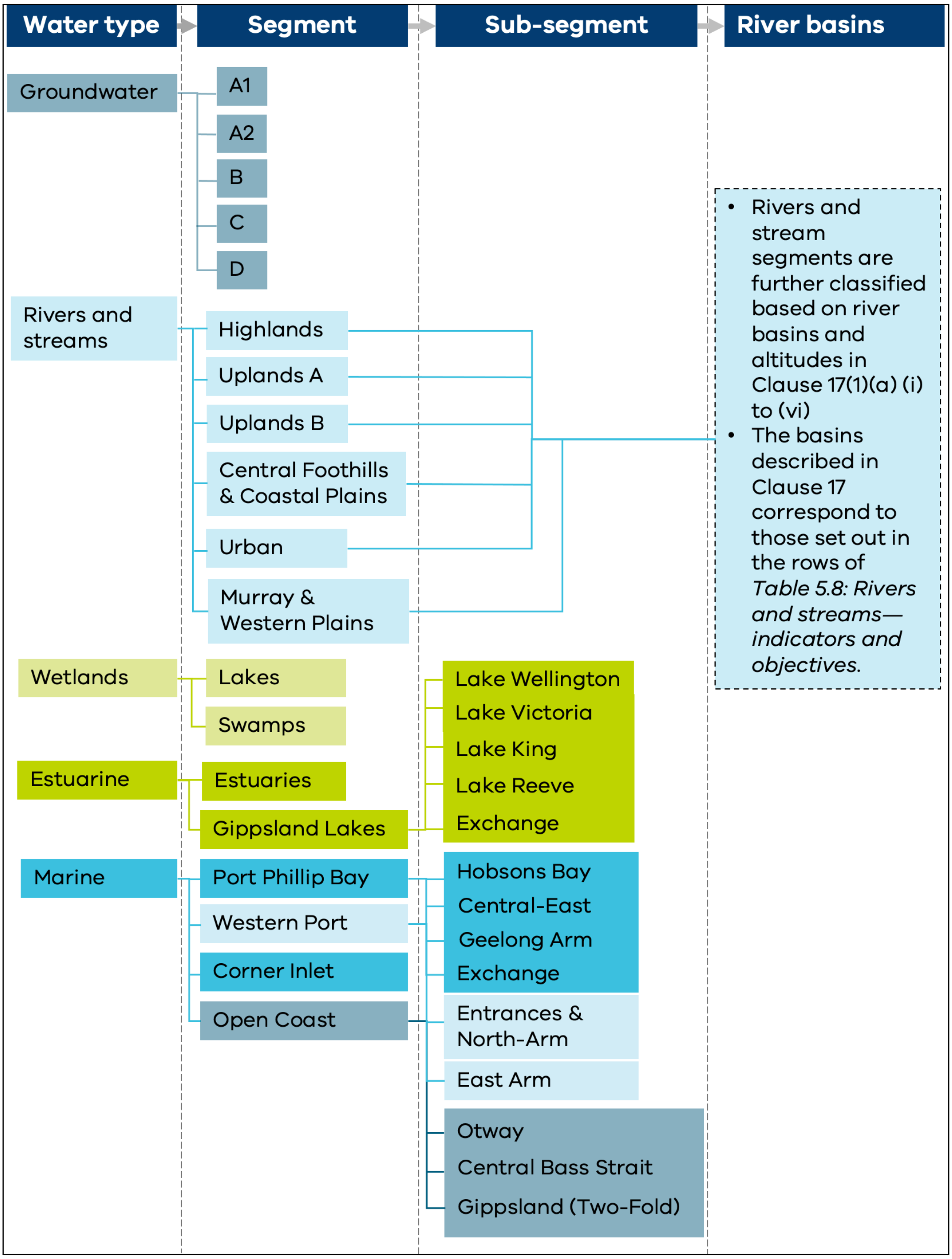


Figure 7.2. Relationships between water types, segments and subsegments described in clause 17 and the map in Figure 1 of the ERS (Aquatic reserves segment not shown as it can apply to any surface waters segment)

a) Groundwater

In groundwater, total dissolved solids (TDS) is used to distinguish segments. This is because the salinity of groundwater affects its use and TDS is an effective way to classify and distinguish the environmental values relevant to groundwater.

Segments for groundwater are described in Table 5.2, clause 14 of the ERS. When determining segments, care should be taken to ensure the TDS (whether adopted from measurements or literature) is representative of the natural background levels. Therefore, TDS should not be influenced by an anthropogenic source, such as a leaky water pipe. A conservative approach should be adopted to groundwater segment classification, such as using the lower value of a range until a TDS, more representative of natural background, can be established.

b) Surface waters

In surface waters, segments and subsegments are identified that describe areas differentiated by their baseline conditions, sensitivities to pollution, and environmental values. This is based on:

- characteristics of the water quality, such as pH, nutrients, salinity and dissolved oxygen
- physical characteristics, such as waves, currents, substrate and altitude
- ecological characteristics of the environment, such as biological communities and habitat types
- climatic influences, such as rainfall, temperature, and climate variability
- population pressure and surrounding land use.

Due to these varying characteristics, different segments and subsegments have distinct objectives for one or more indicators.

In surface waters, the ERS classifies 14 broad state-wide segments, as well as the *Aquatic reserves* segment which can apply within any segment. Some rivers and streams segments are separated into disconnected areas (for example, Uplands A). Port Phillip Bay, Western Port, Gippsland Lakes and Open Coast segments are further classified into subsegments (Figure 7.2).

Surface water segments and subsegments are described in three locations in the ERS:

- the Figure 1 map in Part 5 - Water
- the segment and subsegment definitions described in clause 17
- the definition of 'Aquatic reserves' in clause 4.

The map and segment/subsegment definitions must be used together to determine which segment or segments apply to a specific area. The segment definitions also clarify areas where segments do and do not apply.

There are four major water types and segments not shown on the map in Figure 1 of the ERS: estuaries, wetlands, urban segments and aquatic reserves. This is because the spatial extent of these segments can change over time.

- ***Rivers and streams water type***

The segment definitions (clause 17 of the ERS) further classify river and stream segments based on major river basins. These correspond to distinct objectives in Table 5.8, clause 19 of the ERS. These river basins correspond to the recognised [Australian drainage divisions and river regions](http://www.bom.gov.au/water/about/image/basin-hi_grid.jpg) (http://www.bom.gov.au/water/about/image/basin-hi_grid.jpg) that were defined by the Australian Water Resources Management Committee in 1997 (BOM, n.d.). This resource can be used to determine a river or stream's basin and which objectives defined in ERS Table 5.8 should be used in decision making.

The *urban segment* (clause 17(1)(a)(v)) is not aligned with major river basins. It is aligned to the metropolitan fringe planning schemes set out in section 46AA of the *Planning and Environment Act 1987*. The urban segment encompasses urban rivers and streams within the urban growth boundary for Metropolitan Melbourne with the exception of the Yarra, Maribyrnong and Werribee rivers. These three larger rivers are included in the Central Foothills and Coastal Plains segment because their size and flows mean they have much better water quality in the urban areas of Melbourne than their tributaries. As such, their environmental values require that a higher level of water quality is supported and maintained.

- ***Wetlands water type***

The ERS defines wetlands in clause 17(1)(b) as: standing water bodies including alpine bogs, large open lakes, inland hyper-saline lakes, floodplains and billabongs, swamps and mudflats. The ERS does not classify tidal and marine waters and constructed water bodies as wetlands. Wetlands are divided into two subsegments: lakes and swamps.

Lakes are wetlands that are dominated by open water (lacustrine), while swamps are wetlands dominated by vegetation (palustrine).

Similar to estuaries, the extent of wetlands changes over time in response to rainfall and flooding. The locations of wetlands recognised by the ERS are described in the Victorian Wetland Inventory (DELWP, 2014), which also defines lacustrine and palustrine wetlands.

The environmental values, indicators and objectives for wetlands apply to the inundated areas of the wetland, not to dried wetland areas. However, the potential for wetland areas to become inundated and be impacted by activities that generate pollution and waste should be considered as part of the segment in decision making. This includes, as far as can be ascertained, the likelihood of objectives not being met if periodically dry wetland areas are polluted and then inundated. For example, depositing pollution or waste on land that is part of wetland floodplain can result in wetlands becoming polluted after heavy rain and flooding.

- ***Estuarine water type***

Estuaries are semi-enclosed waterbodies where there is substantial mixing between fresh and marine waters. This occurs where creeks, streams and rivers meet bays and the open ocean. Estuaries can extend large distances inland and into coastal lakes and marine waters. They sit between the broader marine and river segments described in the ERS.

Clause 17(1)(c)(i) of the ERS defines a generic estuary segment for Victorian estuaries, and clause 17(1)(c)(ii) defines the Gippsland Lakes segment and subsegments. Clause 17(1)(c)(i)(A) notes that estuaries can also extend into the marine segments, such as Corner Inlet, Western Port and Port Phillip Bay where there can be substantial mixing between fresh and marine waters due to freshwater inflows.

The extent of estuaries changes over time, depending on the amount of freshwater inflows and penetration of marine waters. This is strongly influenced by whether an estuary mouth is open or closed to the ocean, tidal cycles (when estuaries are open) and the volume of riverine flows. As such, salinities in estuaries can vary from fresh to very saline (between 0 and greater than 35 practical salinity units (PSU)) over time and space. It is common for Victorian estuaries to become stratified with a distinct fresh surface water layer and marine bottom layer. Therefore, determining the boundaries of estuaries should involve several types of observations to identify the extent of regions where there is substantial mixing of fresh and marine water. This includes identifying regions where freshwater inflows meet marine waters, the variation between fresh and very saline water (35 PSU or greater), variation in salinity over multiple tidal cycles when an estuary is connected to the ocean (partially or completely open) and the presence of flora and fauna that are reliant on estuarine water.

The landward boundary of an estuary is where there is no longer observable tidal variation in salinity (estuary ‘head’). The seaward boundary (estuary ‘mouth’) is where salinity is consistently indistinguishable from marine waters over a sustained time. Because estuary heads can move with tides and freshwater inflows, and can be stratified with a marine bottom layer, the landward boundary of an estuary should be determined based on multiple tidal cycles and at surface and bottom depth.

- ***Marine water type***

Marine waters typically have salinities greater than 35 PSU, and waters in bays or the open ocean that are not commonly influenced by freshwater inflows (have levels of salinity that are stable at this level or greater over time) can be considered as ‘predominantly marine’ as described in clause 17(1)(d) of the ERS. In these cases, the environmental values, indicators and objectives for those specific segments apply, not those for estuaries.

The ERS defines marine segments as comprising Port Phillip Bay, Western Port, Corner Inlet and the Open Coast. Each is bounded by high water across their relevant segments, and the seaward extent of estuaries where they may occur within a marine segment. Indicators and objectives for Port Phillip Bay, Western Port, Corner Inlet and the Open Coast are provided in Tables 5.13 to 5.15 and 5.17 that can be used in decision making.

- ***Aquatic reserves segment***

Aquatic reserves represent a distinct segment that is described in the general definition section of the ERS (clause 4) and in the segment definitions (clause 17). Aquatic reserves are smaller segments occurring within the broader segments. They encompass areas of high environmental value, such as national and state parks, marine parks and conservation areas. Areas with aquatic reserves are described in the legislation listed in clause 4 of the ERS in the definition of ‘Aquatic reserves’.

c) Segment boundaries

In some cases, an area within an aquifer or surface water body may be on the boundary of segments or subsegments. In these cases, it may be unclear which segment and corresponding environmental values or objectives apply. In such circumstances, the segment with the most protective objective should be adopted and all the environmental values for all segments on the boundary should apply. For example, if an area is on the boundary of the Central-East and Hobsons Bay subsegments and an objective for chlorophyll-a is needed for assessment, then the lowest objective of 1.5 µg/L (found in the Central-East segment) should be adopted. This conservative approach ensures the most sensitive segments and environmental values are considered where there is uncertainty about which segment applies.

7.2.2 Step 2: Determining environmental values

In Part 5 of the ERS, environmental values are the water dependent ecosystems, their ecosystem services and human uses that require water to be of a suitable quality to support that use or value. These environmental values include those that may not be found in water but depend on clean water, such as some groundwater dependent terrestrial and riparian vegetation.

A description of each of the environmental values of water is provided in Table 5.1, clause 13 of the ERS. Column 1 of this table lists the environmental values and column 2 describes the purpose or intent of each value. For example, to protect *aquaculture* (the environmental value), water quality must be suitable for the production of fish and any aquatic plant, algae or invertebrates for human consumption (the purpose/intent). These descriptions should be used to aid the interpretation of environmental values, as well as identifying whether they apply to a specific water body. In water environments it is common for environmental values to closely co-exist and at times, affect one another (such as aquaculture and water dependent ecosystems). Therefore, it is important to consider the requirements of all environmental values in a water body.

The environmental values of water are further divided into those found in groundwater and surface water in the ERS (Table 5.3 (clause 15) and Table 5.5 (clause 18), respectively). Environmental values are recognised within each groundwater and surface water segment, depending on whether the baseline quality of the water is suitable to support that use or value. For groundwater, environmental values are assigned based on TDS levels, as the salinity of groundwater affects what it can be used for. For surface waters, an environmental value is assigned to a segment where the quality of water is, or has the potential to, support that use or value.

a) Where environmental values don’t apply

There are some circumstances where environmental values set out in the ERS (Tables 5.1, 5.3 and 5.5 of the ERS) do not apply where they otherwise might. These circumstances are described in clauses 13(2), 15(2) and 18(3) of the ERS. For all waters, environmental values do not apply for the artificial assets specified in clause 13(2). This is because these assets have been constructed for a particular purpose or use of water and are not designed to directly support the environmental values in the ERS. Supporting environmental values in these assets will typically impede the important services they support and were designed for. For example, stormwater wetlands may have been specifically designed to intercept stormwater to treat and remove pollution, however they may also support aquatic plants and wildlife that could be affected by pollution. Because stormwater wetlands have been primarily designed to treat pollution and not to support aquatic life, *water dependent ecosystems* is not a recognised environmental value in this situation. Circumstances where environmental values are not recognised in the ERS still must be managed in accordance with the general environmental duty (GED). This means that a person must still take reasonably practicable measures to minimise risks from pollution and waste to the environment or human health, even where environmental values may not apply in the ERS.

When determining whether an environmental value applies, both potential and future environmental values need to be considered. Importantly, temporary changes in background water quality may mean that while an environmental value might not be supported at a given time, it may be supported again in the future. In these cases, the environmental value still applies. An example of this is the drying of creek beds, or hypersalinity in lakes due to low rainfall. During future periods of higher rainfall, such creeks and lakes may be able to support environmental values.

In groundwater, an environmental value may not apply when there is insufficient aquifer yield to sustain the environmental value. However, care needs to be taken to ensure that the indication of insufficient yield is not due to variations in the aquifer being monitored, such as a clay lens in a sedimentary aquifer or a poorly developed bore. Fractured rock and karst systems, where flow is dominated by fractures or natural cavities, may have highly variable yield. Care also needs to be taken to ensure the insufficient yield is not a temporary effect or a problem that could be overcome through engineering, such as installing an extraction well with a large sump or reservoir. Consideration should also be given to the use of groundwater in the surrounding area and the existing environmental values (for example, it can be appropriate to conclude that there is sufficient yield to support the environmental values if groundwater is being extracted on a neighbouring property).

Aquifer yield is represented by hydraulic conductivity, which is a measure of permeability. The permeability of an aquifer defines the potential rate of flow through a porous media. For the purpose of clause 15(2)(a), insufficient aquifer yield can be considered as any porous media with a hydraulic conductivity less than 0.0001 m/day. This should be demonstrated via measurement of the aquifer properties and consideration of the factors described above.

Groundwater environmental values may also not apply if the application of groundwater poses a risk to environmental values of land or the broader environment due to soil properties. For example, using groundwater with a high sodium content for irrigation would result in land degradation.

- ***Exclusions due to background levels***

For both groundwater and surface water, environmental values do not apply where background water quality levels are not suitable to maintain or achieve an environmental value. The interpretation of background water quality levels is described in more detail below in section 7.2.3b). Excluding one environmental value due to unsuitable background water quality does not mean that other environmental values are excluded. This is because distinct environmental values typically require different water quality to be supported and maintained. Therefore, the suitability of background water quality needs to be considered for each individual environmental value. Examples of this include where water quality is not suitable for supporting drinking water without treatment, such as is the case with the naturally high salinity in groundwater and seawater. In these clear cases, environmental values are not marked by a tick in Tables 5.3 and 5.5 of the ERS. However, there may be circumstances where background water quality levels are not suitable for supporting environmental values in specific water bodies. For example, lakes that support large colonies of birds may not be appropriate for recreation due to elevated bacterial indicator levels. Clauses 16(2) and 18(3) of the ERS allow discretion to exclude some environmental values from decision making in such cases.

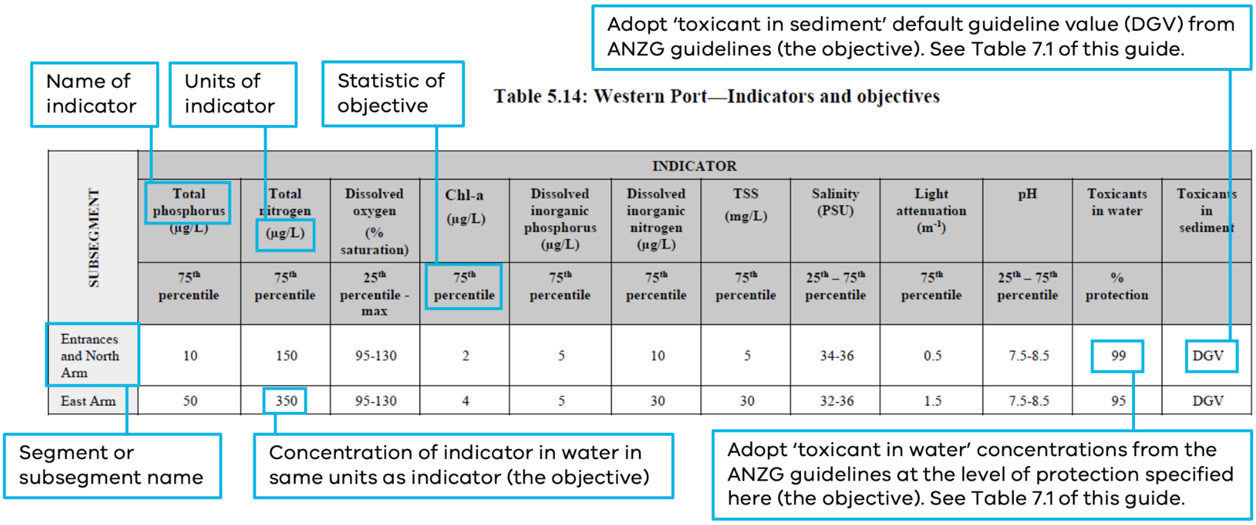
b) Levels of protection for water dependent ecosystem values

Different water dependent ecosystems can have different ‘levels of protection’ applied to them in the ERS. These levels of protection correspond to the amount of modification a water body has experienced due to human activity. The ERS distinguishes three levels of protection: largely unmodified; slightly to moderately modified; and highly modified.

These levels of protection also correspond to the objectives for water dependent ecosystems within a segment, in particular the toxicant objectives described in ERS Tables 5.8 to 5.18 (see Table 7.1 below for further explanation on the derivation of the objectives). This is because water dependent ecosystems vary greatly in their sensitivity to pollution between unmodified and heavily modified environments. Unmodified environments commonly support species that are sensitive to pollution which in turn require higher quality water to be supported and maintained. In contrast, more modified environments support those that are less sensitive and can persist (to some extent) in water of lower quality. The approach adopted in the ERS is to set levels of protection required to protect the highest quality ecosystem condition commonly found within a segment. Within many segments there are typically more localised areas that have experienced higher levels of modification, such as ports in marine waters or waterways in towns. However, because of the high level of connectivity of water between more modified and less modified areas within a segment, these highly modified areas must meet the levels of protection needed to support and maintain the most sensitive ecosystems in the broader segment.

7.2.3 Step 3: Determining water indicators and objectives

The indicators and objectives for water are specified in the ERS in Table 5.4 for groundwater and Tables 5.7 to 5.21 for surface water, as well as in clauses 16 and 19. Clauses 16 and 19 of the ERS set out some additional considerations needed for the interpretation of the objectives tables. Figure 7.3 presents an example showing how to interpret the indicators and objectives tables.



SUBSEGMENT	INDICATOR											
	Total phosphorus (µg/L)	Total nitrogen (µg/L)	Dissolved oxygen (% saturation)	Chl-a (µg/L)	Dissolved inorganic phosphorus (µg/L)	Dissolved inorganic nitrogen (µg/L)	TSS (mg/L)	Salinity (PSU)	Light attenuation (m^{-1})	pH	Toxicants in water	Toxicants in sediment
	75th percentile	75th percentile	25th percentile - max	75th percentile	75th percentile	75th percentile	75th percentile	25th – 75th percentile	75th percentile	25th – 75th percentile	% protection	
Entrances and North Arm	10	150	95-130	2	5	10	5	34-36	0.5	7.5-8.5	99	DGV
East Arm	50	350	95-130	4	5	30	30	32-36	1.5	7.5-8.5	95	DGV

Figure 7.3. Schematic with annotations describing key components of an indicators and objectives table for water dependent ecosystems

There are objectives applicable to water, sediment and the tissue of organisms. If any of these objectives are not met, there is a potential risk to the relevant environmental value from pollution and/or waste. There are a range of reasons for why objectives may not be met, including natural processes unrelated to the impacts of pollution and waste. Therefore, when an objective is not met, further investigation should be undertaken to determine the actual risk to environmental values. The level of investigation should be proportionate to the predicted risk to environmental values. Examples of appropriate approaches for further investigation when objectives are not met are described in *Guidelines for risk assessment of wastewater discharges to waterways* (publication 1287).

a) Derivation and interpretation of specific indicators and objectives

Some objectives have been developed from long-term studies specific to Victorian waterbodies. In other cases, where such studies were not available, objectives have been derived from national standards and guidelines. The differences in methods for deriving objectives mean that there are nuances in how risks to environmental values should be interpreted. Table 7.1 of this guide provides an overview of how water objectives have been derived, and how they should be interpreted.

b) Situations where objectives are applied differently

There are a range of circumstances set out in the ERS where the water quality objectives (set out in Tables 5.4 and 5.7 to 5.21 of the ERS) do not apply or should be applied differently.

- ***Background water quality***

Background water quality levels refer to those levels of an indicator found outside the influence of waste and pollution. These are essentially the natural levels in water free of human influence. Background levels can include those influenced by some large-scale drivers of water quality, such as climate change, that can be attributed to human actions. In this way, although the influences may not be considered 'natural' the levels are not attributable to a source of pollution or waste.

Background levels should not be confused with 'ambient' water quality levels. Background levels represent those levels entirely outside the influence of pollution and waste. In contrast, ambient water quality refers to the levels of indicator that include background levels and levels introduced by waste or contaminants from human actions, from diffuse or non-point sources. Ambient water quality is not a term referred to in the ERS, but it is used in various other EPA guidelines (for example, *Guidelines for risk assessment of wastewater discharges to waterways* (publication 1287).).

In the ERS, 'background water quality' for an individual indicator is the level in water or in aquatic ecosystems outside the influence of any waste or contaminant containing a measurable level of that same indicator. This is because there may be water bodies that have experienced some impacts of pollution and waste but background levels of a specific indicator can still be determined because the pollution does not include that indicator. For example, a river or stream may have been polluted with nutrients historically, but if the indicator of interest is a heavy metal which has not been a previous source of pollution to that river or stream, then background levels can still be determined for that heavy metal.

Background water quality levels should be adopted as objectives in two circumstances, as set out for groundwater in ERS clauses 16(2) and 16(3) and for surface water in ERS clauses 19(2) and 19(3):

- when background levels better protect environmental values
- when objectives cannot be attained because background levels are worse than, or exceed, objectives specified in ERS Table 5.4 and Tables 5.7 to 5.21.

In the first circumstance, background water quality levels ‘better protect’ environmental values when they are more stringent than the objectives specified in Table 5.4 and Tables 5.7 to 5.21 of the ERS. There are two main types of objectives set out in ERS Tables 5.4 and 5.7 to 5.21. They use indicator levels in different ways to indicate risk to environmental values:

- objectives using an upper limit – when levels of an indicator in ambient water are greater than the objective specified
- objectives using a lower limit – when levels of an indicator in ambient water are less than the objective specified.

Table 7.1 below presents descriptions of these different types of objectives. Background levels that are lower than objectives specified as an upper limit (such as a 75th percentile or maximum) can be considered to ‘better protect’ environmental values. In these cases, the background level becomes the objective. However, in cases where background levels are higher than an objective specified as a lower limit (for example, a 25th percentile or a minimum), background levels can be considered to better protect environmental values and become the objective.

In the second circumstance, if the background level of an indicator exceeds the objective, the objective does not apply in that waterbody. In these instances, the background levels become the objective. This ensures that the natural characteristics of specific waters are supported and maintained in circumstances where water quality does not meet objectives due to reasons other than pollution and waste. Examples of this include water bodies where the geology results in naturally elevated metals that exceed ERS objectives or where natural intrusions of saline groundwater result in highly saline lakes or rivers.

In general, background levels are the preferred objective to be adopted over the default objectives defined in Tables 5.4 and 5.7 to 5.21 of the ERS, as they will be the most appropriate for many water bodies. There is a number of water bodies where determining background levels will be practicable, such as in near-natural waters or some marine waters where there has been little to no influence by pollution and waste. There will also be circumstances where background levels can be determined in modified streams for specific indicators that are not a common or widespread pollutant. Historical data or other methods capable of determining conditions prior to pollution impacts can also be used to determine background levels.

However, it is sometimes not practicable, or even possible, to determine background water quality for indicators. For example, in water bodies where there has been a legacy of diffuse and point source pollution and comparable areas outside of the influence of a particular pollutant do not exist. This is common for indicators such as nutrients and sediments in rural and urban rivers and streams. Where it is not practicable to determine background water quality levels for an indicator, the default objectives (set out in the ERS, Tables 5.4 and 5.7 to 5.21) should be adopted in decision making. This approach ensures that protective objectives are adopted and is consistent with the philosophy of the water quality management framework stated in the Australian & New Zealand guidelines for fresh & marine water quality (ANZG) (ANZG, 2018a).

- ***Aquatic reserves***

Aquatic reserves encompass areas of high environmental value, such as marine national parks, and rivers, streams and wetlands within land-based national parks. In these environments, human impacts are minimal or have been greatly reduced so as to preserve the natural character of these environments. They typically represent areas that support largely unmodified ecosystems or seek to minimise further modification. As such, background levels are the objectives for aquatic reserves (ERS clause 19(2)), which ensures that any changes in the levels of indicators outside natural unpolluted levels are identified as a risk to their environmental values. The indicators for aquatic reserves are those set out for the wider segment that aquatic reserves are situated within (ERS clause 19(1) Note). For example, indicators for marine national parks situated within the Otway subsegment are the indicators specified for the Otway subsegment. Where it is simply not possible to determine background levels in aquatic reserves, the objectives of the wider segment can be used to provide some estimate of potential risks to environmental values. This will usually occur when there is a lack of areas or historical data to determine conditions outside the influence of pollution. However, segment objectives should only be used when it can be clearly determined that they will be sufficient to support and maintain environmental values within the aquatic reserve.

- ***Where no objectives are provided***

In some circumstances, no objectives are provided for the indicators set out in tables in the ERS. This is due to a lack of appropriate data. In this circumstance, objectives are specified as either an R75 or R25 to signify where indicators are known to represent a risk to environmental values but that a specific objective cannot be set due to knowledge gaps. As defined is clause 19(4)(d) of the ERS, R75 and R25 mean the objective must be calculated as the 75th percentile or the 25th percentile, respectively, of the data collected at a reference site. This ensures that the objectives are determined in a way that is consistent with the approach used for established objectives.

In the ERS, the swamps segment doesn't have any tables of specific indicators and objectives for *water dependent ecosystems and species*. Therefore, any decision making relating to swamps will require the development of suitable objectives through monitoring or synthesis of existing data. Swamps have been included in the ERS because they represent unique water environments that support important environmental values that need to be supported and maintained.

c) Which objectives should apply where multiple objectives are available?

In some cases, the ERS specifies multiple objectives for the same indicator. This is because the same indicators can be used to assess risks to different environmental values. The objective of that indicator can change significantly for distinct environmental values, reflecting the different level of risk it poses. Multiple environmental values also typically co-exist in close proximity within a waterbody. As such, it is common that different objectives for the same indicators can be applicable in the same location. For example, there are many commonalities in indicators for water-based aquatic ecosystems and aquaculture, but objective levels can be quite different, reflecting the different levels of sensitivities between aquaculture and wild species.

Where multiple environmental values co-exist and share the same indicators, the most protective objective should be adopted. This ensures that water quality objectives are applied that correspond to the most sensitive environmental values. This in turn ensures the objectives will support all environmental values in an area.

Table 7.1. Derivation and interpretation of indicators and objectives for ERS water environmental values

Environmental value	Indicator type	Derivation	Interpretation
Water dependent ecosystems and species	Physical chemical stressors (ERS Tables 5.8 to 5.17 – all parameters except 'Toxicants in water' and 'Toxicants in sediment')	The objectives are derived from long-term monitoring of 'reference' condition waterways and sites in Victoria. These sites are considered to be near natural or minimally disturbed versions of that environment, and representative of the major characteristics of the water from which it is sampled. Where reference sites were unavailable (e.g., streams in urban Melbourne), the sites with the least disturbance were adopted. For more information, refer to *Development of indicators for SEPP (Waters)*(publication 1733).	Not meeting the objectives indicates that: • indicator levels are outside those that are typically observed in healthy waterbodies • there is a risk to water dependent ecosystems from poor water quality. Poor water quality can be caused by pollution and waste but may also be due to natural processes (e.g., drought and floods). When objectives are not met, further assessment should be undertaken to determine whether the causes of poor water quality are due to pollution and/or waste impacts. A 75th-percentile or maximum-value objective indicates a risk to environmental values when indicator levels **are greater** than the objective. A 25th-percentile or minimum-value objective indicates a risk to environmental values when indicator values **are less than** the objective.
	Toxicants in water and sediments (ERS Tables 5.8 to 5.17)	ERS specifies two types of toxicants: toxicant concentrations in water and toxicant concentrations in sediments. Sediment and water toxicant values come from the default guideline values (DGVs) (https://www.waterquality.gov.au/anz-guidelines/guideline-values/default) in the ANZG guidelines (ANZG, 2018b). DGVs for toxicants in water are largely derived from ecotoxicity testing, using a species sensitivity distribution of chronic toxicity data (refer to the section on the revised method for deriving Australian and New Zealand water guideline values for toxicant (ANZG, 2018c)	Exceedances of the objectives indicate there is a potential risk of other adverse effects to water dependent species and ecosystems. The ERS specifies different levels of protection for toxicants. This reflects a water body's level of modification and the desired ecosystem condition. Levels of protection correspond to different concentrations of toxicants needed to meet that level of protection. In ERS Tables 5.8 to 5.17, the levels of protection are: 99, 95 and 90, meaning 99%, 95% and 90% protection respectively. DGVs differ for freshwater and marine waters. The correct DGV needs to be adopted as the objective for the relevant water type. ANZG guidelines do not provide specific toxicant DGVs for estuaries or groundwater. However, for water types other than fresh and marine water, information on how to use guideline values is available in the section 'guideline value for other water types' (https://www.waterquality.gov.au/anz-guidelines/guideline-

Environmental value	Indicator type	Derivation	Interpretation
		(https://www.waterquality.gov.au/anz-guidelines/guideline-values/derive/warne-method-derive)). The ERS uses DGVs that represent concentrations that will protect 90, 95 or 99% of species. Sediment quality DGVs are derived from studies of the cause-effect relationships between toxicants in sediment and biota. For more information, refer to the section on toxicant default guideline values for sediment quality in the ANZG guidelines (ANZG, 2018d).	values/default/water-quality-toxicants#guideline-values-for-other-water-types) in the ANZG guidelines section on toxicant default guideline values for sediment quality (ANZG, 2018e). Sediment toxicant objectives adopt the default ANZG guidelines DGVs for sediments. There are no levels of protection for sediment DGVs, and the same objectives apply to both marine and freshwaters. For bioaccumulative toxicants, the ANZG guidelines recommend adopting the next highest level of protection than that specified in the ERS. For example, for a toxicant in the lowlands of the Yarra Basin, you would typically adopt the 95% level of protection concentration from the ANZG guidelines (consistent with ERS Table 5.8). However, if this toxicant is bioaccumulative (e.g., mercury) then the 99% level of protection should be adopted. Information sheets for each toxicant are available and identify if a toxicant is bioaccumulative. These information sheets are available via the 'search for toxicant default guideline values' (https://www.waterquality.gov.au/anz-guidelines/guideline-values/default/water-quality-toxicants/search) section of the ANZG guidelines (ANZG, 2018f)
	Biological indicators for rivers and lakes (ERS Tables 5.9 and 5.11)	The biological objectives are based on data from long-term monitoring of macroinvertebrates at reference sites across Victoria: Five main indices of macroinvertebrate communities are used to indicate the health of waterways: • EPT: an estimate of the relative abundance of three major orders of stream insects that have a low tolerance to water pollution (*E: Ephemeroptera, P: Plecoptera, T: Tricoptera*). A high EPT score indicates high abundance of these invertebrates, and low pollution levels. • SIGNAL2: an index of water quality based on the tolerance of	The biological objectives specify a number, based on macro-invertebrate indices, that represents levels found in healthy water dependent ecosystems. These objectives indicate low risks to water dependent ecosystems when: • EPT scores are equal to or greater than those specified for a segment in ERS Table 5.9 • SIGNAL2 scores are equal to or greater than the objective specified in ERS Table 5.9. • Number of families are equal to or greater than those specified in ERS Tables 5.9 and 5.11 • AUSRIVAS scores are within the bands set out for each segment and season in ERS Table 5.9 • VLAKES scores are equal to or greater than the scores set out in ERS Table 5.11

Environmental value	Indicator type	Derivation	Interpretation
		aquatic biota to pollution. Generally high-quality sites have high SIGNAL scores, and low-quality sites have low SIGNAL scores. • Number of families: the number of macroinvertebrate families sampled in a stream. Healthier, less polluted waterbodies generally have higher numbers of families. • AUSRIVAS: index based on models that predict the aquatic macroinvertebrate fauna at a site in the absence of environmental stress. It indicates the overall ecological health of a site. • VLAKES: biotic index developed by EPA Victoria based on the abundance of macroinvertebrate found at a site weighted by their sensitivities to pollution.	Guidance on the interpretation, monitoring and assessment of macro-invertebrate objectives is provided in *Rapid bioassessment methodology for rivers and streams* (publication 604) and *Environmental quality guidelines for Victorian lakes* (publication 1302).
	Seagrass cover, extent and condition (ERS Table 5.7)	A narrative objective based on well-understood relationships between seagrasses, ecosystem health and the impacts of nutrient and sediment pollution.	A reduction in the cover, extent and condition of seagrasses in marine water can indicate that levels of nutrients and sediments in waters are excessive and pose a risk to water dependent ecosystems. In these cases, a reduction is outside of what is considered natural, such as seasonal die back, natural disturbance, burial by sand or grazing.
	Harmful algal blooms frequency, duration or spatial extent (ERS Table 5.7)	A narrative objective based on the response of algae to excessive nutrients entering water bodies.	An increase in the frequency, duration or spatial extent of harmful algal blooms in water bodies can indicate that nutrients (particularly nitrogen and phosphorous) in water are excessive and pose a risk to water dependent ecosystems.

Environmental value	Indicator type	Derivation	Interpretation
	Subterranean species of troglofauna and stygofauna (ERS Table 5.4)	A narrative objective based on the response of stygofauna (fauna that live in the water of a groundwater system) and troglofauna (fauna that live in the spaces above the water table within groundwater systems) to pollutants, including total suspended solids, salinity, toxicants in water, toxicants in sediment and dissolved oxygen.	A change in the levels of any indicator that has the potential to adversely affect stygofauna and troglofauna that depend on groundwater indicates that there is a potential risk to subterranean water dependent ecosystems of groundwater systems. This objective applies to groundwaters and only to those groundwater systems where conditions are suitable for supporting subterranean water-dependent ecosystems
	Sediment quality in rivers and streams, wetlands, estuaries and marine waters ('Indicator or segment' column in Table 5.18)	These indicators and their objectives are based on a 'weight of evidence' (WoE) approach. WoE is used to identify and assess if water- dependent ecosystems are at risk from complex pollutant mixtures or from pollutants without specific ERS indicators and objectives. WoE testing uses five lines of evidence to make an overall assessment of sediment quality to assess risk from toxicants: 1. chemistry 2. ecotoxicity 3. ecology 4. bioaccumulation 5. other (including biomarkers). The ecotoxicity line of evidence uses an indicator species (such as benthic macroinvertebrates) to test whether chemicals are toxic to biota. The ANZG guidelines provide guidance in their 'Weight of evidence' section (ANZG, 2018g), (https://www.waterquality.gov.au/anz-guidelines/resources/key-concepts/weight-of-evidence#applying-	A score of medium or high risk indicates that there is a risk to water dependent ecosystems from pollution impacts. These impacts may be due to complex mixtures of pollutants or emerging contaminants that do not have specific objectives in Part 5 of the ERS. An objective of 'low risk' needs to be met to support and maintain water dependent ecosystems for all waters. To do this, the assessment of each line of evidence used must meet the conditions described for each indicator or segment in the column '1- low risk' in ERS Table 5.18. For example, water and sediment toxicant concentrations should meet 95% protection levels and sediment DGVs; ecotoxicity tests should not be significantly different between controls and treatment and have an effect size less than 20% of a control test; and ecology tests should detect no significant effects on abundance or diversity. EPA is developing more detailed guidelines to outline the methodology for assessing sediment toxicity using multiple lines of evidence. More information on the application of this assessment is included in Simpson and Batley (2016), refer to the 'Weight of evidence' section of the ANZG guidelines (ANZG, 2018g) (https://www.waterquality.gov.au/anz-guidelines/resources/key-concepts/weight-of-evidence#applying-the-process-to-watersediment-quality-assessments).

Environmental value	Indicator type	Derivation	Interpretation
		the-process-to-watersediment-quality-assessments.) including which type, and how many lines of evidence, should be used to achieve different levels of quality. Adopting lines of evidence to meet the ANZG's criteria for 'high' to 'very high' is preferable when making assessments against the objectives for water in the ERS.	
	Load indicators (ERS Table 5.21)	Load objectives describe the mass over time as an annual average tonne of significant pollutants entering Lake Wellington, Corner Inlet, Western Port and Port Phillip Bay from the surrounding catchment. Load objectives have been set for key pollutants that pose a major threat to the environmental values of these water bodies. The objectives have been estimated using hydrological, hydrodynamic and biogeochemical models. These simulate the physical and ecological behaviour of catchments and marine bay waters. For more information on derivation of load objectives, see *Development of indicators and objectives for SEPP (Waters)* (publication 1733).	Load objectives are expressed as annual average tonnes. This means that an annual load should be measured for a number of years, and that the average of those annual loads compared against the objective. As such, multiple years are needed to assess whether load objectives have been met. Precipitation and riverine flows are significant influences on loads entering bays, which can vary substantially between years and in response to longer-term climate cycles. The period selected for assessing loads should be representative of both wet and dry periods to capture inter-annual variation in loads. Load objectives for Western Port and Port Phillip Bay represent current loads entering bays. Therefore, the objectives are for there to be no increase in pollutant loads beyond best estimates of current loads. Load objectives for Corner Inlet (including Nooramunga), and Lake Wellington are lower than current best-estimated levels. As such, current loads need to be reduced to achieve objectives.
Human consumption after appropriate treatment	Indicators specified in the *Australian drinking water guidelines (ADWG)* (NHMRC, NRMMC, 2011)	Environmental values relating to drinking water apply where water is sourced in accordance with the *Safe Drinking Water Act 2003* (and in a special water supply catchment area set out in Schedule 5 of the *Catchment and Land Protection Act 1994*). The purpose of the *Safe Drinking*	The ADWG provide the minimum requirements for drinking water of good quality, both aesthetically and from a public health viewpoint. Water suppliers should adopt a preventive risk management approach, as stipulated in the ADWG, to maintain the supply of water at the highest practicable quality. The guideline values should never be seen as approval to degrade the quality of a drinking water supply to that level.

Environmental value	Indicator type	Derivation	Interpretation
Potable water supply **Potable mineral water supply**		*Water Act 2003* is to make provision for the supply of safe drinking water. The *Australian Drinking Water Quality Guidelines* (ADWG) (NHMRC, NRMMC, 2011) describe: • health related guideline value – concentration or measure of a water quality characteristic (microbial, chemical, physical) that, based on present knowledge, does not result in any significant risk to the health of the consumer over a lifetime of consumption. • aesthetic guideline value – concentration or measure of a water quality characteristic that is associated with acceptability of water to the consumer, for example, appearance, taste and odour. ADWG values have been derived from epidemiological data, experiments examining toxicological effects on laboratory animals and from overseas guidelines. The derivation of the guideline values are conservative to ensure they are protective of human health. For the rationale for drinking water guideline values see Chapter 6 of the ADWG.	Whether or not a deviation poses a risk to human health depends on: • the amount by which a guideline value is exceeded • how long a guideline value is exceeded for • the chemical involved • other risks (i.e., vulnerability in children and pregnant women), and benefits to public health. Each exceedance of a guideline value should be a trigger for further investigation and notified to the Department of Health in accordance with the *Safe Drinking Water Act 2003.* Sources other than pollution can also cause these guideline values to be exceeded. Therefore, within the ERS framework, exceedances of objectives should trigger further assessment to determine whether elevated levels of contaminants are due to the impacts of pollution and waste.
Agriculture and irrigation (irrigation)	Indicators specified for irrigation and water for general on-farm use are provided in the ANZG	These indicators and their objectives are from the default guidelines values in the section on water quality for primary industries of the ANZG guidelines (ANZG, 2018h) (https://www.waterquality.gov.au/anz-	Exceedances of objectives/DGVs indicate a potentially adverse effect to crop growth and the soil environment from irrigated water. Where objectives are exceeded, further investigation should be undertaken using the indicators guidance in the ANZG guidelines (‘Water quality for primary industries’ section (ANZG, 2018h)(https://www.waterquality.gov.au/anz-guidelines/guideline-

Environmental value	Indicator type	Derivation	Interpretation
		guidelines/guideline-values/default/primary-industries) DGVs are thresholds within which there should be minimal risk of adverse effects to the soil environment and crop growth from irrigated water and to general on-farm water use (e.g., for the maintenance of farm equipment) due to the corrosive and fouling potential of waters. Guidelines for irrigation water quality are for biological parameters, salinity and sodicity, inorganic contaminants (specific ions, including heavy metals and nutrients), organic contaminants (pesticides) and radiological characteristics. DGV thresholds have been developed from extensive literature reviews, contemporary research data and public comment.	values/default/primary-industries)) and section 4.2, volume 1 (https://www.waterquality.gov.au/sites/default/files/documents/anzecc-armcanz-2000-guidelines-vol1.pdf) of the 2000 *Australian and New Zealand guidelines for fresh and marine water quality* (ANZEC, ARMCANZ, 2000). For some objectives, interactive factors that must be considered include irrigation water quality, soil properties, plant salt tolerance, climate, landscape and water and soil management. Refer to the ANZG guidelines for more information.
Agriculture and irrigation (stock watering)	Indicators specified for livestock drinking water quality in the ANZG	These indicators and their objectives are from the DGVs in the guidance relevant to primary industries – livestock drinking water (https://www.waterquality.gov.au/anz-guidelines/guideline-values/default/primary-industries/stock-water-guidance) in the ANZG guidelines (ANZG, 2018i). DGVs are thresholds within which there should be minimal risk of adverse effects to animal health. Thresholds have been developed from local research data and extensive literature reviews. In some cases, DGVs are derived from data on chronic and toxic effect levels on animals. These take into account animal weight,	Exceedances of objectives indicate a potentially adverse effect to the health of animals. At levels below the objective, there should be little risk of adverse effects on animal health. If a parameter does not meet a DGV, the ANZG guidelines recommend further investigation to evaluate the risks from other factors (e.g., animal age, condition and other dietary sources). If objectives are exceeded, refer to ANZG guidelines for information on specific indicators, refer to the guidance and default guideline values for primary industries – livestock drinking water (https://www.waterquality.gov.au/anz-guidelines/guideline-values/default/primary-industries/stock-water-guidance) in the ANZG guidelines (ANZG, 2018i).

Environmental value	Indicator type	Derivation	Interpretation
		percentage intake from water and safety factors for data not specific to species.	
Human consumption of aquatic foods	Physical and chemical stressors and toxicant objectives specified for water dependent ecosystems (ERS Tables 5.8 to 5.17 – all parameters)	These indicators and their objectives adopt the indicators and objectives for water dependent ecosystems. Using the water dependent ecosystem indicators and objectives assumes that if water quality is suitable for supporting and maintaining healthy ecosystems and species then they should be appropriate for human consumption. However, for some bioaccumulative toxicants the aquatic ecosystem objectives may not be protective of aquatic foods for human consumption. In these cases, follow the approach set out in the ANZG guidelines, which include information for adopting DGVs for substances that are capable of bioaccumulating. This information can be accessed via the 'search for toxicant default guideline values' (https://www.waterquality.gov.au/anz-guidelines/guideline-values/default/water-quality-toxicants/search) section of the ANZG guidelines (ANZG, 2018f).	Exceedances of water quality objectives for water dependent ecosystems indicate there is a potential risk to the consumption of aquatic foods due to pollution in waters. This will largely be due to the potential uptake of toxicants and other compounds through the food chain.
	Indicators for metal contaminants, non-metal contaminants, natural toxicants, and mercury in Schedule 19 (Maximum levels of contaminants and natural toxicants) of the Food Standards Code	Indicators and objectives are also adopted from Schedule 19 (Maximum levels of contaminants and natural toxicants) (https://www.foodstandards.gov.au/code/Documents/Sched%2019%20Contaminant%20MLs%20v157.pdf) of the *Australia New Zealand Food Standards Code* (FSANZ, n.d.).	Exceedances of the maximum levels of contaminants and natural toxicants indicate there is a potential risk to human health from consuming aquatic foods with elevated contaminants in their tissue. There may be other causes of contamination in aquatic foods that are unrelated to pollution, such as accumulation of natural toxicants found in algae. Therefore, when these objectives are exceeded, they should trigger further investigation.

Environmental value	Indicator type	Derivation	Interpretation
		The objectives represent maximum concentrations in aquatic foods that are acceptable for human consumption. As such, if the maximum levels are exceeded it may be that: • the condition of the environment does not support production of food for public consumption • action must be taken to address risks to human health and restore the utility of the environmental value.	
Aquaculture	Faecal (thermotolerant) coliforms (median from 5 samples)	Indicators and objectives come from the ANZG guidelines, which have used guideline values from the 2000 *Australian and New Zealand guidelines for fresh and marine water quality* (ANZEC, ARMCANZ, 2000). These guidelines were informed by practices required by the Australian Shellfish Quality Assurance Program, US EPA and Canadian Department of Environment water quality guidelines for shellfish. For more information see section 4.4.5.3, Volume 1, (https://www.waterquality.gov.au/sites/default/files/documents/anzecc-armcanz-2000-guidelines-vol1.pdf) and section 9.4.3.3 to 9.4.3.5, Volume 3, (https://www.waterquality.gov.au/sites/default/files/documents/anzecc-armcanz-2000-guidelines-vol3.pdf) of the 2000 *Australian and New Zealand guidelines for fresh and marine water quality* (ANZEC, ARMCANZ, 2000).	Exceedances of faecal thermotolerant coliforms in water indicates a risk to human consumers of aquaculture species from aquatic bacterial food-borne diseases due the presence of faecal contamination.

Environmental value	Indicator type	Derivation	Interpretation
	Physical and chemical stressors	These indicators and their objectives are from the DGVs of the ANZG guidelines (ANZG, 2018h) DGVs are concentrations where there should be minimal risk to aquaculture species. DGVs are based on a comprehensive review of relevant levels in literature, databases, and from unpublished evidence from practitioners. DGVs are developed for eight indicative groups of finfish, molluscan and crustacean species and one or two common representative species for each group. See ANZG guidelines for further information.	Exceedances of physical and chemical stressor objectives for aquaculture indicate a risk of harm to aquaculture species due to pollution in water environments.
	Toxicants	These indicators and their objectives are from the DGVs of the water quality for primary industries (https://www.waterquality.gov.au/anz-guidelines/guideline-values/default/primary-industries/stock-water-guidance) section of the ANZG guidelines (ANZG, 2018h). The methodology for developing these DGVs is the same as for physical and chemical stressors (see above).	Exceedances of toxicant objectives for aquaculture indicate a risk of harm to aquaculture species.
	Off-flavour compounds	These indicators and their objectives are from the DGVs of the water quality for primary industries (https://www.waterquality.gov.au/anz-guidelines/guideline-values/default/primary-industries/stock-water-guidance) section of the ANZG guidelines (ANZG, 2018h).	Exceedances of objectives for off-flavour compounds indicate a risk to the palatability of fish, crustaceans and molluscs due to the accumulation of these compounds in tissues.

Environmental value	Indicator type	Derivation	Interpretation
		The methodology for developing these DGVs is the same as for physical and chemical stressors.	
	Indicators for metal contaminants, non-metal contaminants, natural toxicants, and mercury in Schedule 19 (Maximum levels of contaminants and natural toxicants) (https://www.foodstandards.gov.au/code/Documents/Sched 19 Contaminant MLs v157.pdf) of the *Australia New Zealand Food Standards Code* for (FSANZ, n.d.).	These indicators and their objectives are from Schedule 19 (Maximum levels of contaminants and natural toxicants) (https://www.foodstandards.gov.au/code/Documents/Sched 19 Contaminant MLs v157.pdf) of the *Australia New Zealand Food Standards Code* (FSANZ, n.d.). The objectives represent maximum concentrations in the tissue of aquatic foods that are acceptable for human consumption As such, if the maximum levels are exceeded it may be that: • the condition of the environment does not support production of food for public consumption • action must be taken to address risks to human health and restore the utility of the environmental value.	Exceedances of the maximum levels of contaminants and natural toxicants indicate there is a potential risk to the consumption of aquaculture species due to elevated contaminants in their tissue. There may be other causes of contamination in aquatic foods that are unrelated to pollution, such as the condition of aquaculture facilities, handling of aquaculture species or exposure to natural toxicants from algae. Therefore, exceedances of these objects should trigger further investigation to assess other lines of evidence and determine whether elevated levels of contaminants in aquaculture species are due to pollution and waste or other sources.
Industrial and commercial use	Indicators specific to the particular industrial or commercial activity and their use of water.	Specific indicators for industrial and commercial use are not specified in the ERS. Instead, indicators can be adopted that have been identified as altering water quality to prevent or reduce the water's usability for industrial purposes. The narrative objective states that water quality must be suitable for industrial or commercial uses of water.	Water quality that does not meet the objective of being suitable for industrial or commercial use indicates a potential risk to those uses due to pollution and waste in water environments. For example, excessive nutrients may cause algal growth that can lead to the fouling and blockage of water intake pipes.
Water-based recreation	Microbial indicators	The objectives are developed from the risk-based approach recommended by the National Health and Medical	The ERS has two types of microbial objectives: long-term (both primary and secondary contact) and short-term (for primary contact only).

Environmental value	Indicator type	Derivation	Interpretation
	e.g., E. coli¸ enterococci (surface waters)	Research Council (NHMRC) *Guidelines for managing risks in recreational water* (NHMRC, 2008) and in the New Zealand *Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas* (MfE,MoH, 2003) Long-term water quality objectives are based on an assessment of microbial water quality (*E. coli* or enterococci) against microbial assessment categories and sanitary inspection categories. These grades determine how susceptible a site is to faecal pollution. Long-term objectives for secondary-contact recreation are not provided for in the NHMRC *Guidelines for managing risks in recreational water* (NHMRC, 2008). Rather, they are based on likely ingestion levels, with secondary contact users assumed to ingest 10 times less water than primary contact users. Therefore, these users can tolerate exposure to microbial levels up to 10-times higher than primary contact users.	Where possible, derive short-term and long-term site-specific microbial water quality objectives using a risk assessment approach that follows industry best practice and guidance published or approved by EPA. If there are no such site-specific microbial water quality objectives, then apply the microbial objectives in the ERS. Long-term objectives for primary contact require a site to be graded as either very good, good, fair, poor or very poor as set out in ERS Table 5.19. Water quality that exceeds a microbial assessment category from column D in ERS Table 5.19 is not suitable for long-term secondary or primary contact water-based recreation. Such exceedances indicate a risk of illness due to faecal contamination. Long-term environmental quality objectives are used for reporting on whether the water quality needed to support water-based recreation is being met. Reporting against these objectives also shows whether water quality is improving or declining in the long term. Exceedances of objectives for *E. coli* and/or enterococci (ERS Table 5.20) indicate there is a short-term risk to primary-contact water-based recreation from illness caused by faecal contamination. Short-term environmental quality objectives for primary contact are intended to be used to inform public warnings of potential health risks. They are also used to identify previously unidentified or new sources of faecal contamination. These include consecutive and single sample objectives, with values based on microbial assessment category values in the NHMRC *Guidelines for managing risks in recreational water* (NHMRC, 2008) and in the New Zealand *Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas* (MfE,MoH, 2003) Assessment of short-term objectives requires data from single samples to be regularly collected during periods of high recreational use. For freshwater, use either *E. coli* or enterococci. For marine and estuarine, use only enterococci. EPA is developing more detailed guidance on microbial risk assessment approaches.

Environmental value	Indicator type	Derivation	Interpretation
	Harmful algae, chemical hazards, aesthetic effects (surface waters)	These indicators and their objectives are from levels specified in the NHMRC *Guidelines for managing risks in recreational water* (NHMRC, 2008). Harmful algal objectives are based on scientific literature describing the concentrations of algae and corresponding probabilities of adverse health effects due to direct ingestion or exposure. Chemical hazard objectives are based on qualitative and quantitative risk assessment criteria. The risks due to ingestion are based on the ADWG (see chapter 9 of the NHMRC *Guidelines for managing risks in recreational water* (NHMRC, 2008)). Objectives for aesthetic effects are qualitive and describe undesirable or unpleasant conditions that can be found in waters as a result of pollution. See chapter 10 of the NHMRC *Guidelines for managing risks in recreational water* (NHMRC, 2008))	Exceedances of algal, chemical hazard or aesthetic effects objectives indicate there is a risk of adverse human health effects associated with water-based recreational activity because of the high levels of algae or chemicals in water, or, due to their unpleasant appearance as a result of pollution.
	E. coli (groundwater)	The objective for *E. coli* in groundwater is based on expert opinion and considers the removal of the *E. coli* due to filtration through the soil while pathogens such as viruses may persist.	Exceedances of the microbial objectives for groundwater indicate a potential risk to water-based recreation from illness caused by the presence of faecal contamination.
Traditional Owner cultural values	Indicators must be developed in consultation with Traditional Owners	No specific water quality indicators are provided for supporting and maintaining *Traditional Owner cultural values*. This acknowledges that Traditional Owner water dependent values, and any appropriate indicators and objectives are	Water quality that does not meet the relevant objectives indicates a potential risk to *Traditional Owner cultural values*.

Environmental value	Indicator type	Derivation	Interpretation
		geographically and culturally specific to individual Traditional Owner groups. In their section on cultural and spiritual values (https://www.waterquality.gov.au/anz-guidelines/guideline-values/derive/cultural-values) (ANZG, 2018j), the ANZG guidelines describe a process by which Traditional Owner cultural values can be determined and indicators and objectives identified, which can be used to support the development of specific Traditional Owner objectives.	
Navigation and shipping	Sediment	No quantitative objectives are provided for shipping and navigation. Sediment pollution can pose a risk to shipping where sedimentation can lead to changes in depth in shipping areas. Poor sediment quality also poses a threat to shipping and navigation if toxicant levels are high enough to affect or prevent dredging operations that are needed to maintain shipping channels. This occurs when contaminated dredging spoils cannot be disposed of appropriately.	Water quality that causes the rate of sedimentation to impact shipping, or the quality of sediment to reach levels that could impact or prevent dredging activities, indicates that there is a risk to navigation and shipping. This objective applies to surface water only, not groundwater.
Buildings and structures	Substances that may have a detrimental impact on buildings or other structures	Indicators for buildings and structures are those chemicals that can impact on the structure of buildings when they are in groundwater. No quantitative objectives are provided for these indicators because they are likely to vary between different types of buildings and structures or are poorly understood. Instead, the ERS has a narrative objective which describes the	If this objective is not met, there is a potential risk to structures or buildings from the corrosive or adverse effects of contaminants in groundwater.

Environmental value	Indicator type	Derivation	Interpretation
		undesirable state of groundwater which could impact on buildings and structure.	
Geothermal	Temperature	The indicators and objectives represent a temperature range that needs to be met in groundwater to maintain the geothermal properties of groundwater.	Exceedances of the temperature ranges indicate there is a risk to the geothermal properties of groundwater and that temperatures may not be sufficient to maintain uses of that groundwater.

Chapter 8. Example of application of the Environment Reference Standard

8.1 Scenario

A wastewater treatment plant (WWTP) in south-west Victoria requires an upgrade to accommodate future increases in sewage inflows from the nearby township. The WWTP treats domestic sewage from the medium-sized township and has minor trade waste inputs, including cattle saleyards. The duty holder, a regional water authority, is applying for a licence amendment to construct an additional treatment lagoon and extra capacity to its existing winter storage.

Due to population growth, there is a projected increase in the volume of treated wastewater discharged to the environment. About 40% of the treated wastewater is currently recycled and used for irrigation, with plans for future expansion. The existing operating licence allows the discharge of treated wastewater to an unnamed creek that is a tributary of the Hopkins River. Groundwater in the region is less than 5 metres below ground and is of good quality. The local aquifer also discharges into the Hopkins River.

When amending an operating licence EPA must consider several matters, including the measures taken or proposed by the WWTP to comply with the general environmental duty (GED). EPA gives regard to whether the impacts of pollution and waste have been minimised to the extent practicable and in a way proportionate to the risks posed to the environment, and the best available techniques and technologies that could be used. EPA must also consider any impacts of the WWTP on human health and the environment, including any environmental values in the Environment Reference Standard (ERS).

In this context, the ERS is a tool used to:

- identify the environmental values for surface waters, land, groundwater, ambient air and ambient sound that may be at risk from the proposed expansion to the WWTP and increase to the volume of wastewater discharged
- identify which indicators may be used to assess the potential risks
- establish the levels of those indicators (that is the objectives) that would minimise the risk to those environmental values.

Choosing indicators to manage emerging risks

Not all harm resulting from an activity will have a suitable indicator in the ERS. Emerging contaminants are an example of this. In this scenario, the study should consider the current knowledge available on the potential risk. For an emerging contaminant like pharmaceuticals, the study should consider potential harm from the discharge, environmental values at risk and choose indicators that best enable understanding and management of this risk.

8.2 Surface waters

As part of their licence amendment application, the water authority commissions a surface water study for EPA's consideration. The study considers the environmental values and their indicators and objectives as part of a broader risk assessment of receiving surface waters. To do this, the study uses Part 5 of the ERS to identify:

- the applicable segments for the unnamed creek and Hopkins River
- which of the environmental values described in the ERS are potentially impacted by the wastewater discharge
- indicators and objectives for the identified environmental values potentially affected by the wastewater discharge.

8.2.1 Identifying the segment

Clause 17 and Figure 1 of the ERS are used to identify the relevant surface water segment. A shapefile with the spatial boundaries of the water segments (EPA, 2020) was downloaded from the page 'Environment reference standard waters segments' (https://discover.data.vic.gov.au/dataset/environment-reference-standard-waters-segments) of the open data website of the State Government of Victoria (Data Vic, n.d.). The shape file was used with GIS software to make it easier to identify the segment. Because the receiving waters are an inland stream, the river basin where the unnamed creek is located is identified using the descriptions in clause 17(1)(a). A map of the Australian Drainage Divisions (http://www.bom.gov.au/water/about/riverBasinAuxNav.shtml) (BOM, n.d.) is also used to help identify the river basin. The study identifies that the unnamed creek and reach of the Hopkins River are located within the Murray and Western Plains Segment and the Hopkins River basin.

8.2.2 Identifying environmental values

Clause 13 of the ERS is used first to identify the overarching environmental values that apply to waters in this scenario. Clause 18 and Table 5.5. are then used to identify which of the environmental values described in clause 13 are relevant and should be considered in the Murray and Western Plains segment. A desktop study, a survey of the waters and catchment surrounding the WWTP, and consultation with local stakeholders identify that the environmental values supported by the unnamed creek and the receiving waters of the Hopkins River are:

- *water-dependent ecosystems and species*
- *agriculture and irrigation*
- *water-based recreation* (primary and secondary contact, aesthetic enjoyment)
- *human consumption of aquatic foods*
- *Traditional Owner cultural values.*

The creek and the downstream reaches of the Hopkins River are not a source of drinking water or used for aquaculture or industrial or commercial purposes. Therefore, these environmental values are not considered further in the assessment.

8.2.3 Identifying indicators and objectives

A conceptual modelling approach is used to identify the main sources of pollution and risks to the identified environmental values from the wastewater discharge. This approach is used to identify which of the indicators in the ERS are appropriate to adopt. While all indicators set out in the ERS should be considered in the initial indicator selection stage, the study only adopts indicators for pollutants that are present in the wastewater discharge. The conceptual modelling determines that the main sources of pollution and risks to environmental values from the discharge are:

- nutrient enrichment with the potential to cause nuisance plant growth
- ammonia and water with high pH capable of causing toxic and harmful effects to biota
- suspended solids capable of reducing the light environment and increasing sedimentation in the waterway
- pathogens that may pose a risk to human health
- organic matter with the potential to impact dissolved oxygen levels.

Based on this, the key indicators adopted from the ERS were:

- nutrients (total phosphorous)
- ammonia
- *E. coli*
- dissolved oxygen
- turbidity
- pH.

Objectives for the lowlands of the Hopkins basin in the Murray and Western Plains segment from Table 5.8 of the ERS are adopted as the appropriate objectives for nutrients, ammonia, dissolved oxygen, turbidity and pH. The objective for ammonia is adopted from the ANZG guidelines (ANZG, 2018) at the 95% level of protection, as specified in Table 5.8. *E. coli* objectives are adopted from Tables 5.7 and 5.20 after it is determined that a short-term assessment of the waste-water discharge is feasible for this study.

In addition, local Traditional Owner groups are engaged to identify any Traditional Owner values supported by the sections of the unnamed creek and Hopkins River receiving wastewater from the WWTP. A key aim of engagement with Traditional Owners is to determine whether the indicators identified above adequately identify risk to Traditional Owner cultural values and to determine if any further indicators needed to be developed.

8.2.4 Next steps/broader context

Once the relevant indicators and objectives are identified for environmental values, they are included in an environmental assessment program. The aim of this program is to understand the spatial and temporal extent of any potential impacts from the proposed discharge to the environmental values supported by the unnamed creek and Hopkins River. This program comprises of water quality monitoring that is designed consistently with guidance provided in Appendix D of this guide. The purpose of water quality monitoring is to establish baseline water quality and understand the potential area over which objectives may be exceeded by the proposed discharge. The results of monitoring are used in combination with the groundwater study to inform modelling of the mixing zone under a variety of flow conditions, to better identify the area affected by the proposed discharge.

The environmental assessment identifies a potential risk to environmental values, with the discharge causing indicator levels in receiving waters to exceed the ERS objectives. Exceedances of objectives also trigger further consideration of whether more detailed monitoring, modelling and risk assessment are needed to better understand risk to environmental values. EPA considers the potential impacts of the discharge on environmental values in this scenario when making its decision on whether to approve the licence amendment.

8.3 Land and groundwater

As part of their licence amendment application, the water authority commissions an environmental assessment of the current soil and groundwater conditions at the site. As the WWTP has an existing groundwater monitoring program, the assessment considers groundwater quality information from the past five years. The assessment considers the environmental values and their indicators and objectives as part of a broader risk assessment of the irrigation activities and potential impacts of the irrigation and WWTP on the underlying groundwater. To do this, the assessment uses Part 4 - Land of the ERS to:

- identify the current land uses and land use zoning
- identify which of the environmental values described in the ERS are potentially impacted by the irrigation, wastewater discharge and other potentially contaminating activities that are associated with the WWTP
- identify the indicators and objectives for those environmental values identified above that are relevant to the potentially contaminating activities at the site (irrigation, wastewater discharge and operation of the WWTP).

The assessment also uses Part 5 (Groundwater) of the ERS to:

- identify the segment of groundwater at the site
- identify which of the environmental values described in the ERS are potentially impacted by the irrigation and wastewater discharge
- identify the indicators and objectives for those environmental values identified above and that are also informative about the potentially contaminating activities at the site (irrigation, wastewater discharge and operation of the WWTP).

8.3.1 Identifying the land use

The land use categories are defined in clause 11 of the ERS. It is preferrable to first consider the current use and land use zoning of the assessment area, followed by the land uses that apply (as per the ERS). In some settings there can be multiple uses. In this case, the current use of the land is a WWTP and the land use zoning is mixed use. So, the assessment needs to consider the current uses onsite and what is allowable under this zoning. The assessment considers that parks and reserves, agricultural, recreation/open space, commercial and industrial land uses are possible at the site.

8.3.2 Identifying the segment

The segment definitions (clause 14) of the ERS are used to identify the segment of groundwater at the site. As there are both regional information about the groundwater (indicating Segment B) and onsite groundwater monitoring (indicating Segment A2 and Segment B), the groundwater is conservatively classified as Segment A2. The existing information about groundwater depth indicates that it is likely to be relatively shallow and interacting with surface water. In considering the regional groundwater conditions, via a search on the website of the 'Visualising Victoria's Groundwater' (https://www.vvg.org.au/) project (VVG, n.d.), it is identified that there are surrounding users of groundwater within 1 km of the site.

8.3.3 Identifying environmental values

In the assessment, clause 10 of the ERS is used to confirm the environmental values for land at the site. Due to the land use zoning, the environmental values supported by the land use are:

- *land dependent ecosystems and species*
- *human health*
- *buildings and structures*
- *aesthetics*
- *production of food, flora and fibre.*

Clause 15 of the ERS is used to identify the environmental values for groundwater based on the segment classification. To determine the groundwater environmental values for the site and proposed activity, both regional groundwater conditions and current use onsite are considered. Another consideration is how groundwater is currently being used offsite and whether this use could change in the future. The relevant environmental values for groundwater are:

- *water dependent ecosystems and species*
- *potable water supply (acceptable)*
- *agriculture and irrigation* (irrigation and stock-watering)
- *industrial and commercial use*
- *water-based recreation (primary contact)*
- *Traditional Owner cultural values*
- *buildings and structures.*

Potable mineral water supply and geothermal properties are not considered to be environmental values at the site as the WWTP is not within or near a mineral springs area and the aquifer does not have geothermal properties.

The only information on the offsite use of groundwater is that it is registered as a stock and domestic bore, so in the assessment potable water supply is considered an environmental value at the site.

8.3.4 Identifying indicators and objectives

The assessment uses a conceptual modelling approach to identify the main sources of pollution and risks to the identified environmental values (for land and groundwater) from the irrigation and wastewater discharge. This is then used to identify which of the indicators in the ERS are appropriate indicators. The assessment only considers indicators for pollutants that are present in the wastewater discharge and associated with the WWTP activities. The conceptual modelling considers what sources of pollution could be in the feed water to the WWTP and the quality of the discharge water used for irrigation. The risks to environmental values from the WWTP are summarised as:

- pollutants in the wastewater that are not treated and able to cause harm to human health and the land and groundwater environment
- nutrient enrichment with the potential to affect plant growth
- ammonia and water with high pH capable of causing toxic and harmful effects to land, groundwater and subsequently surface water biota
- pathogens that may pose a risk to human health.

Based on this, the relevant indicators and objectives (referring to the relevant incorporated documents such as the NEPM (ASC) and ANZG) are:

- heavy metals
- emerging contaminants (such as PFAS, pharmaceuticals)
- nutrients (nitrogen species, total phosphorous)
- ammonia
- *E. coli*
- dissolved oxygen and TDS (for groundwater)
- pH.

8.3.5 Next steps/broader context

Based on the assessment, it is identified that an additional assessment of soil conditions is needed to confirm the potential changes over time due to irrigation practices. This may include modelling, for example, to ascertain soil contaminant loading or inform crop choices to ensure nutrient loadings can be managed.

It is also identified that the existing groundwater monitoring program at the site needed to include the full range of potential pollutants and include the installation of additional bores to better represent up- and down- hydraulic gradient conditions.

Groundwater fate and transport modelling is also identified to be required to ensure that risks posed to land, groundwater and surface water environmental values were not unacceptable.

8.4 Ambient air and odour

As part of their licence amendment application, the water authority commissions an ambient air and odour study for EPA's consideration. The study considers the environmental values and their indicators and objectives as part of a broader risk-assessment of the surrounding ambient air environment. To do this, the study uses the ERS to identify:

- nearby receptors (for example residential dwellings)
- which of the environmental values described in Part 2 - Ambient air of the ERS are potentially impacted by the operation of an expanded WWTP
- indicators and objectives for the identified environmental values that are relevant to the emissions from the WWTP in this scenario.

8.4.1 Identifying nearby receptors

Planning maps and aerial photomaps can be used to identify potential residential dwellings near the WWTP, as this is an existing plant and there should be a buffer already in place. However, it is important to identify changes that may have taken place since the original plant was established. These may include changes to planning which have allowed additional residential dwellings to be built closer to the plant than intended. The planned increase in plant capacity may also mean that existing buffers may not be sufficient.

8.4.2 Identifying environmental values

Clause 5 of the ERS is used first to identify the environmental values for ambient air which are relevant to this scenario. In this case, the following environmental values are likely to be the most relevant:

- *local amenity and aesthetic enjoyment*
- *climate systems that are consistent with human development, the life, health and well-being of humans, and the protection of ecosystems and biodiversity.*

Local amenity and aesthetic enjoyment may be impacted by odorous substances generated by the operation of the WWTP. Climate systems may also be impacted in the long term by the generation of methane as a result of the operation of the WWTP.

8.4.3 Identifying indicators and objectives

The study uses a desktop approach to identify the potential sources of emissions. In this case, the WWTP inlet is open to air so the lagoon systems are a potential source of odorous emissions. Table 2.2 of the ERS refers to the odour indicator as having the objective "an air environment that is free from offensive odours from commercial, industrial, trade and domestic activities". An estimate of the existing emissions of odour along with projected changes as a result of increased capacity are modelled using the regulatory model. Odour surveys are also included to assess the existing odour impact of the WWTP.

For climate systems, there is no specific indicator or objective defined in Table 2.2 of the ERS. However, as methane is a known greenhouse gas which can impact on climate systems, the study includes it as part of the assessment.

8.4.4 Next steps/broader context

Once the relevant indicators and objectives are identified for the environmental values, they are included in an environmental assessment program. The aim of this program is to understand the spatial and temporal extent of any potential impacts from the existing WWTP and any proposed changes as a result of the increased capacity.

Where odour surveillance or modelling indicates there is potential for amenity impacts, more detailed monitoring, modelling and risk-assessment may be needed to better understand risk to environmental values. The potential impacts of the discharge on environmental values are considered by EPA when assessing the proposal and making a decision on whether to approve the licence amendment.

For climate systems, application of the GED and best practice identify that where possible, methane emissions should be captured and treated. If this process involves energy recovery and combustion in a turbine, then additional consideration of Table 2.2 of the ERS is required to ensure that the indicators and objectives of the combustion products are properly assessed.

8.5 Ambient sound

Operational noise from the WWTP is regulated under the Environment Protection Regulations 2021 (the Regulations) as it is a commercial, industrial and trade premises. Therefore, impacts on *noise sensitive areas* as defined in the Regulations are not assessed using the ERS, since direct regulation takes precedence over the ERS (see section 3.1 of this guide).

Nevertheless, in this scenario, the objectives in Part 3 - Ambient sound of the ERS are relevant to the protection of the environmental value of *human tranquillity and enjoyment outdoors in natural areas.* This is because natural areas as defined in the ERS are not noise sensitive areas (except for tourist establishments, campgrounds and caravan park).

As part of their licence amendment application, the water authority commissions an acoustic study for EPA's consideration regarding the impact of the proposal on *human tranquillity and enjoyment outdoors in natural areas* for Category V land impacted by the proposal. This study is conducted following the methodology discussed in section 5.4.2 of this guide.

Moreover, ambient sound part of the ERS is relevant to construction noise, as it is not assessed under the Regulations. The environmental management plans for construction works considers the impacts to all relevant environmental values for ambient sound (ERS table 3.1) in land uses that may be impacted by construction activities. While the ERS objectives are not compliance criteria, they can be used to assess the residual construction noise once all opportunities to minimise noise and its impacts as far as reasonably practicable have been taken. Chapter 4 of the *Civil construction, building and demolition guide* (publication 1834) provides guidance on managing construction noise. Assessing the residual noise can inform whether the impacts on the environmental values need to be further considered.

References

All links provided in this section were accessed in April 2021.

Environment Protection Act 2017 and subordinate legislation

Environment Protection Act 2017
https://www.legislation.vic.gov.au/in-force/acts/environment-protection-act-2017

Environment Protection Regulations 2021
https://www.legislation.vic.gov.au/as-made/statutory-rules/environment-protection-regulations-2021

Victoria Government (2021). *Environment Reference Standard*. Victoria Government Gazette No. S245, 26 May 2021. Melbourne. Victoria. Australia
http://www.gazette.vic.gov.au/gazette/Gazettes2021/GG2021S245.pdf

Other Victorian Acts

Acts of Parliament are available on the Victorian legislation website https://www.legislation.vic.gov.au/

Catchment and Land Protection Act 1994

Environment Effects Act 1978

Environment Protection Act 1970

Flora and Fauna Guarantee Act 1988

Major Transport Projects Facilitation Act 2009

Marine and Coastal Act 2018

Mineral Resources (Sustainable Development) Act 1990

Planning and Environment Act 1987

Safe Drinking Water Act 2003

Subdivision Act 1988

Water Act 1989

National Environment Protection Measures (NEPM)

NEPM (AAQ) National Environment Protection (Ambient Air Quality) Measure (as amended). Compilation prepared on 25 February 2016. Federal Register of Legislation. Canberra, Australian Capital Territory, Australia.
https://www.legislation.gov.au/Details/F2016C00215

NEPM (ASC) National Environment Protection (Assessment of Site Contamination) Measure 1999 (as amended). Compilation start date:16 May 2013. Federal Register of Legislation. Canberra, Australian Capital Territory, Australia.
https://www.legislation.gov.au/Details/F2013C00288

Australian & New Zealand guidelines for fresh & marine water quality (ANZG)

ANZG (2018) Australian & New Zealand guidelines for fresh & marine water quality, Australian and New Zealand Governments and Australian State and Territory Governments, 2018. Canberra, Australian Capital Territory, Australia.
https://www.waterquality.gov.au/anz-guidelines

Specific sections of the ANZG guidelines referred to in this guide include:

a. Water Quality Management Framework (https://www.waterquality.gov.au/anz-guidelines/framework)

b. Default Guideline Values (https://www.waterquality.gov.au/anz-guidelines/guideline-values/default)

c. Revised method for deriving Australian and New Zealand water quality guideline values for toxicants (https://www.waterquality.gov.au/anz-guidelines/guideline-values/derive/warne-method-derive)

d. Toxicant default guideline values for sediment quality (https://www.waterquality.gov.au/anz-guidelines/guideline-values/default/sediment-quality-toxicants)

e. Guideline values for other water types (https://www.waterquality.gov.au/anz-guidelines/guideline-values/default/water-quality-toxicants#guideline-values-for-other-water-types)

f. Search for toxicant default guideline values (https://www.waterquality.gov.au/anz-guidelines/guideline-values/default/water-quality-toxicants/search)

g. Weight of evidence (https://www.waterquality.gov.au/anz-guidelines/resources/key-concepts/weight-of-evidence#applying-the-process-to-watersediment-quality-assessments)

h. Water quality for primary industries (https://www.waterquality.gov.au/anz-guidelines/guideline-values/default/primary-industries)

i. Primary industries – livestock drinking water (https://www.waterquality.gov.au/anz-guidelines/guideline-values/default/primary-industries/stock-water-guidance)

j. Cultural and spiritual values (https://www.waterquality.gov.au/anz-guidelines/guideline-values/derive/cultural-values)

k. Conceptual models (https://www.waterquality.gov.au/anz-guidelines/resources/key-concepts/conceptual-models)

l. Monitoring (https://www.waterquality.gov.au/anz-guidelines/monitoring)

EPA publications

EPA publications are available on the EPA website, via https://www.epa.vic.gov.au/about-epa/publications/

EPA publication 440.1, *A guide to the sampling and analysis of air emissions and air quality*. Environment Protection Authority Victoria, 5 December 2002, Melbourne Victoria. Australia

EPA publication 604.1, *Rapid bioassessment methodology for rivers and streams*. Environment Protection Victoria, 22 October 2003, Melbourne, Victoria, Australia

EPA publication 668, *Hydrogeological assessment (groundwater quality) guideline*. Environment Protection Victoria, 8 April 2006, Melbourne, Victoria, Australia

EPA publication 669, *Groundwater sampling guidelines*. Environment Protection Victoria, 17 April 2000, Melbourne, Victoria, Australia

EPA publication 1287, *Guidelines for risk assessment of wastewater discharges to waterways*. Environment Protection Victoria, 2 July 2009, Melbourne, Victoria, Australia

EPA publication 1302, *Environmental quality guidelines for Victorian lakes*. Environment Protection Victoria, 25 February 2010, Melbourne, Victoria, Australia

EPA publication 1518, *Recommended Separation Distances for Industrial Residual Air Emissions – Guideline*. Environment Protection Authority Victoria, 7 March 2013, Melbourne, Victoria, Australia

EPA publication 1551, *Guidance notes for using the regulatory air model AERMOD in Victoria*. Environment Protection Authority Victoria, October 2013, Melbourne, Victoria, Australia

EPA publication 1666.1, *Determination of odour concentration by dynamic olfactometry*. Environment Protection Authority Victoria, 17 October 2018, Melbourne, Victoria, Australia

EPA publication 1733, *Development of indicators and objectives for SEPP (Waters).* Environment Protection Victoria, 1 May 2019, Melbourne, Victoria, Australia

EPA publication 1826.3, *Noise limit and assessment protocol for the control of noise from commercial, industrial and trade premises and entertainment venues*. Environment Protection Victoria, 17 March 2021, Melbourne, Victoria, Australia

EPA publication 1834, *Civil construction, building and demolition guide*. Environment Protection Victoria, 17 March 2021, November 2020, Melbourne, Victoria, Australia

EPA publication 1856, *Reasonably practicable*. Environment Protection Victoria, 22 September 2020, Melbourne, Victoria, Australia

EPA publication IWRG701, *Sampling and analysis of waters, wastewaters, soils and wastes*. Environment Protection Victoria, 30 June 2009, Melbourne, Victoria, Australia

Australian Standards (AS) and International Standards (IEC, ISO)

AS 1055:2018, Acoustics – Description and Measurement of Environmental Noise - General Procedures. Standards Australia, 2018, New South Wales, Australia

AS/NZS 2107:2016, Acoustics — Recommended design sound levels and reverberation times for building interiors. Standards Australia, 2016, Sydney, New South Wales, Australia

AS 2159-2009, Piling-Design and Installation. Standards Australia, 2016, Sydney, New South Wales, Australia

AS 4482.1-2005, Guide to the investigation and sampling of sites with potentially contaminated soil Non-volatile and semi-volatile compounds. Standards Australia, 2005, Sydney, New South Wales, Australia

AS 4482.2, Guide to the sampling and investigation of potentially contaminated soil Volatile substances. Standards Australia, 2016, Sydney, New South Wales, Australia

AS IEC 60942-2004 Electroacoustics – Sound calibrators. Standards Australia, 2004, New South Wales, Australia

AS IEC 61260.1:2019, Electroacoustics—Octave band and fractional octave-band filters, Specifications. Standards Australia, New South Wales, Australia

AS/NZS IEC 61672.1:2019, Electroacoustics—Sound level meters, Part 1, Specifications. Standards Australia, New South Wales, Australia

IEC 60942:2017 Electroacoustics – Sound calibrators, International Electrotechnical Commission, 2017, Geneva, Switzerland

ISO 1996-2:2017 Acoustics —Description, measurement and assessment of environmental noise – Part 2: Determination of sound pressure levels. International Standard Organization, 2017, Geneva, Switzerland

ISO 12913-1:2014 Acoustics — Soundscape — Part 1: Definition and conceptual framework. International Standard Organization, 2014, Geneva, Switzerland

ISO 12913-2:2018 Acoustics — Soundscape — Part 2: Data collection and reporting requirements. International Standard Organization, 2018, Geneva, Switzerland

ISO/TS 12913-3:2019, Acoustics — Soundscape — Part 2: Data analysis, International Standard Organization, Geneva, 2019, Switzerland

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Appendices

Appendix A
Monitoring and assessing the indicators for ambient air

The ERS provides a reference for the assessment of the environment based on environmental values, indicators and objectives. As the environmental values are generally broad in definition, the monitoring of the indicators is used to assess the state of the environment and determine whether the environmental value has been adversely impacted. The objective may include the number of times that the indicator can be exceeded before the environmental value is at risk.

Depending on the indicator, there may be a range of tools and ways to assess performance against the ambient air objectives in the ERS. This includes the measurement of air pollutant concentrations and air quality forecasting. Any assessment against the ERS objectives should consider variables such as meteorology, climatology, topography and anthropogenic activities.

Guidance on the monitoring of the air environment has previously been provided by *A guide to the sampling and analysis of air emissions and air quality* (publication 440). This publication provided guidance for sampling and analysing environmental samples. It was designed to assist licence holders, consultants and industry with background information and guidance on performance monitoring for environmental purposes.

A.1 Ambient air monitoring methods

High quality monitoring methods (commonly referred to as reference or equivalent instruments) should be used to measure and assess pollutant concentrations against ambient air objectives. It is important that the measurements are scientifically valid, representative and consistent. To manage these complexities, monitoring should be undertaken only by a laboratory accredited by the National Association of Testing Authorities (NATA) to perform testing in accordance with relevant Australian Standards or internationally recognised methods.

In addition to monitoring for ERS indicators, high-quality ambient air monitoring is also used for compliance or regulatory purposes. High-quality ambient air monitoring may also be used for site management objectives, risk assessments, research or short-term data gathering (for example, screening surveys). High quality ambient air monitoring is generally not used for air pollution source monitoring or for community-based or citizen science activities. Ambient monitoring generally occurs at the point of potential impact, rather than at the source of the pollutant that may be affecting the environmental value.

In some situations, it may not be possible to use high-quality monitoring methods. This may occur when high-quality monitoring is cost prohibitive or when suitable infrastructure, such as power or telemetry, is unavailable, or where greater spatial coverage with high uncertainty is more informative than a single, high-quality monitoring location. In these circumstances, indicative measurements have a place in assessing against the objectives. Indicative measurements may be an appropriate useful in by filling in the gaps in understanding or highlighting areas that may need further investigation.

Indicative monitoring should only be used after consultation with EPA, to ensure this is acceptable.

Predictive tools (prognostic models) can be used to assess against ERS objectives when there is no monitoring data available. They can be used to estimate current or predict future exposure levels.

Tools such as prognostic models may be used to estimate ambient concentrations. This may be useful when particularly localised high-quality or indicative air quality monitoring is not available.

A.2 Source monitoring

Monitoring at a source is generally not used for ERS indicators. However, it is sometimes used for collection of samples to characterise a pollution source or indicator. The emission rate of the indicator may be used in conjunction with a dispersion model to estimate potential ambient concentrations. This is typically done prior to the development of a project to assess the potential risk of the indicator to the environmental value, when it is not possible to directly monitor the ambient environment.

A.3 Assessment of ambient odour

Determination of odour concentration by dynamic olfactometry (publication 1666) can assist licence holders and consultants to obtain and report reproducible odour measurements. This methodology is also suitable for the assessment of the ERS indicator for odour.

Appendix B
Monitoring and assessing the indicators for ambient sound

B.1 Purpose of monitoring for the environmental values of ambient sound

Monitoring the ambient sound environment is undertaken to assess and report on the condition of the environment using the indicators and objectives in Part 3- Ambient sound of the ERS.

To do this, the levels of indicators in the ambient sound environment need to be measured at appropriate scales and time frames for comparison with the relevant ERS objectives. Where measured levels exceed the objectives, there can be an increased risk to environmental values.

Monitoring of indicators and objectives in the ERS can be undertaken for a range of purposes including:

- broadscale assessments of environmental quality to understand the general condition of the ambient sound environment and identify areas where environmental values may be at risk from noise pollution
- assessment of the impacts (actual or potential) of developments and activities.

B.2 Developing effective ERS monitoring programs for ambient sound

Ambient sound monitoring programs typically include one or more of the following goals, which are broadly consistent with the application of the ERS:

- characterise the state of the acoustic environment
- assess population exposure
- evaluate the effectiveness of interventions
- provide information to government and the community
- inform science-based policy and planning.

A rigorous monitoring design is needed to effectively assess environmental quality and determine whether environmental values are at risk from noise pollution. This appendix outlines key considerations and provides guidance for developing monitoring programs that will be effective for assessing indicators and objectives for ambient sound in Part 3 of the ERS. These considerations are linked decisions that will shape an effective monitoring program (see Figure B.1).

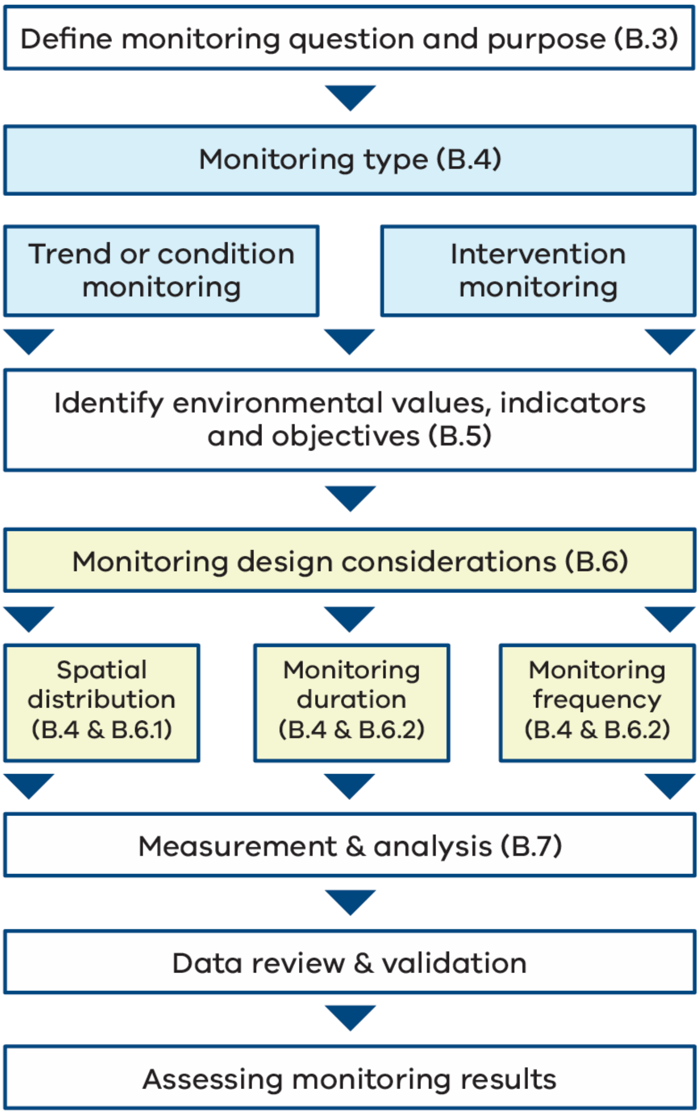

Figure B.1. Design considerations for ambient sound monitoring, with relevant section references

B.3 Define specific monitoring question and purpose

Defining a specific monitoring question helps focus and define the purpose of monitoring, which will influence the choice of monitoring type, indicator selection, scale, duration and frequency. Further questions will need to be considered when refining the purpose of monitoring. These include (where relevant):

- What are the threats or risks to the environment?
- What are the environmental values of interest?
- What are the appropriate indicators to be monitored?
- What will be a sufficient monitoring scale, duration and frequency to capture data that represents environmental quality and impacts of pollution? This can include changes due to meteorological conditions, seasonality and operating conditions of noise sources.
- What decision or management actions will this data inform?

Answering these questions early will help in the design of the measuring or monitoring campaign, as described in the subsequent sections B.4 to B.6.

B.4 Determine appropriate monitoring type

There are two broad types of monitoring that will commonly use indicators and objectives for ambient sound in the ERS:

- **Trend or condition monitoring** involves ongoing measurement of the trends in the ambient sound environment across a broad spatial scale to identify variations in sound levels within and between years. Where trend monitoring is more localised, it should be of sufficient duration or be repeated at appropriate intervals to identify how the sound levels vary across time, or in relation to other parameters that can also be measured, such as traffic volume.
- **Intervention monitoring** focuses on assessing environmental quality to inform, or in response to, particular management and regulatory interventions or to understand the risk or impact of an activity or development (potential or actual).

A key for developing effective monitoring programs is to ensure they can attribute changes to environmental quality to specific management actions or activities of interest. This will commonly require interlinked monitoring of the status of environmental quality and activities of interest that may be impacting environmental quality. Management intervention monitoring should be used within an adaptive management framework to learn about the effectiveness of management actions and to improve them over time.

B.5 Identify ERS environmental values, indicators and objectives

To ensure that indicators are being compared with the correct objective, it is important to determine the environmental values of interest, where the monitoring is occurring, and based on this, which is the relevant ERS objective for comparison with monitoring data.

Firstly, choose the **monitoring locations to represent the relevant environmental values**, such as schools, homes or other residences, or natural areas. In developed areas, measurement positions that represent the sound level at these locations may be used as proxies.

Secondly, identify the **land use category** using the general description in column 2 of ERS Table 3.2 and the corresponding planning zones.

Thirdly, choose the indicator for the time of day relevant to the environmental value being considered. For example, for the environmental value of *sleep during the night*, measure and report on the indicator outdoor $L_{Aeq,8h}$ from 10 pm to 6 am.

Finally, compare the monitoring results with the corresponding objective for the land use category and time of day using ERS Table 3.3.

The environmental value of *human tranquillity and enjoyment outdoors* applies to land use category V, described as *natural areas* in section 5.3.2 of this guide. The corresponding objective is a quality of the ambient sound environment that is conducive to human tranquillity and enjoyment of the natural soundscape. The environmental quality should be assessed on a case-by-case basis using the methods described in section 5.4.2 of this guide.

B.6 Monitoring design considerations

B.6.1 Spatial distribution

The spatial distribution of monitoring locations should be driven by the purpose of monitoring. This should consider:

- for general condition and trend monitoring, the spatial distribution of monitoring locations will represent a balance to identify changes in the ambient sound environment over distance and across land use categories. It should have sufficient coverage to describe a widespread area or region. Monitoring can be supported by sound level modelling, land use regression techniques, and sensor technologies, which can be more cost effective.
- the spread of proposed sound sources and potential threat to environmental values, such as how far from a proposed source is the sound likely to impact. For the ERS, the risk to environmental values can vary over the area potentially affected. Therefore, the monitoring needs to be sufficiently broad to represent all relevant areas – not just the closest receptors or most at risk of impact. Modelling of sound propagation can be used to inform monitoring locations.

B.6.2 Monitoring duration and frequency

Monitoring duration should be informed by the purpose of the monitoring and an understanding of how the ambient sound environment varies with time. Typical conditions that represent the ambient sound environment at the locations considered will help inform monitoring timing, its duration, and the repeat frequency. The monitoring frequency and duration should account for changes due to atmospheric conditions and seasonal variation in the sound sources.

B.7 Measurement, analysis and reporting of environmental quality indicators and objectives

Monitoring indicators for ambient sound in the ERS requires effective measurement and analysis to determine whether objectives have been attained or are at risk. This section sets out the measurement, analysis and reporting for the ambient sound indicators in land use categories I to IV that apply to all environmental values other than *musical entertainment and human tranquillity* and *enjoyment outdoors in natural areas*.

B.7.1 Measurement descriptor

The indicators are measured outdoors, in free field conditions as an L_{Aeq} over a given time interval using the F(fast) time-weighting.

L_{Aeq} means ***equivalent continuous A-weighted sound pressure level*** and is defined in the ERS. It represents the average acoustic energy of the sound over the same measurement time.

The time intervals used for ambient sound in the ERS are:

- 16 hours from 6 am to 10 pm
- 8 hours from 10 pm to 6 am.

A-weighted sound pressure level means sound pressure level measured using the A-frequency weighting. It is devised to attempt to represent the human response to sound and its variation with frequency, in the typical range of magnitude for environmental noise levels, as specified in Australian Standard AS/NZS IEC 61672.1:2019.

Shorter reference time intervals of duration τ of 15 minutes to 1 hour can be measured to provide information on the time-varying nature of the sound environment. In this case, the average of the time interval for daytime (T = 16 hours) and night time (T = 8 hours) must be obtained by using equation (B.1), consistent with AS 1055:2018 clause 3.10.

$$L_{Aeq,T} = 10\log_{10}\left[\frac{1}{n}\sum_{k=1}^{T/\tau} 10^{0.1L_{Aeq,\tau_k}}\right] \qquad \text{(B.1)}$$

Where the purpose of the monitoring supports the use of a long-term average, such as a long-term annual average for trend or condition monitoring, the long-term average ($L_{Aeq,\,LT}$) is represented by the log-average across each day ($L_{Aeq,16hr}$) or night ($L_{Aeq,8hr}$) measurement, consistent with clause 6.8 of AS 1055:2018.

$$L_{Aeq,LT} = 10\log_{10}\left[\frac{1}{N}\sum_{i=1}^{N} 10^{0.1L_{Aeq,T_i}}\right] \qquad \text{(B.2)}$$

As specified in a note to this clause: *'all data should be reported and the reason(s) for discarding atypical results should be stated. Atypical results may occur as a result of infrequent use of nearby machinery, such as lawnmowers, unusually dominant natural or human-made sounds or other factors affecting measurements*.'

B.7.2 What to monitor

For the indicators with numerical objectives, consistent with AS 1055:2018, the ambient sound to be monitored includes the overall sound. This includes all contributions from any ambient sound or noise source typically occurring in the environment.

Where short-term measurements are used to represent a long-term average, exclude or discard atypical measurement results affected by short-term events that are not representative of the ambient sound environment over the long-term, such as noise from nearby construction activities that last only a few weeks.

B.7.3 Where to measure

The indicator is an outdoor L_{Aeq}, measured outdoors at a point that is not affected by the reflection of sound from any surface other than the ground (free field measurement).

Consistent with AS 1055:2018 clause 6.2.2, the microphone should be positioned at least 3.5 metres from any reflecting structure other than the ground and at a height of 1.2 to 1.5 metres above the ground.

Where a free-field measurement cannot be obtained, such as an outdoor measurement near a building, an adjustment is to be made to account for reflected sound to approximate the free field incident level as described in AS 1055:2018 clause 6.2.3 and its notes.

B.7.4 Meteorological conditions

AS 1055:2018 clause 6.3.1 describes meteorological conditions suitable for the measurements of the ambient sound environment so that meteorological conditions including wind and rain do not affect the sound levels being measured.

Consistent with clause 6.3.2 of AS 1055:2018, long-term measurements of the ambient sound environment, such as for condition or trend monitoring, should be calculated from the individual measurement results, representing all relevant weather conditions. Measurements made during high wind and rain should be discarded.

Depending on the purpose of the monitoring, such as intervention or targeted assessments, the measurements may be conducted under specific meteorological conditions for which the sound pressure levels at the receiver position are the highest as described in clause 6.3.3 of AS 1055:2018.

B.7.5 Equipment

Primary measurements are to be conducted using class 1 or class 2 sound level meters as specified in AS/NZS IEC 61672.1, or equivalent performance data loggers. Use an integrating-averaging sound level meter or data analyser for measuring L_{Aeq} in accordance with clause 5.2 of AS 1055:2018.

Class 1 sound level meters are preferred because of their higher accuracy, an important factor especially when seeking to inform variations in noise levels and trends. If class 2 sound level meters are used, the additional uncertainty is to be factored into any analysis of the result.

B.7.6 Calibration

The complete measuring system for primary measurements must be calibrated at least every two years in accordance with AS/NZS IEC 61672.1 consistently with clause 5.5 of AS 1055:2018.

Field checks of calibration must be undertaken in accordance with clause 5.6 of AS 1055:2018, using a reference sound source designed and calibrated to the requirements of IEC 60942:2017.

B.7.7 Optional additional measurements

The following measurements may be considered as additions to the measurement of L_{Aeq} using class 1 or class 2 sound level meters.

- **Frequency spectrum, statistical levels and audio recording**

Measuring the frequency spectrum (octave or one-third octave band) may provide useful information about the components of the ambient sound environment. It may also help identifying anomalous noises that are atypical for the environment considered. The spectral filters used to measure the frequency spectrum should be designed and calibrated according to the requirements of AS IEC 61260.1:2019.

Similarly, measurement of statistical levels (for example, L_{A90}, L_{A10} or L_{A50}, referred to as *percent exceedance A-weighted sound pressure levels* in AS 1055:2018) can provide relevant information on the variations in noise levels across the measurement intervals.

- **Alternative sensors**

Alternative low-cost sensors in conjunction with class 1 or class 2 sound level meters can provide extended spatial coverage. However, they must allow checking using a calibrated reference sound source (refer clause 5.6 of AS 1055:2018) and their performance must have been assessed prior to the measurement campaign. This is necessary to ensure they are suitable for use and stable in an outdoor environment and that their limitations (for example, frequency range, noise floor and dynamic range) have been identified. This verification also ensures the accuracy of the measurement conducted using these sensors can be reported and factored in the assessment. It must be documented in an appendix to the measurement report.

With all sound measuring equipment, the choice of technology must be consistent with the objectives of the monitoring and measurement. Therefore, using sensor alternatives to class 1 and class 2 sound level meters would only produce indicative data.

B.7.8 Records and reporting

As a minimum, the monitoring report must include:

- purpose of the monitoring
- relevant environmental values, indicators and objectives
- monitoring positions and corresponding land use zone and ERS land use category
- results of the monitoring
- interpretation of risk to the environmental values
- measurement technique
- description of equipment used and its calibration
- conditions during the measurements, such as atmospheric conditions, ground conditions and the variability of any relevant sound sources.

Include relevant qualitative data describing the ambient sound environment that may be significant for the interpretation of the results. Clause 7 of AS 1055:2018 can be used as a guide to monitoring records.

The uncertainty of the measurement should be evaluated and reported. Annex F of AS 1055:2018, Annex F and Annex G of international standard ISO 1996-2:2017 and the good practice guide published by the University of Salford (Craven & Kerry, 2007) provide guidance on uncertainty regarding environment noise measurements.

Appendix C
Monitoring and assessing the indicators for land

C.1 Purpose of monitoring for the environmental values of land

Monitoring of environmental values for land by assessing the indicators and objectives in the ERS can be undertaken for a range of purposes including:

- broadscale assessments of environmental quality to understand the general condition of land and identify areas where environmental values may be at risk from pollution or waste
- assessment of the impacts (actual or potential) of licensed and development activities
- individual assessment of land as part of an environmental assessment or environmental audit.

C.2 Developing effective ERS monitoring programs for land

Land environments are complex and variable. A scientifically rigorous monitoring design is needed to effectively assess environmental quality and determine whether environmental values are at risk from pollution and waste. The following sections outline key considerations and provide guidance for developing effective monitoring programs for assessing the indicators and objectives for land in the ERS. These considerations are interlinked decisions that will shape an effective monitoring program (see Figure C.1).

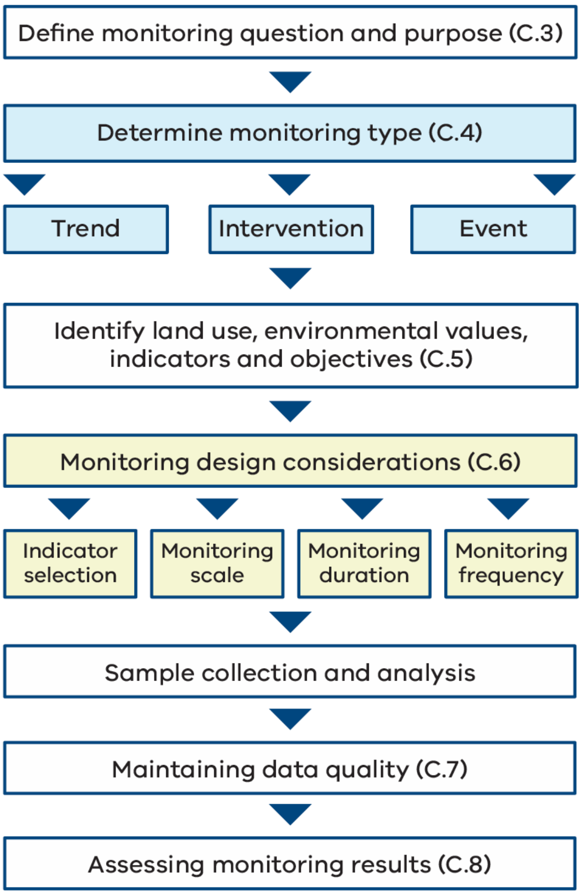

Figure C.1. Design considerations for land environment monitoring, with relevant section references

C.3 Define specific monitoring question and purpose

Creating a specific monitoring question helps focus and define the purpose of monitoring. This will influence the choice of monitoring type, indicator selection, scale, duration and frequency. When designing effective monitoring, further questions will need to be considered when refining the purpose of monitoring. These include (where relevant):

- What are the environmental values of focus?
- What are the threats or risks to the environmental values under consideration?
- What is the problem that the monitoring is trying to understand and address?
- What is the management or regulatory intervention or focus?
- What are the appropriate indicators to be assessed?
- How long are expected impacts likely to occur for?
- What monitoring scale, duration and frequency will be sufficient to capture data that represents environmental quality?

C.4 Determine appropriate monitoring type

There are three broad types of monitoring that commonly apply to land:

- **Condition monitoring** is systematic monitoring that involves identifying the general condition (status), trends and changes in environmental quality. Condition monitoring has an important role for developing baselines and characterising environmental quality. It is also used to identify and trigger further action on land where environmental values are at risk due to the impacts of pollution and waste. Condition monitoring often involves broader scale monitoring to provide a representative picture of the conditions and trends in areas of interest. It should span spatial and temporal scales that are sufficient to capture the condition or trend of interest. However, in some cases, it may involve smaller scale or shorter-term monitoring aimed at understanding the condition of smaller discrete areas. This may also include assessment of background levels in soils.
- **Investigative monitoring** involves assessing environmental quality pertaining to a regulatory response or intervention or management response to understand the risk of or impact from pollution and waste. This may include monitoring of ERS indicators in specific areas and may require elements of condition monitoring to establish a comparable benchmark using a reference site to distinguish from naturally occurring contaminants of concern and those that can be attributed to pollution and waste.
- **Management intervention monitoring** involves assessing environmental quality to inform management, regulatory interventions and environmental best practice. It can also be used to determine the best available technology when monitoring the efficacy of engineering controls for an activity that may pose a risk to human health or the environment.

A key for developing effective monitoring programs for management intervention and investigative monitoring is to ensure they can attribute changes to environmental quality to specific management actions or activities of interest. This will commonly require linked monitoring of the status of environmental quality and activities of interest that may be impacting environmental quality. Management intervention monitoring should be used within an adaptive management framework to learn about and improve the effectiveness of management actions.

The three major types of monitoring have distinct scale and duration requirements and indicators adopted, described below.

C.5 Identify ERS environmental values, land use, indicators and objectives

To ensure that indicators are being compared with the correct objective, it is important to determine which environmental values are of interest, which ERS category of land use the monitoring is occurring in, and based on this, the relevant objective for comparison with monitoring data. Chapter 6 provides an overview of how to do this.

C.6 Monitoring design considerations

C.6.1 Indicator selection

Table 4.3 of the ERS sets out indicators (and associated objectives). Indicators should match the purpose of monitoring and be based on:

- relevance – indicators being monitored should directly reflect the issue of concern. For land, this includes current and historical potentially contaminating activities and the associated contaminants
- validity – indicators should respond to changes in the environment and be able to distinguish differences. For example, be able to distinguish natural variation from impacts that are due to pollution and waste
- diagnostic value – indicators must be able to demonstrate changes or trends in conditions for the specified period or event
- responsiveness – indicators should demonstrate changes over a sufficient time to enable management action
- reliability – indicators should change and respond in a reproducible and predictable way
- appropriateness – indicators should be appropriate for the temporal and spatial scales of monitoring.

Condition monitoring typically measures a broad suite of the most common indicators of soil health. These may include physical and chemical parameters that reflect the potential complex composition of the soil. The chosen parameters may be direct indicators of environmental condition and/or descriptive parameters for predicting contaminant behaviour (for example, organic carbon content). In cases where more integrative measures of impacts and recovery from multiple pollutants are needed, biological and weight of evidence indicators can be adopted. For example, some of the ecological investigation levels in the NEPM (ASC) require the collection of soil data such as pH, cation exchange capacity, and the percent of organic carbon, and clay.

The types of indicators monitored for management intervention/investigative monitoring should only be those that are informative and responsive to management actions or activities of interest. The choice of indicators must be informed by the purpose of monitoring, past land uses, future land use and an understanding of the anticipated background condition. For example, assessing the effectiveness of a soil remediation project would include monitoring for the original contaminant, degradation or transformation products, and potential incidental changes to soil physio-chemistry. Monitoring to understand the effects of management on the impacts of multiple pollutants and the response of environmental quality to impacts over time should focus on an appropriate combination of physio-chemical and biological indicators.

Once indicators have been selected, their levels in the environment can be monitored and assessed against ERS objectives taking into account the considerations in section C.8 below.

- **Control/reference counterfactual sites**

Control and/or reference sites may need to be included in monitoring programs. The purpose of a control site can be either to collect data prior to an activity commencing, or when a reference site is required, to make inferences on impacts from pollution and waste. Both types of monitoring are to distinguish changes in background levels. Such monitoring will help distinguish between naturally occurring changes and those related to management interventions (engineering controls) or pollution impacts. Careful consideration is required to ensure control sites are closely matched to sites that are assessing status, impacts or the outcomes of management interventions. This principle applies to each of the major monitoring types described above.

- **Monitoring scale and duration**

The appropriate scale and frequency of monitoring are directly linked to the purpose of the monitoring and dependent on the circumstances of the land environment being assessed (such as geology, past uses and surrounding activities). These characteristics vary across sites and need to be considered on a case- by- case basis. Where feasible, knowledge and observations (for example, research and existing monitoring) should be incorporated.

Condition monitoring typically requires broader scale and longer-term monitoring to provide a representative picture of the conditions and trends for a site of interest. However, smaller scale and shorter-term monitoring may be suitable when the condition of a smaller discrete area is of interest. Effective condition monitoring commonly consists of fixed sites or transects that are periodically to continuously monitored to enable comparison over time.

Management intervention/investigative monitoring requires monitoring programs to be at the appropriate scale, locations and resolution to detect changes in environmental quality due to interventions or an activity. Local to large scale monitoring may be required, depending on the activity being examined.

Management intervention/investigative monitoring needs to occur for long enough to identify changes due to management actions or impacts and capture the legacy of any changes.

Monitoring frequency refers to the frequency and number of indicator measurements. The frequency needs to be sufficiently robust to determine whether objectives have been attained and detect any trends of interest. The consequence of any pollution/waste also needs to be considered. For example, pollution/waste which can cause greater harm to human health or the environment may therefore require a greater monitoring frequency. The three major considerations for effectively determining appropriate monitoring frequencies are:

- requirements set out in the ERS and supporting guidelines (see the Sampling and analysis section below and Table C.1)
- the variability or rate of change of the environment
- the consequence of the change.

The most obvious consideration for determining appropriate monitoring frequencies is the extent and rate of indicator variation. Natural land environments typically change slowly but activities undertaken on land may lead to rapid changes. The frequency of monitoring should be governed by the extent and rate of changes that may occur.

Closely linked to this is the consequence of the change. For example, a slow change that poses a significant risk to environmental values or requires a rapid response to manage or mitigate that risk, may require more frequent monitoring than a change that poses a low risk or can be managed or mitigated over a longer period.

Pilot studies and past information about sites can provide information about seasonal and local variation of indicators being measured, where current and recent data are unreliable or in the absence of such data. Monitoring programs may need to adopt a high frequency until a sufficient dataset can be obtained to assess variability, at which point a more suitable frequency can be determined. Statistical methods should be employed to demonstrate that the frequency of data collection and number of samples collected are sufficient for the situation being monitored.

C.7 Maintaining data quality

Effective data collection, management and quality assurance are essential for supporting analysis and the assessment of the land environment against ERS objectives. This requires the development of guidance and standard operating procedures on the collection, handling and usage of data. It also means ensuring systems are available to store and manage data. Assessing data quality also requires a program of assurance to ensure that the results obtained are precise and accurate. NEPM (ASC) and the Australian Standard 4482.1 provide data quality methodology that is acceptable to EPA.

C.8 Assessing monitoring results against environmental quality indicators and objectives

Monitoring indicators for land requires effective sampling and analysis to determine whether objectives have been achieved or are being maintained. The three main stages in assessing indicators against ERS objectives are: sampling, laboratory analysis and statistical analysis.

Sampling design is a crucial step to ensuring the data collected during monitoring is sufficient to draw conclusions necessary to meet monitoring objectives. Broadly, a sampling design sets out the number of samples to be collected, together with the geographic location of samples. Importantly, choices made about sampling numbers and locations should be explained and justified. Types of sampling designs, including probability-based sampling and judgmental sampling, and the choice of sampling design, should be based on meeting monitoring objectives. Guidance on considerations during sampling design is presented in Section 6 in Schedule B2 of the NEPM (ASC).

A suitable number of samples must be taken to ensure that they are representative of conditions in the environment of interest and allow for statistically robust comparisons to be made.

When collecting samples for laboratory analysis, appropriate sampling equipment, containers, preservation methods, quality assurance/quality control measures and holding time limits must be adopted to maintain integrity and representativeness of samples prior to laboratory analysis. Where possible, laboratory analysis must be undertaken under NATA accreditation. Where NATA accreditation does not exist for a certain analyte or method, EPA should be consulted on the proposed method of analysis. The *Industrial waste resource guidelines: Sampling and analysis of waters, wastewaters, soils and wastes* (publication IWRG701), the NEPM (ASC) Schedule B3 and AS 4482 provide more detailed guidance on appropriate sampling and laboratory analysis of soils and sediments. These should also be adhered to for monitoring programs using the ERS.

For assessments that require evaluation of trends in the attainment of environmental quality objectives, a range of statistical methods of varying levels of sophistication can be used. For example, statistical analysis of the data using 95% upper confidence limits can be useful for soil characterisation. Control charts or time series plots are useful for graphing data values in comparison to objective values over time. Control charts require minimal processing of data, making it easy to see trends and allowing for early identification of the need for remedial action. Other more sophisticated statistical analysis and modelling techniques, such as regression analysis, time series analysis, generalised linear mixed models, generalised additive models and others can be used to understand and predict the response of environmental quality to factors, such as climate, changes in management practices or land use, and interventions. Trend analysis requires the calculation of the relevant metric to compare with objectives at each time step, followed by analysis of the trends in these metrics over time, space or in response to a predictor, such as a management intervention.

Table C.1. Analysis of ERS indicators for land

Environmental value	Indicator type	Specific indicators	Guidelines for monitoring design and standard analysis methods
Land dependent ecosystems and species	Physical chemical stressors (Background or NEPM (ASC) EILs or ESLs)	All indicators presented in the NEPM (ASC) for terrestrial ecosystems (EILs or ESLs). Indicators may be specific to the particular land use being applied.	For general advice on the design of monitoring programs: NEPM (ASC) Schedule B2 AS 4882.1-2005 AS 4882.2-1999 For standard sampling and laboratory analysis methods: Standard Methods for the Examination of Water and Wastewater (APHA, AWA, WEF, 2018) *Industrial waste resource guidelines: Sampling and analysis of waters, wastewaters, soils and wastes* (publication IWRG701) NEPM (ASC) Schedule B3:
Human health	Indicators specified in the NEPM (ASC)	All indicators presented in the NEPM (ASC) HILs or HSLs. Indicators may be specific to the particular land use being applied	For human health criteria, refer to NEPM (ASC) Schedule B1. The NEPM (ASC) Schedule B4 provides a framework for deriving site-specific criteria/indicators where there is no indicator in the NEPM (ASC)
Production of food and fibre	Physical chemical stressors (NEPM (ASC) EILs or ESLs)	All indicators presented in the NEPM (ASC) for terrestrial ecosystems in NEPM (ASC) (EILs or ESLs)	For general advice on the design of monitoring programs, refer to NEPM (ASC) Schedule B2.
	Indicators specified for metal contaminants, non-metal contaminants, natural toxicants, and mercury in Schedule 19 (Maximum levels of contaminants and natural toxicants) of the Food Standards Code (FSANZ, n.d.)	All indicators specified in Sched 19 of the FSANZ	

Environmental value	Indicator type	Specific indicators	Guidelines for monitoring design and standard analysis methods
Buildings and structures	Soil quality that is not corrosive to buildings, structures, property and materials	pH, sulfate, chloride, redox potential, salinity or any chemical substance or waste that may have a detrimental impact on the structural integrity of buildings or other structures.	For indications of potentially corrosive conditions (not 'limits'), refer to Australian Standard AS 2159-1995.
Aesthetics	Visual and olfactory indicators	Any chemical substance or waste that may be offensive to the senses.	For discussion of aesthetic considerations, refer to section 3.6 of NEPM (ASC) Schedule B1.

Appendix D
Monitoring and assessing the indicators for water

D.1 Purpose of monitoring for the environmental values of water

Monitoring of indicators and objectives for water in the ERS can be undertaken for a range of purposes including:

- assessment of pollution impacts (actual or potential) from licensed and development activities
- determining whether a specific event, such as a chemical spill or industrial fire, has resulted in the pollution of a waterbody
- understanding the general condition of waters and identifying areas where environmental values may be at risk from pollution. This can range from site-specific assessments of sections (or parts of waterbodies) to state-wide assessments of many waterbodies.

D.2 Guidance for developing effective ERS monitoring programs for water

Water environments are dynamic, complex and variable. A scientifically rigorous monitoring design is needed to effectively assess environmental quality and determine whether environmental values are at risk from pollution and waste. The following sections outline key considerations and provide guidance for developing monitoring programs that will be effective for assessing indicators and objectives for water in the ERS. These considerations are interlinked decisions that will shape an effective monitoring program (see Figure D.1).

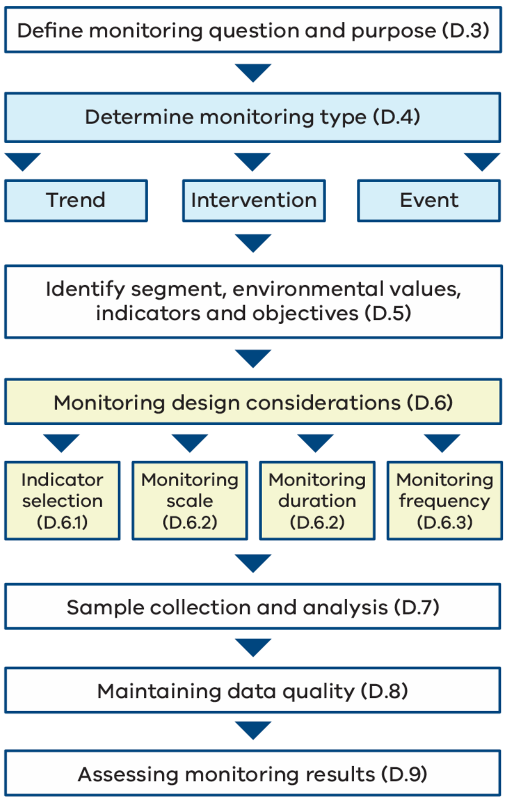

Figure D.1. Design considerations for water environment monitoring, with relevant section references

D.3 Define specific monitoring question and purpose

Defining a specific monitoring question helps focus and define the purpose of monitoring, which will influence the choice of monitoring type, indicator selection, scale, duration and frequency. When designing effective monitoring, further questions will need to be considered when refining the purpose of monitoring. These include (where relevant):

- What are the threats to the environment?
- What are the environmental values of interest?
- What are the appropriate indicators to be monitored?
- What will be sufficient monitoring scale, duration and frequency to capture data that represents environmental quality and impacts of pollution?
- What decision or management actions will this data inform?

D.4 Determine appropriate monitoring type

There are three broad types of monitoring that will commonly apply to water:

- **Trend monitoring** is systematic and focuses on identifying the general condition (status), trends and changes in environmental quality and threatening processes. Trend monitoring has an important role for developing baselines and characterising environmental quality. It is used to identify and trigger further action in waters where environmental values are at risk due to poor and/or declining environmental quality. It often involves broader scale monitoring to provide a representative picture of the conditions, and trends, of large areas of interest (for example, a catchment or bay). It should span time periods that are sufficient to capture the condition or trend of interest. However, in some cases, it may involve smaller scale or shorter-term site-specific monitoring aimed at understanding the condition of smaller discrete areas, such as sections of waterbodies.
- **Intervention monitoring** focuses on assessing environmental quality to inform, or in response to, particular management and regulatory interventions or to understand the risk or impact of an activity (potential or actual). Effective monitoring programs of this type should be capable of attributing changes to environmental quality to specific management actions or activities of interest. This will commonly require interlinked monitoring of the status of environmental quality and activities of interest that may be impacting environmental quality. Management intervention monitoring should be used within an adaptive management framework to learn about the effectiveness of management actions and improve them over time. It can be used to evaluate whether actions taken to meet the general environmental duty (GED) are sufficiently preventative of harm to water bodies.
- **Event monitoring** is undertaken in response to sudden and unexpected events, such as a significant pollution spill. Event monitoring typically requires rapid deployment in situations where they may be limited background information about the cause or type of pollution involved. It is typically aimed at providing timely and reliable information that will help in decision making to address an emergency event.

The three major types of monitoring have distinct requirements in terms of their scale and duration and indicators adopted and are described below.

D.5 Identify ERS environmental value, segment and objectives

To ensure that indicators are being compared with the correct objective, it is important to determine which environmental value is of interest and in which ERS segment monitoring is occurring. Then, based on this, determine the relevant objective for comparison with monitoring data. Chapter 7 provides an overview of how to do this.

D.6 Monitoring design considerations

D.6.1 Indicator selection

The ERS describes a broad range of indicators and objectives. The indicators have been selected because they are reliable, reproducible and cost effective. They also have explanatory power about pollution in the environment. When designing a monitoring program, it is not always necessary to use all the indicators provided in the ERS. Indicators should be selected that are informative about the threat or issue of concern, informative about the risks to the environmental value of concern, capable of detecting changes that will permit management action (where appropriate) and appropriate for the time and spatial scale of monitoring. A simple, effective way to determine if an indicator fulfills these conditions is to develop conceptual models that link the major threats and issues of concern to environmental values and indicators. Select indicators that suit the type of monitoring being undertaken. Further guidance can be found in the ‘conceptual models’ (https://www.waterquality.gov.au/anz-guidelines/resources/key-concepts/conceptual-models) section (ANZG, 2018k) of the in the ANZG guidelines. For groundwater monitoring design, further guidance is provided in *Hydrogeological assessment (groundwater quality)* (publication 668) and *Groundwater sampling guidelines* (publication 669), as well as Schedules B1 and B2 of the NEPM (ASC).

Trend monitoring typically adopts a broad range of the most common indicators of health for particular water types. For example, in surface waters, common condition indicators are nutrients (nitrogen and phosphorous), turbidity (or total suspended solids), salinity, dissolved oxygen and, in lakes, estuaries and marine waters, chlorophyll-a. Where more integrative measures of impacts and recovery from multiple pollutants are needed, biological and weight of evidence indicators can be adopted. This approach is common for trend monitoring that is not focused on a specific threat but seeks to track the overall condition of water environments. In some cases, where a particular pollution threat is of interest, trend monitoring may involve one or just a few indicators. For groundwater, monitored natural attenuation is a common form of trend monitoring which occurs to track ongoing degradation of pollution following cleanup activities.

Intervention monitoring should involve only indicators that are informative and responsive to management actions or activities of interest. For example, monitoring the effectiveness of actions to reduce nutrient inputs into surface waters will focus on nutrient indicators and objectives. Monitoring the impacts of actions to reduce faecal contamination will focus on microbiological indicators. Monitoring to understand the effects of management on the impacts of multiple pollutants and the response of environmental quality to impacts over time should focus on an appropriate combination of physical, chemical and biological indicators.

Event monitoring indicators will depend on how well the causes of the event are understood. If an event involves a readily identified source of pollution, such as a petroleum spill, then only indicators that are informative about that type of pollution need to be adopted. Where an event involves complex mixtures, or the precise nature of pollution has not been identified (such as water run-off from an industrial fire), a broad suite of indicators should be adopted to capture the widest possible range of potential impacts.

The ERS describes two broad categories of indicators: physical/chemical parameters and biological indicators.

Physical/chemical parameters include the physical and chemical stressors and toxicants described in Table 7.1 of this guide. Physical and chemical indicators identify the presence of pollution or indirect changes in water quality attributable to pollution. These indicators are usually simple and cost-effective to measure. Levels of these indicators can be compared with ERS objectives, which represent levels considered to pose a low risk to environmental values. However, physical/chemical indicators do not provide a direct measure of impacts to environmental values. Impacts from pollution can remain long after physical/chemical indicator levels return to acceptable levels. For example, the impacts of a large spill of toxicants on aquatic biota can persist well after the toxicant has passed through the system. Hence, physical/chemical indicators are effective for determining whether there is likely to be a risk to environmental values but are less effective for quantifying the actual impacts of pollution on environmental values. They are appropriate for most monitoring programs seeking to assess the risk to water bodies from pollution.

Biological indicators in the ERS include chlorophyll-a, microbial indicators, phytoplankton, freshwater macro-invertebrates and seagrasses. Weight of evidence indicators also commonly incorporate biological indicators. Biological indicators provide integrative measures that respond to the effects of multiple physical and chemical pollutants acting together and provide measures of longer-term impacts and responses of environmental condition. They are often more expensive and resource intensive to monitor but provide much more direct and comprehensive information on the actual impacts and response of environmental values to pollution. Adopting biological indicators is appropriate for situations where longer term impacts and responses to pollution are of interest and where the cost of monitoring is proportionate to the risks an activity poses to the environment.

D.6.2 Monitoring scale and duration

Monitoring programs need to be deployed at an appropriate scale and duration. Scale refers to where, and over how large an area, monitoring occurs. It includes the number and spatial arrangement of monitoring locations. The scale of monitoring should represent the area affected by any pollution or issue of interest and will often need to include reference areas outside affected areas. Duration refers to the length of time of the monitoring program. The duration of monitoring should be sufficiently long to capture enough information to characterise risks or determine whether an impact, or recovery from an impact, has occurred. The time required to capture this information is often difficult to determine in advance and is likely to be strongly governed by monitoring that determines whether an impact is ongoing or has ceased.

Selecting the appropriate scale and duration of monitoring requires a strong consideration of the dynamics of the water environment, including patterns of flow, circulation, mixing and connectivity. These characteristics are unique among water bodies and need to be considered on a case-by-case basis and incorporate knowledge and observations. Knowledge and observations can include modelling, such as of the predicted spatial footprint or likely dilution of pollution, relevant research findings, guideline recommendations (see below), previous or existing monitoring, and use of preliminary sampling and pilot studies.

For groundwater it is important to understand that the assessment and monitoring of an aquifer needs to consider both vertical and horizontal scales. Groundwater within a single aquifer may have both vertical and horizontal flow components or there may be multiple aquifers present through the geological profile. Groundwater bores screen discrete parts of the aquifer, so it is important to confirm that they are monitoring the area, or 'thing', of interest for the study. The extent and duration of the monitoring will also need to consider the spatial and temporal changes in groundwater over time, and the monitoring locations or duration may need to be adjusted to suit. Detailed guidance on the assessment, monitoring and sampling of groundwater is provided in *Hydrogeological assessment (groundwater quality)* (publication 668) and *Groundwater sampling guidelines* (publication 669),.

Trend monitoring commonly requires larger scale and longer-term monitoring to provide a representative picture of the conditions, and trends in the conditions, of a waterbody over time. However, there may be occasions where smaller scale and shorter-term site-specific trend monitoring is suitable when determining the condition of a small discrete area, such as a reach of a waterway. Effective trend monitoring commonly consists of fixed sites or transects that are periodically to continuously monitored and enable comparison over time.

Intervention and event monitoring requires monitoring programs to be at the appropriate scale, locations and resolution to detect changes in environmental quality due to interventions or an event. Small to large scale monitoring may be needed, depending on the activity being examined. For example, the (intervention) monitoring of the achievement of load targets for marine bays is likely to require broad scale monitoring across rivers, streams and bays. The (intervention) monitoring of the environmental impacts of a wastewater discharge will typically require monitoring only of reaches of a single waterbody.

Intervention and event monitoring needs to occur over a sufficiently long time to identify changes due to management actions or impacts, and to capture the legacy of any changes. The time expected for environmental quality objectives to respond to an intervention or impact will dictate the monitoring period. For example, the reduction of sediment and nutrient loads entering marine bays from waterways may take tens of years to achieve and will require long-term monitoring over many years. Event monitoring to understand the impacts of emergency incidents may take only weeks to months during the incident and subsequent recovery. Appropriate durations (and scales) will need to be determined case by case to account for both the characteristics of the water environment, and the expected outcomes of management interventions or the duration of potential impacts.

- **Control/reference sites**

In many cases, control or reference sites should be included in the design of monitoring programs. These are important for determining whether changes in ambient environmental quality are due to a management intervention or pollution impact and not to other factors such as natural processes. Control or reference sites may also be used to determine the background levels of an indicator in areas largely outside the influence of pollution and waste (see section 7.2.3). Control sites need to be well matched with sites where there are impacts of pollution or management interventions. This principle applies to each of the major monitoring types described above.

D.6.3 Monitoring frequency

Monitoring frequency refers to how often and the number of indicator measurements that are taken. Monitoring should be frequent enough to determine whether objectives have been attained and detect any trends of interest. The two major considerations to determine appropriate monitoring frequencies are:

- requirements set out in the ERS and supporting guidelines (see section D.10 below)
- the variability of the environment.

A major consideration for determining appropriate monitoring frequencies is the extent that the levels of indicators vary over time, which can differ significantly between water environments, time of day, seasons and climate. For example, water quality varies substantially in estuaries due to changing influences such as tides, rainfall and estuary opening, but water quality is relatively stable in large coastal waters. Estuaries typically require higher frequency monitoring to characterise water quality than coastal waters. In general, water environments that have highly variable water quality will require higher monitoring frequencies than those that are relatively stable.

Where there is no data that shows variability in environmental quality for sites, pilot studies and past information can provide insights into seasonal and local variation in indicators being measured. If there's data that captures patterns of variability in environmental quality, there are analyses that can be used to determine the appropriate number of samples needed to effectively resolve trends (such as power analysis). A statistician should be consulted when conducting these sorts of analyses.

Adopting higher frequency monitoring can better resolve extreme events that typically pose the greatest risk to environmental quality and environmental value. This should be prioritised, particularly in areas where extreme but rare events such as high rainfall pose serious risks to environmental values.

D.7 Sampling collection preservation and analysis

When collecting samples for laboratory analysis, appropriate sampling equipment, containers, preservation methods and holding time limits must be adopted to prevent the degradation of samples prior to lab analysis. Only NATA accredited laboratories should perform analyses of tests unless EPA gives permission to use a non-accredited laboratory. *Sampling and analysis of waters, wastewaters, soils and wastes* (publication IWRG701) provides more detailed guidance on appropriate sampling and laboratory analysis from waters and sediments. *Groundwater sampling guidelines* (publication 669) provides additional sampling guidance for groundwater. These guidelines should be adhered to by monitoring programs using the ERS in assessments.

D.8 Maintaining data quality

Effective data collection, management and quality assurance are essential for supporting analysis and the assessment of water environments against ERS objectives. This requires the development of guidance and standard operating procedures on the collection, handling and usage of data, as well as ensuring systems are available to store and manage data.

D.9 Assessing monitoring results against environmental quality indicators and objectives

Monitoring indicators for water requires effective analysis to determine whether objectives have been attained. The three main stages to assessing indicators against ERS objectives are: sampling, laboratory analysis and statistical analysis.

A suitable number of samples must be taken to ensure that they are representative of conditions in the environment and that statistically robust comparisons can be made. For example, most default physical and chemical objectives described in Tables 5.8 to 5.17 of the ERS are set at a 75th (or 25th) percentile value, calculated from long-term monitoring data sets spanning years to decades. A simple assessment of whether indicator levels meet these objectives requires a 75th percentile to be calculated from samples in the field. A minimum of 11 samples collected over one year is needed to compare with ERS physical and chemical 75th percentile objectives with 95% confidence. Microbial indicators are set at 95th percentiles and require 60 samples to compare with objectives with 95% confidence.

The period over which samples are collected is an important consideration. For example, samples collected during one month will provide data that is representative only of the condition during that time. Samples collected over many seasons and years will provide a better representation of conditions over many seasons and years.

Other indicators and objectives provided in the ERS require specific sampling, laboratory and statistical analysis methods, such as freshwater and marine biological indicators, weight of evidence toxicant objectives and water-based recreation. Standard and accepted methods for analysing these indicators are described in detail in Section D.10 below.

For assessments that require evaluation of trends in the attainment of environmental quality objectives, a range of statistical methods of varying levels of sophistication can be used. Control charts or time series plots are useful for graphing data values against objectives values. Control charts require minimal processing of data, clearly show trends, and the need for remedial action can be identified early. Other more sophisticated statistical analysis and modelling techniques, such as regression analysis, time series analysis, generalised linear mixed models and generalised additive models, can be used to understand and predict the response of environmental quality to factors such as climate, changes in management practices or land use, and interventions. Trend analysis of ERS objectives requires the calculation of the relevant metric to compare against objectives (for example, a 75th percentile for physical and chemical indicators, 95th percentile for microbial indicators, or the SIGNAL, AUSRIVAS or Band score for stream macro-invertebrates) at each time step. This is then followed by the analysis of the trends in these metrics over time, space or in response to a predictor, such as a management intervention. In general, an expert in statistics should be consulted for more sophisticated analysis of trends in indicators and objectives.

D.10 Standard methods for the monitoring, sampling and analysis of ERS indicators

This section provides reference to more detailed guidance on the design of monitoring programs as well as the standard methods for sampling and analysing indicators. EPA recommends using only the analytical methods recommended in this document or those in the guidelines referred to below. Alternatively, methods which have been validated, shown to be proficiently equivalent and have been approved by the EPA may also be used.

For general guidance on the design of monitoring programs, including sampling and analysis, refer to:

- the framework (https://www.waterquality.gov.au/anz-guidelines/framework) of the ANZG guidelines (ANZG, 2018a)
- the monitoring guidelines (https://www.waterquality.gov.au/anz-guidelines/monitoring) in the ANZG guidelines (ANZG, 2018l).

For standard sampling and laboratory analysis methods, refer to:

- Standard Methods for the Examination of Water and Wastewater (APHA, AWA, WEF, 2018).
- *Industrial waste resource guidelines sampling and analysis of waters, wastewaters, soils and wastes* (publication IWRG701) and reference therein.
- *Hydrogeological Assessment* (publication 668).
- *Groundwater sampling guidelines* (publication 669), for relevant groundwater environmental values and indicators.

The information in the guidelines listed above is appropriate for the following environmental values (and indicators):

- water dependent ecosystems and species (Physical chemical stressors and toxicants in water and sediments in Tables 5.8 to 5.17 and load objectives in Table 5.21)
- agriculture and irrigation (irrigation and stock watering)
- human consumption of aquatic foods (all)
- aquaculture (all)
- navigation and shipping (sediment and sedimentation indicators)
- geothermal (temperature).

The biological indicators for **water dependent ecosystems** in rivers and lakes set out in ERS Tables 5.9 and 5.11 can be assessed according to the methods described in *Rapid bioassessment methodology for rivers and streams* (publication 604) for rivers and streams and *Environmental quality guidelines for Victorian lakes* (publication 1302) for wetlands.

Sediment quality indicators for **water dependent ecosystems** in rivers and streams, wetlands, estuaries and marine waters set out in Table 5.18 must be assessed according to Weight of Evidence methods. Detailed guidance is provided in the ANZG guidelines (in their 'Weight of evidence' section (https://www.waterquality.gov.au/anz-guidelines/resources/key-concepts/weight-of-evidence#applying-the-process-to-watersediment-quality-assessments) (ANZG, 2018g)) and in publications by Simpson, Batley and Chariton (2013) and Simpson and Batley (2016).

Standard monitoring, sampling and analysis approaches are not readily available for Victorian seagrass and harmful algal bloom indicators for **water dependent ecosystems** set out in Table 5.7 of the ERS. Well-developed approaches from other jurisdictions, or in the published scientific literature, can be used to help inform monitoring programs using the ERS. Differences between the environmental conditions and ecology of indicators in other jurisdiction may mean that some approaches are not appropriate for Victoria. Only methods that are appropriate to Victorian indicators, or can be modified to be so, should be followed.

Indicators for **human consumption after appropriate treatment**, **potable water supply** and **potable mineral water supply** should be monitored, sampled and analysed according to Chapters 9 and 10 of the *Australian drinking water quality guidelines* (NHMRC, NRMMC, 2011) and to the *Groundwater sampling guidelines* (publication 669).

No specific indicators are defined for **industrial and commercial** uses. However, where indicators are adopted that are also used for different environmental values, then the standard methods for those indicators/environmental values can be used.

Indicators for **water based recreation** should be monitored, sampled and analysed according to the Guidelines for Managing Risks in Recreational Water (NHMRC, 2008).

Indicators for **Traditional Owner cultural values** must be developed in consultation with Traditional Owners. The ANZG guidelines describe a process by which Traditional Owner cultural values can be determined and indicators and objectives identified (refer 'Cultural and spiritual values' (https://www.waterquality.gov.au/anz-guidelines/guideline-values/derive/cultural-values) in the ANZG guidelines (ANZG, 2018j)). Other approaches developed in consultation with Traditional Owners can be adopted.

No specific indicators are provided for **buildings and structures.** Any indicators of corrosion of buildings, structures property or material should follow standard methods to the extent available.