Recycled Water Regulation Review

Key Issues for Aotearoa New Zealand

Prepared for Taumata Arowai
Prepared by Beca Limited

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Contents

Appendices

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Executive Summary

In New Zealand, a key driver for irrigation of municipal wastewater to land (which could be considered recycling of water) has been the cultural view of tangata whenua, who generally consider discharging human sewage directly to water bodies unacceptable. However, other drivers for wastewater reuse are emerging for water resilience, or as part of the circular economy journey and water sustainability. There is no framework in New Zealand for encouraging and/or regulating this recycled water use, and there is an opportunity to set nationally consistent standards for recycled water before its use becomes more widespread, and before higher risk uses for recycled water (i.e. for potable use) are seriously considered.

Taumata Arowai has engaged Beca to review approaches to recycled water use overseas with the purpose of identifying key issues for the development of recycled water policies and regulation for Aotearoa New Zealand. The scope of this review is high-level and broad, covering all uses of recycled water. This report summarises the regulations and standards that exist elsewhere, discusses how recycled water is viewed within New Zealand, and identifies the opportunities and challenges that may arise as recycled water regulations are developed. This report draws on the experiences of Beca staff in Australia, some of whom were involved in the development of the New South Wales Standards, and also in the application of Federal and State recycled water regulations. The report also includes perspectives from Watercare and other contacts within the Australian and USA water industry.

The key messages from this review for Taumata Arowai are:

- Current municipal recycled water use in New Zealand is centred around the issue of disposing of wastewater. Changing the framing for recycled water to a water source, rather than a waste product, will help to change perceptions and mindsets about it. Development of any communications materials, policies and regulations should carefully consider the terminology used to avoid reinforcing the associated with waste products and instead promote recycled water as beneficial.
- Recycled water can come from many different sources and be used for many different purposes, with different risk profiles. There is considerable complexity in regulating such a product, and trying to simplify it to a single profile or standard has the potential for inadequate management of risks, or a system that tries to manage every risk resulting in a very high level of treatment at a high cost.
- Tangata whenua views on the disposal of human wastewater are relatively widely understood, but the same level of discussion around recycled water, and under what circumstances it would be acceptable or not acceptable, has yet to take place. Engaging with iwi and hapū to fill this gap in knowledge, would fulfill the Crown's obligations under Te Tiriti o Waitangi to include Māori upfront in decision making, and also may place constraints and boundaries around the source and use of recycled water that usefully guide the shape of the regulations.
- Just as recycled water use in New Zealand will depend on the support of tangata whenua, social licence from the wider community is also an important factor in the success of recycled water schemes. The level of understanding about recycled water (and water literacy in general) is average in New Zealand so education will be a key step in establishment of a recycled water regulatory regime.
- Design of a regulatory regime needs to take into account the scope and regulatory framework. Staged implementation of recycled water regulations may address the immediate need around disposal of wastewater in the New Zealand context, but at the same time create a manageable pathway for a wider regulatory system and other uses of recycled water in the future. There are several options for creating a recycled water regulatory framework in New Zealand, and further consideration needs to be given as to whether the simpler and more straightforward mechanisms (such as creating recycled water standards similar to the under-development Wastewater Performance Standards) will provide a sufficiently robust mechanism for managing human health risks.

1 Introduction and Background

1.1 Purpose

In New Zealand, a key driver for irrigation of municipal wastewater to land (which could be considered recycling of water) has been the cultural view of tangata whenua, who generally consider discharging human sewage directly to water bodies unacceptable. However, other drivers for wastewater reuse are emerging for water resilience, or as part of the circular economy journey and water sustainability.

There is no framework in New Zealand for regulating this recycled water use, currently it is considered on a case-by-case basis by Regional Councils under the Resource Management Act 1991. There is an opportunity to set nationally consistent standards for recycled water before it's use becomes more widespread, and before higher risk uses for recycled water (i.e. for potable use) are seriously considered.

Taumata Arowai has engaged Beca to review approaches to recycled water use overseas and in New Zealand to support policy development for New Zealand. The purpose of this review is to identify key issues for the development of recycled water policies and regulation for Aotearoa New Zealand.

1.2 Scope of Review

The scope of this review is high-level and broad, covering all uses of recycled water. This report summarises the regulations and standards that exist in a number of other jurisdictions, discusses how recycled water is viewed within New Zealand, and identifies the opportunities and challenges that Taumata Arowai may encounter as it considers their own approach to recycled water. Five focus areas were identified after discussions with Taumata Arowai, and these form the subsequent chapter headings:

- Development of regulatory requirements overseas
- Building social licence
- Iwi and hapū views
- Technology, operations and monitoring
- Emerging contaminants

The learnings from these focus areas are then discussed and the key issues that need to be considered in the development of regulations for recycled water in New Zealand and areas that need further investigation are identified.

This report draws on the experiences of Beca staff in Australia, some of whom were involved in the development of the New South Wales Standards, and also in the application of Federal and State recycled water regulations. The report also includes perspectives from Watercare and other contacts within the Australian and USA water industry. Our research for this report included:

- Three workshops, one with Beca Australia, and two with Black & Veatch America
- Two interviews with recycled water operations and (seconded) regulatory staff from South Australia.
- Input and information from Watercare.

1.3 Definition and Uses of Recycled Water

Recycled water refers to any form of wastewater that has undergone appropriate treatment for beneficial reuse. Sources of recycled water might be domestic sewage, industrial wastewater, or stormwater runoff. Recycled water can provide an alternative source of water for agriculture, urban activities and use by industry, however, while wastewater reuse provides benefits as an alternative source of water and nutrients, it also presents potential risks to human health and the environment. (Leonard, Russell, & Cressey, (n.d.))

Generally, recycled water is split into two types:

- Non-potable reuse refers to end uses such as agricultural or landscape (parks, golf courses etc) irrigation, industrial processes such as cooling or manufacturing, environmental restoration, firefighting, and toilet flushing.
- Indirect or direct potable reuse is where the treated wastewater is fed directly into a drinking water supply, or indirectly by discharging it to ground or surface water which is a drinking water source.

Generally, in this report, recycled water use refers to non-potable reuse and potable reuse is specifically identified. Recycled water can also be municipal or industrial in origin. We note that the Water Services Act defines wastewater networks to only include municipal, departments and defence systems, meaning that private industrial wastewater (where not connected to a municipal system) is not included under the Water Services Act. This report addresses this issue in Section 8.

1.4 Glossary

Term	Definition
AGWR	Australian Guidelines for Water Recycling
BOD	Biochemical Oxygen Demand
BVP	Bacteria, Virus and Protozoa
DPR	Direct potable reuse
EPA	Environmental Protection Agency
ESR	The Institute of Environmental Research
GWRS	Groundwater Replenishment System
Hinekōrako	Taumata Arowai's data platform
IPR	Indirect potable reuse
LRV	Log removal value
LTS	Land Treatment Scheme
MF/RO/AOP	Microfiltration/reverse osmosis/advanced oxidation processes
NRSBU	Nelson Regional Sewerage Business Unit
PFAS	Per- and polyfluoroalkyl substances
RO	Reverse Osmosis
RMA	Resource Management Act
TCC	Tauranga City Council
USEPA	United States Environmental Protection Agency
WSAA	Water Services Association of Australia
WTP	Water treatment plant
WWTP	Wastewater treatment plant

2 Current Approach in New Zealand

2.1 Current Regulatory Framework

There are currently no specific regulations or standards associated with recycled water (non-potable / potable) in New Zealand. Disposal of wastewater to land is relatively common practice in New Zealand, but this is not currently classified as recycling or reuse of water. This can be to dedicated wastewater disposal areas of fields for example the Masterton WWTP, or maybe to land used for other purposes such as golf courses, forestry, viticulture, or other uses. All these discharges are managed as part of the consenting process under the Resource Management Act 1991 and fall to Regional Councils to determine what limits should be placed on uses of recycled water. This is often undertaken on a case-by-case basis as applications for the use (discharge) of water are made, rather than there being standard rules or guidelines for the use of recycled water. These applications are currently considered more as disposal of wastewater, as opposed to recycling of water. Iwi, hapū and other community groups, industry and interest groups are often able to comment on resource consent applications that affect them. Figure 2-1 shows the current policy framework under the Resource Management Act 1991.

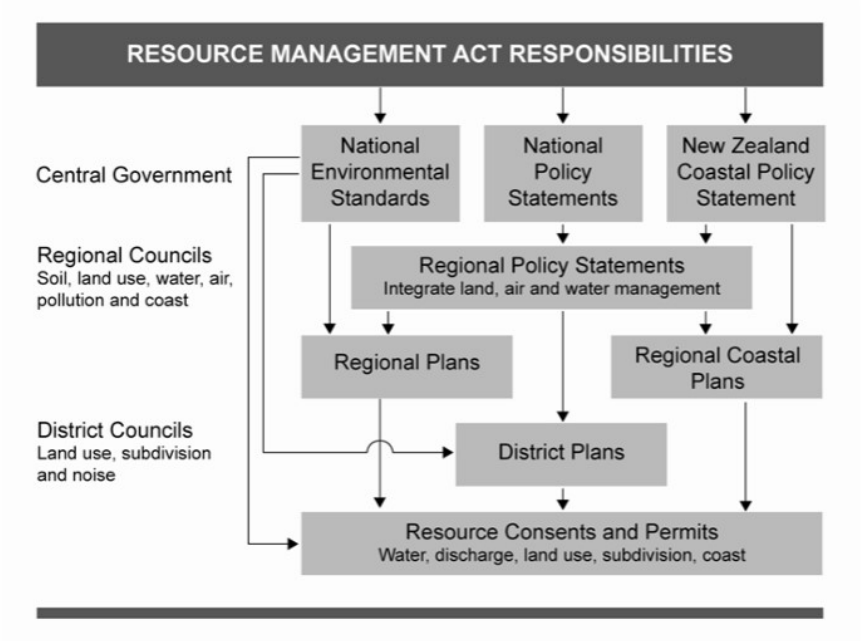

Figure 2-1 Policy framework for natural resource management in New Zealand (From Ministry for the Environment)

Some industry groups have developed their own guidelines for recycled water use. In 1999 the dairy industry issued a policy statement on the reuse of wastewater. This allowed for the use of water treated to a certain (achievable) standard, it has effectively been used as a blanket ban on the reuse of treated human effluent on dairy land (discussed further in Section 2.2).

Discharges to land from onsite sewage disposal systems are common and well regulated by local and regional councils under the existing Resource Management and Local Government Acts. Some councils have also published advice on the domestic reuse of water, such as the Kāpiti Coast Rainwater and Greywater Code of Practise Guidelines (Kāpiti Coast District Council, 2017).

Guidelines have been established by councils for the reuse of wastewater as part of on-site management for small domestic systems. Auckland Council, for example, has drafted guidelines for on-site wastewater management in the Auckland region (Chen & Roberts, 2021). This document provides guidance on various

urban wastewater reuse applications, including toilet flushing and garden irrigation. The guidelines are intended for households and small facilities, with flow limits of 3,000 litres per day in the draft guidance document (Chen & Roberts, 2021).

The New Zealand Land Treatment Collective developed "Guidelines for the Utilisation of Sewage Effluent on Land" in 2000, but these are not official regulatory guidelines.

Taumata Arowai is working on wastewater performance standards for municipal wastewater discharges. The standards will be secondary legislation and will relate to the quality of wastewater discharged to the environment. These will be applied to individual discharge consent applications, and continue to be regulated by Regional Councils, with Taumata Arowai reporting on the performance against the discharge standards. There may be an opportunity to consider recycled water standards as part of the same mechanism.

2.2 Examples of Recycled Water Use in New Zealand

Water sources suitable for usable water are not unlimited, and with climate change some regions of New Zealand can expect to experience longer and/or more frequent periods of drought. Along with a cultural aspiration to minimise the discharge of human waste to water, there is already a latent demand for recycled water in New Zealand.

Disposal of wastewater to land is relatively common practice in New Zealand to address iwi concerns about discharge of human sewage to water, with standards existing for treated wastewater disposal to land (Standards New Zealand & Australia, 2012) (Leonard, Russell, & Cressey, (n.d.)) The goal currently in New Zealand is more about disposal of wastewater, as opposed to using recycled water in situations where potable water may have been used before (for non-potable purposes) e.g. irrigation crops or parks. Recycled water standards may provide greater clarity around the requirements for using treated wastewater, and thereby encourage it's use for these purposes.

There are a number of current or potential non-potable recycled water uses in New Zealand and these are described in more detail in the following sections:

- Fonterra
- Greenacres Golf Club
- Blenheim irrigation to vines
- Tauranga City Council using wastewater for irrigating road reserves
- Taupo WW effluent irrigation scheme

NZ effectively already has unplanned indirect potable reuse of treated wastewater. Watercare takes a large potable water volume from the Waikato River at Tuakau. Upstream of that, discharges of treated wastewater effluent to the Waikato River occur at Meremere, Huntly, Ngaruawahia, Huntly, Cambridge, Tokoroa and other places. Watercare is also considering recycled water for potable use, and the citizen's assembly project is discussed further in the following section.

2.2.1 Watercare Citizens Assembly

The Watercare Citizens Assembly Project engaged with 37 community members to deliberate on Auckland's next major potable water source beyond 2040. The final recommendation of the citizens assembly was direct potable reuse for Auckland's next source of water (while still investigating the feasibility of desalination). (Citizens' assembly project, (n.d.)) The group was representative of Auckland residents based on age, gender, ethnicity, education, and varying home ownership. Independent experts provided information, discussion and answered questions so the assembly could understand the complexity of this issue and the different source waters. Mana whenua was also engaged to ensure the views of Māori were considered and the principals of Te Mana o te Wai were understood. The assembly went over four sessions throughout

August and September 2022 exploring potential water supply options and undergoing a deliberative democracy process.

A copy of the Citizens Assembly report was circulated to all iwi across Tāmaki Makaurau (Auckland) with the opportunity to provide feedback. Several iwi supplied feedback showing the desire to be involved in decision making and that any recycled water projects need to be developed in a way that accords with tikanga.

2.2.2 Fonterra

Since 1999 Fonterra has required California Title 22 Standard for any wastewater used to irrigate grass or crops that might be eaten by lactating dairy cows. The California Title 22 Standards are part of broader regulatory framework that govern recycled water in California, specifically covering the reuse of domestic wastewater, and consist of a series of treated effluent quality standards for different uses. (California Department of Public Health, 2023) The standards are very prescriptive with strict requirements on source water quality, treatment processes and disinfection. Fonterra didn't specify which specific standard would be applied in New Zealand, but this has essentially discouraged the use of recycled (human sourced) water for dairy irrigation at Fonterra due to the high level of treatment and monitoring required. This has created a barrier for the irrigation of municipal wastewater to dairy land. Instead the water that is used for irrigation is instead sourced from the environment (Lincoln Environmental , 2000) (National Institute of Water & Atmospheric Research Ltd (NIWA), 2018).

However, Fonterra has incorporated the use of recycled dairy processing water which does not have a human pathogen risk, extensively for irrigation of its own farms and for several processes within some of its factories. Fonterra carefully separate human and industrial wastewater streams on their sites.

The Edendale plant in Southland recycles about half the water present in cow milk and uses it in its processing operations. About 10 million litres of cows' milk were carted from dairy farms to the plant each day, where it was processed into products including milk powders and protein products. (Harding, 2024) Since cow milk consists of 86% water, about half of that water was removed in an evaporation process during processing, and historically sent down the river. Now, Fonterra purifies this water through a filtration and disinfection process onsite and then uses the purified water in its milk processing operations for the likes of cleaning its plant.

Similarly, the Maungatūroto plant recycles water from the evaporation process. The evaporator condensate is directed to an existing wetland on the site which acts as a natural bioreactor to filter the evaporator condensate before it is discharged to the Wairau River. The biota within the wetland removes nutrients and organics in the evaporator condensate before it is discharged into the river under Fonterra Maungaturoto's resource consent conditions. Following this, the water is treated by the Fonterra WTP and is subsequently reused throughout the site, including for drinking water.

2.2.3 Bell Island WWTP and Greenacres Golf Club

The Nelson Regional Sewerage Business Unit (NRSBU) have added a pseudo-water recycling plant at the end of the Bell Island WWTP. The recycling plant treats part of the wastewater stream and consists of tertiary membrane treatment using 'pst guarantee' membranes recycled from the Nelson WTP. NRSBU makes the treated wastewater (recycled water) available to users, but the user must get their own consent to discharge and may need to provide additional treatment depending on the end use.

Greenacres Golf Club has two existing freshwater bores which are consented and used for irrigation purposes. They are proposing to supplement the existing irrigation regime by utilising water and nutrients from the tertiary treated wastewater from the Bell Island WWTP for irrigation of the fairways and greens.

Bell Island, where the Greenacres Golf Club and Bell Island WWTP are located, is surrounded by the Waimea Inlet, which is a popular location for recreational boating and fishing and culturally important to Te Tau Ihu

iwi. The Te Tau Ihu iwi have previously expressed concerns about the discharge of treated wastewater into the Waimea Estuary and the discharge of treated wastewater to land for irrigation purposes held significantly less concern for iwi, and indeed, was a preferred option to minimise impacts on the Waimea inlet.

Other golf courses at Omaha and Pauanui have previously and may still irrigate recycled wastewater from their local WWTPs, as does the Awatere Golf Course, which uses treated wastewater from the Seddon WWTP. In line with this, the Kaipara District Council is planning to upgrade the Mangawhai WWTP to meet Class A Victorian EPA standards, to allow for unrestricted irrigation of the local golf course.

2.2.4 Blenheim WWTP Discharge to Vines

Two significant grape growers on the outskirts of Blenheim town have requested to receive recycled wastewater from Marlborough DC (MDC) to provide irrigation water to facilitate significant expansion to their grape growing areas. They wish to receive wastewater treated to the same standard as used in the Willunga Basin Scheme in South Australia. That is, Class C recycled water in accordance the Victorian Guideline for Irrigation with Recycled Water.

Apart from these two, there is a very large expansion of grape growing proposed by various wine companies around Blenheim and there is only very limited availability of water resources to support such expansion in this very dry region.

The Blenheim WWTP is situated in and discharges to areas (land and estuary) of very great cultural significance to Te Rūnanga o Ngāti Rārua, and discharges treated wastewater into the Wairau Estuary. Te Rūnanga o Ngāti Rārua have expressed deep concern with the effects of the WWTP discharge on the awa, moana and mahinga kai.

Marlborough District Council aims to limit wastewater discharge into local awa and moana. As one mitigation measure, MPDC is currently investigating and considering the ‘irrigation to grapes’ proposal and initiating a consent process to allow that to happen. This consenting would be informed by the Victoria EPA Guidelines. South Australian Guidelines do not include numerical standards. Irrigation of vines (as with most crops) would not be viable all year round.

2.2.5 Tauranga City Council irrigation of road reserves

In 2005 Tauranga City Council (TCC) was granted resource consent (consent number 62886) for the irrigation of treated wastewater from the Chapel Street WWTP. This water, which is secondary-treated and UV disinfected, was intended for spray irrigation at eight sites within the Tauranga District. However, the consent has not been fully utilized due to the consent conditions being overly restrictive and not practical for TCC to implement. As a result, no reclaimed wastewater from Chapel Street WWTP has been used for irrigation since 2010. TCC is now seeking to re-explore the option of using treated wastewater from either Chapel Street WWTP or Te Maunga WWTP for the irrigation of newly planted juvenile trees rather than the eight sites specified in consent 62886. This requires a re-evaluation due to the change of application area(s), and technological developments since the last consent was lodged.

2.2.6 Taupo WW effluent irrigation scheme

The surface waters of the Taupo district are of high quality and are sensitive to nitrogen inputs. To reduce nitrogen discharge into these waters the Taupo District Council (TDC) employed a land treatment scheme (LTS) in 1995, in which treated municipal wastewater from the Taupo WWTP is irrigated onto ryegrass pasture. (Sunich, 2016) Previous to this scheme, the wastewater effluent was discharged into the Waikato River. The movement from direct disposal into the water to application onto land was seen as a big improvement both culturally and environmentally. In 2008, the scheme was expanded to accommodate projected population increases and connection to two additional sites, Acacia Bay and Rakaunui Road. (Sunich, 2016) Lucerne was added to the irrigated crop. The current consent allows for the irrigation of up to

15,000 m^3 per day of treated wastewater effluent across nearly 500 hectares of farmland. (Sunich, 2016) The haylage crop produced through this irrigation is baled and sold to dry stock farmers, helping to fund the scheme which at the time was the largest municipal wastewater irrigation scheme in New Zealand.

2.3 Related Agencies and Activities

The Ministry for the Environment and Regional Councils are likely to be interested in being involved in the development of recycled water regulations due to their roles in freshwater management, their responsibilities as resource management regulators, and the potential impacts on the environment.

Local councils may also be interested in recycled water regulations as they may also have a role to play in regulation via district plans, and as potential producers and users of recycled water.

The Ministry of Health will be interested in the development of a recycled water regulatory framework due to the potential impacts on human health.

The Ministry of Primary Industries is also likely to be interested in the development of Recycled Water Standards as many of the uses for recycled water sit within primary industries.

Other groups that are likely to have an interest in recycled water standards are:

- Industry bodies like Fonterra
- Iwi and hapū
- Communities
- Other producers of sources of recycled water

Note that changes to the Resource Management Act are currently being considered, which may affect the development and form of recycled water regulations for New Zealand.

3 International Regulatory Requirements

This section provides a summary of recycled water regulations overseas, focusing on Australia, the USA and Singapore. Other countries (like South Africa and Canada) also practice recycling of highly treated wastewater, but the American, Australian and Singaporean standards have most commonly been referenced in New Zealand consents for recycled water use to date. It draws on a review of relevant literature, feedback from interviews and workshops with water industry practitioners in Australia and the USA, and key elements of the work already completed by Watercare. (Dennis, Dawson, & Atkinson, 2024) (Hunter, Recycled Water USA Workshop, 2024) (Citizens' assembly project, (n.d.)) (Measuring Water Literarcy Research Report - Auckland (NZ), 2023) (Erdal, 2024) A high-level overview is provided in the following sections, with additional detail provided in Appendix A to supplement the discussion.

3.1 United States of America

3.1.1 Summary of Standards and Regulations

In the USA, the legislation for drinking water and discharges of pollutants in wastewater was developed by the United States Environmental Protection Agency (USEPA) at a national level with the Safe Drinking Water Act (SDWA) (Safe Drinking Water Act (SDWA), 1974) and the Clean Water Act (CWA) (Clean Water Act, 1972).

There are no federal regulations for water recycling, but the USEPA has published the Guidelines for Water Reuse (2012) (Guidelines for Water Reuse, 2012) which summarise the standards and approaches in different states into one document and clarifies some of the variations in the regulatory framework between states (refer summary table in Appendix A). The USEPA guidelines also provide regulatory guidance to state agencies on developing or revising regulations, offer technological information, present case studies and best practises, and emphasise community and stakeholder engagement.

The lack of federal involvement has led to recycled water standards and regulation becoming the responsibility of state and local agencies. One of the strongest and most referenced regulations is the California Code of Regulations (Title 22, Division 4, Chapter 3).

California developed recycled water regulations early on, due to water quantity pressures. Initially recycled water was used for groundwater injection to mitigate saline intrusion and over-abstraction risks. Over the years California have developed standards and regulations for recycled water, direct potable reuse (California State Water Resources Board, 2019) and indirect potable reuse. Because California was an early adopter (for example, Orange County commenced re-injection of potable standard recycled water, to their groundwater aquifer, in 2008), their regulations are more developed than other places and there has been more research done. California regulations are sometimes seen as the gold standard, and many other states have used the California regulations as a base but adapting them for their own priorities and needs.

This has led to multiple different approaches across the states. For example, there are different regulatory requirements for different end uses. Direct Potable Reuse (DPR) regulations have now been adopted in several states, with California implementing very onerous and prescriptive rules, Colorado recognizing DPR under its regulations, and other states like Arizona and Florida revising or drafting DPR-specific rules. Texas, Oregon, and Washington approve DPR projects on a case-by-case basis. Currently, the only operational DPR project is in Big Spring, Texas, since 2013, with more projects anticipated following recent regulatory advancements.

Indirect potable Reuse (IPR) is more widely practised in many of the USA states with each state having its own regulations/standards and regulatory body.

California requires detailed management plans to be in place with approaches for managing risks and setting out contingencies for process failure or if the water is out of specification.

3.1.2 First Nations Perspectives

A comprehensive review of First Nations perspectives on Recycled Water in North America was not conducted, but the following comments originated from the workshops:

- General mistrust of public institutions due to historic actions
- Concerns about toxicity from modern materials
- Concerns about mismanagement of schemes

A more comprehensive review of approaches to First Nations peoples in the USA and Canada might be helpful to inform approaches in New Zealand.

3.1.3 Strengths/weaknesses

One of the strengths of the USA's approach to water reuse regulation is the different regulations for differing uses. Treatment standards vary depending on whether the water is used for industrial processes, irrigation, wetlands restoration, and other applications. This is important because the diverse end uses for recycled water have different risk profiles. Although this approach requires substantial effort to develop (if developing from scratch), it benefits the end user by ensuring the water is treated appropriately for its end use.

A state-based approach to regulation allows each state to cater to their distinct requirements, resources, climate, and land uses regarding water reuse. However, in practice this has not been universally well implemented. There have been issues with some states adopting recycled water standards from other states without fully considering local contexts or developing the necessary technical expertise. For example, California has extensively validated its treatment technologies and built significant regulatory expertise with the regulator. When Minnesota adopted California's standards, they did so without being prepared for the validation processes or technical skills that would be required. (Hunter, Recycled Water USA Workshop, 2024)

The state-specific approach also leads to each state having its own interpretation of reuse standards, and inconsistencies and a lack of uniformity that might be better addressed by a national framework. There were also cases where political interference damaged the implementation of water reuse regulations. For example, in Oklahoma a drought put considerable pressure on the regulator to develop recycled water standards for direct potable reuse. Political interference led to the regulations not taking into account the existing industrial recycled water use that was already occurring, and considerable time and money required to revise them.

When state regulators and local government decision-makers lack specific criteria or guidance for significant water supply decisions, the outcomes may not reflect modern technology, could involve unnecessary treatment complexities, and lead to increased costs, delays, and confusion among regulators and the public. (Mosher, 2015) An example of a prescriptive approach is that of California, who have created a list of things people can understand well and gives clear rules to follow but took a lot of time and effort for the regulator to develop. It may also lead to higher costs where there is no flexibility in approach. It also creates a limitation around the adoption of new technologies. The process for validating new or updated treatment methods is lengthy and expensive, discouraging innovation. For instance, demonstrating equivalency to established processes like microfiltration – reverse osmosis – advanced oxidation processes (MF/RO/AOP) can take years and substantial financial investment. Balancing the need for rigorous validation with the flexibility to adopt new technologies is crucial to advancing water reuse practices, or the technology and testing knowledge stagnates.

It's noted that the litigious culture in the USA may also have led to a more conservative approach being taking that may not be warranted (from a health risk perspective) in other jurisdictions.

3.2 Australia

3.2.1 Summary of Standards and Regulations

Water resilience and drought management is a significant issue in Australia, making water recycling a valuable strategy to supplement conventional potable water sources. The national guidelines for water recycling were based on earlier work on the NSW guidelines in the 1990s, forming the Australian Guidelines for Water Recycling (AGWR): Managing Health and Environmental Risks (2006) (Australian Guidelines for Water Recycling (AGWR): Managing Health and Environmental Risks (Phase 1), 2006).

These national guidelines were developed by the Environment Protection and Heritage Council, the Natural Resource Management Ministerial Council & the Australian Health Ministers' Conference and are managed by the National Department of Climate Change, Energy, the Environment and Water. The guidelines include two phases, Phase 1 providing a generic framework that applies to all end uses, and Phase 2 focusing on augmentation for drinking water supplies, managed aquifer recharge, and stormwater harvesting and reuse. The national guidelines take a robust risk-based approach, for managing health and environmental risks considering use-type and exposure. This approach allows flexibility to adapt to emerging contaminants and new applications. There is consistency between the approaches taken for recycled water and drinking water.

Implementation of the guidelines is done at a state level. Similar to the USA, this has led to each state having its own interpretation and requirements for recycled water regulations, and approach to definition of quality requirements and usage constraints for different end uses. Different states such as Victoria and Queensland have developed ‘classes’ of recycled water which prescribe different usage constraints for different uses, dependent upon the level of treatment used and quality achieved. Victoria has defined quality and usage requirements for Classes A, B and C (Environmental Protection Agency Victoria, 2021), whilst in Queensland an additional Class A+ is also defined (Department of Regional Development, Manufacturing and Water, 2008) (Queensland Health, (n.d.)). In South Australia, no classes are defined, and the approach taken is based on the development of ‘fit for purpose’ recycled water qualities, tailored to individual supply and usage conditions and risks (SA Health, (n.d.)).

Further to this, although there are accepted qualities that can be achieved by different treatment processes, there is no standardised approach (national or state) to the design or technology requirements for recycled water treatment facilities (refer Section **Error! Reference source not found.** for further details).

A detailed summary table of the Australian regulations is provided in Appendix A.

3.2.2 Indigenous Perspectives

Indigenous Australians (including Aboriginal and Torres Strait Islander people and Traditional Owners), like Māori in New Zealand, are diverse and therefore hold a diverse range of views about water, but all have a deep connection to water. For Indigenous Australians, who often coped with arid environments across their thousands of years of habitation in Australia, surface and groundwaters hold special importance and they hold profound knowledge of water systems in Australia.

Participation of Indigenous Australians in water decision making has been limited in Australia to date, and tends to be on a project-by-project basis. It is often focussed on the development of Cultural Heritage Management Plans to obtain approval for contruction, rather involvement and partnership in policy and strategic decision making. Watercorp (Western Australia) led the way with demonstration plants in groundwater which have taken into account cultural aspects. More recently, the Victorian government has developed the Water is Life framework, (Victoria State Government, 2024) which aims to increase Traditional Owner roles in and resources for water management across Victoria. Implementation of the framework may also enable Traditional Owners to have the opportunity to access diverse water sources and entitlement types as relevant on their Country, for example access to recycled water. Guidelines are also proposed to enable the interests of Traditional Owners to be considered early in the development of all infrastructure

projects with water recovery opportunities. (Moggridge, Thompson, & Radoll, Indigenous research methodologies in water management: learning from Australia and New Zealand for application on Kamilaroi country, 2022) (Moggridge, Betterridge, & Thompson, Integrating Aboriginal cultural values into water planning: a case study from New South Wales, Australia, 2019) (Moggridge, AborIginal People and Groundwater, 2020) (Moggridge & Thompson, Cultural value of water and western water management: an Australian indigenous perspective, 2021)

3.2.3 Strengths/weaknesses

The regulatory approaches to recycled water are highly aligned with the approach taken for drinking water, ensuring a robust and unified approach to water safety and management. Both take a risk-based approach, which allows consideration of site-specific risks and circumstances. In the context of recycled water, it means the regulatory system is able to adapt to individual treatment processes, end uses and usage controls, emerging contaminants, new types of application, decarbonisation and advances in treatment technologies, water resilience issues and more.

Although a strong foundation is provided with the Australian Guidelines for Water Recycling (Australian Guidelines for Water Recycling (AGWR): Managing Health and Environmental Risks (Phase 1), 2006), the implementation of regulation at a state level has led to each state having their own interpretation on the national guidelines, and varying definitions of water quality requirements for different applications. This has created a disconnect between what the national guidelines describe and the practicalities of the regulatory approval processes in each state. Broad wording of some requirements in the national guidelines can also lead to misinterpretation or confusion about what level of treatment is required for approvals when undertaking planning, budget allocation and system design. Whilst large water authorities are technically strong and work closely with health departments on application of the guidelines, some smaller delivery agencies such as councils may lack the technical expertise needed, which can lead to confusion and/or delayed decision making in planning and design of recycled water schemes. The technical knowledge of recycled water customers also varies, which can create challenges for the design, development and approval of recycled water schemes, and challenges in the implementation and management of usage controls defined in approvals.

This gap can result in delays and hesitancy in decision-making. An example of this is a situation has played out in Tamworth, Australia. An industrial site wants to use recycled water for direct potable substitution, but industrial sources of water are not recognised within the regulations and the regulator will not accept it as a source.

3.3 Singapore

Singapore is one of the most-water-stressed locations in the world and has implemented a high-tech recycled water strategy called NEWater. Although tropical and with the physical size of Lake Taupo and a population of 5 million (and growing), the island state has traditionally relied on importation of water from nearby Johor State in Malaysia. In order to reduce this reliance, Singapore has embarked on a strategy of developing alternative sources of potable, and higher water quality. This involves desalination plants, recycling of Stormwater and recycling of treated wastewater.

The strategy involves distribution of highly treated recycled water to industrial users for non-potable uses. Although not used for direct potable supply, the level of treatment is compliant with the Singapore Food Agency’s regulations for drinking water quality according to the 2019 Environmental Public Health Regulations (Water Suitable for Drinking) (Singapore Statuses Online, 2023) and there is indirect potable reuse where some water is pumped to raw water reservoirs. Both NEWater and potable water in Singapore must meet all applicable requirements for chemical and microbial contaminants stipulated by local and

international drinking water standards and guidelines such as the World Health Organization (WHO) guidelines for drinking-water quality ((WHO), 2022).

All the recycled water is treated to the same potable level, there are no different classes/treatment options, and there is one standardised multi barrier process: ultrafiltration/microfiltration (UF/MF) to reverse osmosis (RO) to disinfection (UV).

The National Water Agency of Singapore, the Public Utilities Board (PUB) manages the overall water system, including the NEWater scheme. The scheme has received governmental support from the highest levels with a consistent and overt effort to promote and defend the NEWater scheme.

The Singapore NEWater system is widely accepted and supported by Singaporeans, with a 2002 survey reporting a 98% acceptance rate – where 82% of respondents would drink NEWater directly and a further 16% would drink it mixed with reservoir water (Water Services Association of Australia, 2019). The PUB has also put significant effort to engage with the community with a proactive and deliberate campaign, taking careful consideration of appropriate terminology and media and stakeholder engagement.

This approach involved a high initial investment to establish the sophisticated infrastructure and technology required to treat wastewater to such a high quality.

3.4 Comparison and Considerations for New Zealand

Table 3-1**Error! Reference source not found.** provides a high-level comparison and key observations of the three approaches taken in Australia, the USA and Singapore. A more comprehensive review of different Australian regulations and the California regulations is provided in Appendix A.

Both Australia and the USA have some sort of national guidance provided for water recycling for the individual states to interpret, implement and regulate. This national direction is stronger in Australia and provides a comprehensive framework for the individual states to work with, albeit still with challenges and risks of inconsistency and/or misinterpretation. In the USA there is little national direction provided and practitioners there felt that the lack of national oversight and associated challenges has likely delayed progress towards greater use of recycled water in some states.

Both the Australian and American experiences highlighted the need for technical skills within a regulator. Many of the frustrations expressed by those working with the regulations were around the interpretation and implementation of the regulations.

For potable water use specifically, the alignment between risk-based approaches for drinking water and recycled water guidelines in Australia may present an opportunity for New Zealand to consider something similar, or to take it further and integrate potable reuse into drinking water regulations by incorporating recycled water as another drinking water source, akin to surface or groundwater. This could offer advantages in New Zealand, such as national regulation of all drinking water sources by a single regulator, normalising recycled water as a water source and improving public acceptance of potable reuse accordingly. This approach would make the drinking water guidelines more complicated to account for the theoretically higher risk profile of using recycled water for potable use and associated quality assurance measures.

Another approach could be to focus on the end product (potable water versus process water versus irrigated water) and protecting health. Both of these approaches (incorporation into Drinking Water Regulations and an end-product based standard) may be challenging in a New Zealand context, however, due to the cultural sensitivities around the management of human waste in particular.

Table 3-1 Comparison of Recycled Water Regulations

	USA	Australia	Singapore
Description	National Guidelines provides general guidance and an overview of state regulations (Guidelines for Water Reuse, 2012) Individual states have developed their own standards and regulations with mixed success. Many are based upon the California Regulations which are highly prescriptive and conservative	National Guidelines provide a strong risk-based framework (Australian Guidelines for Water Recycling (AGWR): Managing Health and Environmental Risks (Phase 1), 2006) Individual states have developed their own standards and regulations with mixed success	National standard treatment process and standard set for a single end product, all water reuse is governed by the national water utility - Singapore Public Utilities Board (PUB)
Strengths	Consideration of many end-uses Ability to account for different needs at a State level	Risk-based approach is highly flexible and internationally recognised Consideration of many end-uses Well-aligned with drinking water risk-based approach – good foundation for direct / indirect potable reuse	PUB manages the entire water cycle, from supply to treatment, which allows for a seamless operation and regulation process Strong government support – consistent government backing Simple and easy to understand
Weaknesses	Lack of national oversight or direction Highly prescriptive approach e.g., California leads to inflexibility Lack of technical understanding in some state regulators Lack of integration of indigenous perspectives	Potential misinterpretation or confusion about technical requirements in system planning and design Resourcing capacity constraints in State health departments can be limiting Lack of integration of indigenous perspectives	One class – all water must be treated to drinking water level which is expensive

4 Building Social Licence

As with other water issues, recycling water is a complex issue and there is a general lack of community understanding about what it is, let alone appreciation of the benefits and risks associated with it. Building social licence is particularly important for potable reuse. International experience has found that people are much more open to recycling of water for non-consumption purposes, but anecdotally the only potable reuse projects that go ahead with widespread public acceptance are where there is a very strong driver and very little alternative or a strong political desire to regulate (such as in Singapore). An example is from Texas where a small direct potable reuse scheme went ahead in 2014 because of a bad drought. (Erdal, 2024)

Anecdotally, public and political support for recycled water schemes can also drop off as the driver (say drought) reduces. During the millennium drought in Australia, several direct and indirect potable reuse facilities were developed to the point where they could be turned on, but once the drought broke they were stopped by a combination of community and political means.

Conversely, engaging with the community well in advance builds trust and then a new recycled water project doesn't seem like a reaction to a drought or other specific situation. Education of school children is a strategy commonly used overseas, as well as using trusted figures in the community, such as doctors, to promote and support water initiatives. (Water Services Association of Australia, 2019)

Examples of recycled water projects that have incorporated water literacy are (all the examples listed are case studies from the Water Services Association of Australia All Options on the Table 2019 Report (Water Services Association of Australia, 2019)):

- Orange County (USA) has been running a successful indirect potable reuse scheme (GWRS) since 2008, which included building an H2O learning centre. Likewise, Hampton Roads Sanitation District in North Virginia are implementing a potable water groundwater reinjection scheme to both prevent saltwater ingress to the aquifer and to attempt to raise ground levels back to pre-pumping levels.
- Perth (Australia) has the only plant in Australia for indirect potable reuse. The scheme includes an educational facility that looks at the water cycle, the need for water recycling and the groundwater replenishment process. They also implemented a school program to educate on recycled water.
- El Paso (USA) has a recycled water scheme and they found levels of acceptance grew with more knowledge. People were generally more at ease with the idea of drinking purified recycled water when they understood the process and how different contaminants are removed.
- San Diego (USA) had a 'toilet to tap' media campaign against the recycled water scheme which gained a lot of exposure. After two decades of education and research centred around a demonstration project and visitor centre to undo the negative perceptions, the program will provide one third of the city's water by 2035.
- Toowoomba (Australia) the recycled water project was abandoned due a combination of different reasons including breaking of drought, health concerns, political pressure, and distrust in the council. The rushed timeframe didn't allow for water education and the community would not support the project without the pressure from the drought.
- In Singapore the program of engagement on water includes primary schools and high schools. Visiting the NEWater Centre is part of the curriculum for every school student. All kinds of community groups are also targeted.

High water literacy, knowledge of the water system and perceived likelihood of drought have a positive impact on acceptance of alternative sources. The Water Services Association of Australia (WSAA) finding of higher acceptance levels of recycled water for drinking were Perth and Brisbane suggesting communication and awareness increases acceptance. (Measuring Water Literarcy Research Report - Auckland (NZ), 2023) Lower levels of support were found in regions where there has not been any significant public discussion

about purified recycled water for drinking. Water literacy is a critical lever in influencing public acceptance of recycled water schemes. Knowledge gaps persist in areas like purified recycled water, perceived likelihood of drought, and desalination.

WSAA identified a number of issues experienced with community engagement on recycled water projects (Water Services Association of Australia, 2019):

- Lack of transparency leading to limited trust
- Rushing the process
- Using words or imagery that confuse/alienate/don't reassure.
- Not engaging with key influencers and the media or leveraging social media
- Lack of good political engagement
- Lack of grass roots education and engagement
- Lack of general education around the water cycle and context
- Lack of good regulatory engagement and transparency

A public outreach program has been identified as an essential tool in building confidence and allaying fears about water reuse projects. (Mosher, 2015) According to the Framework for Direct Potable Reuse (Mosher, 2015) the program should ideally launch during the early stages of planning and be maintained throughout the project lifetime. A list of key activities in developing a public outreach program for water recycling was developed from the Framework for Direct Potable Reuse (Mosher, 2015) and is shown in Table 4-1.

Table 4-1. Key activities for developing a public outreach program for recycled water

Outreach Activity	Purpose
Provide a rationale for the need for water recycling	Raise public confidence of the benefits and value of the recycled water project to the community.
Identify public perception challenges to the water recycling project	Use to assist in the development of strategies to alleviate these concerns and improve public perception.
Develop a water reuse Communication Plan	Provide strategies to communicate about the water recycling project to the public, elected officials, and others, with the goal of building public confidence in and support of the recycled water project. This could include targeting different sectors of the community, for example school children, iwi and hapū, people that live in cities
Develop and spread communications materials on the water reuse project	Provide objective, accurate, and timely information to raise awareness of the project and address public concerns.
Learn from existing water reuse facilities	Gain information and lessons learned from the real-world experiences of other water reuse public outreach efforts.

Recent research on Measuring Water Literacy for WSAA (Across Australia and Auckland) highlights a mixed response among Auckland residents toward recycled water. According to their water literacy study, only 35% of Aucklanders will accept drinking purified recycled water, while 59% would be comfortable using recycled water for non-drinking purposes. The primary concerns for those not comfortable to drink purified recycled water centre around the origin of the water as sewage or wastewater (24%), distrust in the treatment process (15%), and a general aversion to the concept (12%). The WSAA also developed water literacy measurement frameworks, producing an overall Water Literacy Score (WLS) based on six core attributes. The findings showed Auckland scored an intermediate Water Literacy Score of 50 out of 100, slightly below the study average of 57, which included eight Australian regions and Auckland. (Measuring Water Literarcy Research Report - Auckland (NZ), 2023)

Although this research shows that there is not currently strong support for recycled water use in New Zealand, the results from Watercare's Citizens Assembly project (discussed more in Section 1.4) (Citizens' assembly project, (n.d.)), demonstrated that there is a growing openness to water recycling with the right education.

In both Australia and the USA, it took time to build understanding around water recycling. Public perception is important for recycled water schemes to be successful and the wrong messaging getting out can take years to overcome. In New Zealand, as our primary driver at the moment for recycled water is disposal of wastewater, a change in framing so that it is seen as a valuable source of water (as opposed to highly treated wastewater) would help with general public acceptance – although the origins of the recycled as human waste will continue to be important for Māori as discussed in the next section.

5 Iwi and Hapū Views

Whatungarongaro te tangata, toitū te whenua
As people disappear from sight, the land remains

The following sections provide an overview of Maōri perspectives towards water and wastewater, and are sourced from a number of scientific resources, existing common-held knowledge and discussions with individuals. Notable sources that contributed to this section include:

- iwi management plans for Tairawhiti, Whakatu, Tai Tokerau and Waikato (Lant & Peneha, 2012) (Te Nehenehenui, (n.d.)) (Ngati Koata No Rangitoto Ki Te Tonga Trust, 2002),
- *Sustainable Wastewater Management* (Minisitry for the Environment, 2003),
- *An indigenous perspective on water recycling* (Morgan, 2005),
- *Cultural Drivers Toward Land Based Disposal and Applications Enabling This* (Simmonds, Austin, & Madison, 2019),
- *From Tapu to Noa – Māori Cultural Views on Human Biowaste Management* (Ataria, et al., 2019),
- *Wai Māori - Māori values in Water* (Grace, 2010),
- *A Guide to the Principles of the Treaty of Waitangi as Expressed by the Courts & Waitangi Tribunal* (Waitangi Tribunal, (n.d.)),

This review found that there is a lack of scientific literature around Māori perspectives on recycled water use, perhaps because it is not that common yet in New Zealand. The specific views of iwi and hapū for particular projects involving recycled water may be recorded in individual Resource Consent decisions, but these were not readily available for the completion of this report.

Is noted that this sectionwill not represent the views of all iwi and hapū and are not intended to be a replacement for robust engagement with tangata whenua.

5.1.1 Origin – Ranginui and Papatuanuku

Māori have a deep cultural connection to the land and surrounding water and consider themselves as ‘kaitiaki o te whenua’ – Guardians of the land. The rooted connection to the environment originates from the Māori creation story of Ranginui (the skyfather) and Papatuanuku (the earth mother). A version of this story is Ranginui’s longed embrace with Papatuanuku after their children separated them. Nga Roimata o Ranginui (the tears of Ranginui) is rainfall, while Nga Puna Tapu o Nga Atua (the weeping of Papa) are the springs. In order to maintain the balance of the world, both rainfall and springs are considered tapu (sacred). The tapu water is only suitable for human use after it has travelled over Papatuanuku to be in a state of noa (ordinary). (Morgan, 2005)

5.1.2 Mātāpono – Principles

Imbedded in the creation story are mātāpono, Māori principles that align with Māori values and traditional knowledge. While some definitions vary among different Māori iwi and hapū, below are several principles that help us understand Māori connection to water and their surrounding environment.

Whakapapa (Genealogy): Māori understand the interconnectedness of all living beings and elements, including water. They recognize the mauri (life force) within water and believe in the importance of maintaining its purity for the well-being of future generations. Treated recycled water would be managed in a way that respects its whakapapa and preserves its integrity.

Tapu and Noa (Sacred/restriction and ordinary/free from restriction): Tapu and noa are key cultural constructs that were central to traditional Māori society and continue to inform thinking and practice in Māori

society today. In Māori culture, human waste is “tapu” (unsafe/dirty/bad) and this needs to be converted to noa (safe/clean/good) prior to water contact. Tapu and noa should be considered in combination with other cultural principles, including mana, for a more complete understanding of the greater cultural landscape. (Ataria, et al., 2019)

Mauri (Life force): Mauri is the essence that has been passed from Ranginui and Papatuanuku down to all living entities through the whakapapa in the Māori creation story. Mauri is the essential quality and vitality of a being or entity. Also used for a physical object, individual, ecosystem or social group in which this essence is located. Any actions that change or degrade the mauri of an entity will have an impact on its surroundings and therefore the integrity of another being or entity. (Morgan, 2005)

Kaitiakitanga (Guardianship): The concept of kaitiakitanga emphasizes the responsibility of individuals and communities to care for and protect the mauri of natural resources, including water. Māori view themselves as kaitiaki (guardians) of the land and waterways and can place restrictions as they see fit to protect the land and waterways. This stewardship would extend to the management of recycled water resources. (Minisitry for the Environment, 2003) (Lant & Peneha, 2012) (Te Nehenehenui, (n.d.)) (Ngati Koata No Rangitoto Ki Te Tonga Trust, 2002)

5.1.3 Bodies of Water

Māori have a range of classifications for water depending on the particular qualities of the waterbody. While there is likely to be Iwi variations of these some examples include: (Grace, 2010)

Wai-ora (pure water): Waiora is the purest form of water. It is used in rituals to purify and sanctify and has the power to give life, sustain wellbeing and counteract evil. It is the physical and spiritual expression of Ranginui in his longed for embrace with Papatuanuku. The tears of Ranginui once in contact with Papatuanuku gives it its purity as water for human consumption, this is where the mauri of the water is also at its most pure. Water can only remain as waiora if its contact is protected through appropriate prayers.

Wai-Māori (freshwater): Water becomes waimāori when there is unprotected contact. This is referred to as ordinary water which runs free or unrestrained and it has no sacred associations. Waimāori has mauri which can be controlled by ritual. (Grace, 2010)

Wai-kino (polluted): Waikino has two meanings. Waikino is the term for water that has the potential to cause harm such as rapids through a gorge, or water submerged snags. The second meaning is which a body of water has its mauri altered through pollution or corruption.

Wai-mate (dead water): Geographically it refers to sluggish water, stagnant or back water. Some tribes refer to it as waikawa. This class of water has lost its mauri and is dead in the sense that it has lost its power to rejuvenate either itself or other living things. Like waikino, waimate is dangerous to humans because it can cause illness or misfortune. However, the difference is the total loss in existence of a mauri.

Wai-tai (salt or water from the ocean): This term refers to rough or angry water as in surf, waves or sea tides. Waitai is also used to distinguish sea water from fresh water. Waitai goes through mauri restoration through the evaporation and precipitation which water is returned to Tangaroa (Māori protector of the sea). This is a natural process of generation, degradation, and rejuvenation.

From a traditional Māori perspective polluted water is in a state of tapu and diminished mauri (Grace, 2010). The process of water passing through Papatuanuku will bring the water from a state of diminished mauri to be purified and have its mauri, or essence, restored. This is considered necessary, irrespective of whether treatment to remove or dilute pathogens, chemicals and metals has occurred. Figure 5-1 below shows a simple water cycle.

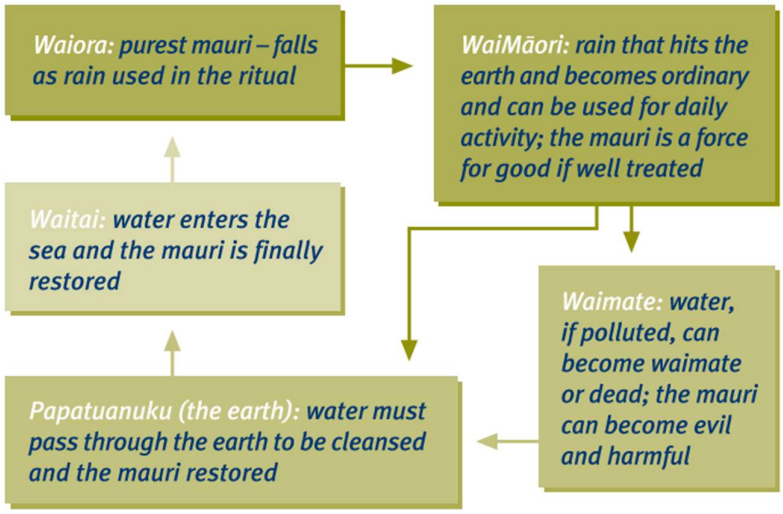

Figure 5-1 Water cycle traditional Te Ao Māori perspective (Minisitry for the Environment, 2003)

5.2 Examples of how Māori principals might be applied to the use of treated recycled water

Māori principles and practices can be applied in practical ways to the use of treated recycled water, promoting sustainability, cultural integrity, and community well-being. By integrating traditional knowledge with modern approaches, Māori communities can continue to uphold their responsibilities as kaitiaki (guardians) of the environment for future generations. This section was informed by *Wai Māori - Māori values in Water* (Grace, 2010), iwi management plans for Tairawhiti, Whakatu, Tai Tokerau and Waikato (Lant & Peneha, 2012) (Te Nehenehenui, (n.d.)) (Ngati Koata No Rangitoto Ki Te Tonga Trust, 2002) and dicussions with mana whenua.

Some examples of how Māori principles and practices might be applied to the use of treated recycled water:

Community-led Water Management: In a Māori community, a water management project involving treated recycled water might begin with extensive consultation and engagement with local iwi and hapū. Traditional knowledge holders could provide insights into the spiritual, cultural, and ecological significance of water in the area, guiding decisions about the treatment and use of recycled water.

Marae Gardens and Agriculture: Many marae (Māori meeting grounds) have gardens or agricultural plots where traditional crops are grown. Treated recycled water could be used for irrigation, reducing reliance on freshwater sources and promoting sustainable land use practices. Community members would work together to ensure that the use of recycled water aligns with cultural values and respects the mauri of the land.

Restoration of Waterways: Māori have a strong interest in restoring and protecting waterways, which are often important cultural and ecological sites. Treated recycled water could be used in restoration projects to support the rejuvenation of streams, wetlands, and other aquatic habitats. Māori would actively monitor water quality and ecosystem health, drawing on both traditional knowledge and scientific expertise to inform their management efforts.

Aquaculture and Fisheries: Māori have a long history of fishing and gathering seafood from coastal waters. Treated recycled water could be used in aquaculture operations, such as mussel or fish farming, with careful consideration given to potential impacts on water quality and marine ecosystems. Māori customary practices for managing fisheries and mahinga kai sites would inform decisions about the use of recycled water in these activities.

Education and Cultural Revitalization: Māori communities may use projects involving treated recycled water as opportunities for education and cultural revitalization. For example, schools and community groups could learn about traditional water management practices, participate in monitoring programs, and engage in ceremonies or rituals to acknowledge the importance of water in Māori culture.

5.3 Considerations for the development of recycled water regulations in New Zealand

In this review, the lack of specific iwi and hapū perspectives on recycled water use is notable. Scientific literature on this subject was minimal. Further investigation of individual Resource Consent decisions may provide specific perspectives on particular projects, however it appears there is a general lack of information on this topic, possibly because these conversations have not yet happened at a large scale. However, there are things that can be learned from the experiences from wastewater disposal projects.

When preparing plans and implementing the resource consent process, local authorities must recognise the principles of the Te Tiriti o Waitangi. (Waitangi Tribunal, (n.d.)) The development of regulations for recycled water must also recognise these principles:

- Partnership
- Protection
- Participation

The provisions of Te Mana o te Wai are currently being reviewed (in particular the hierarchy of water use) but it is likely that future recycled water standards would also need to give effect to Te Mana o te Wai, particularly the parts requiring tangata whenua to be involved in decision making. The considerations outlined in this report are aligned with both the Te Tiriti o Waitangi and Te Mana o te Wai.

Important considerations when working with iwi and hapū (Minisitry for the Environment, 2003):

- Work in a partnership framework, including at the decision-making deign level.
- Wider kaitiaki responsibilities are respected and statutory requirements understood.
- The particular spiritual concerns of all groups are recognised and given respect.
- Iwi organisations work well with local hapū or marae groups, and vice versa.
- There is willingness to seriously consider Māori perspectives about waste management and re-entry into the environment.
- All people who have a right to speak for the groups are included and consulted.
- Enough time is set aside for internal discissions.

Not following Māori practices, particularly in relation to water management, can have several consequences, including:

Loss of Mauri (due to the mixing of waters): In traditional Māori environmental philosophy, every element of the natural environment has its own unique mauri – be it a specific stream, river, bush, tree, mountain, or person. Mixing the mauri of two different sources can be seen as a disruption to the natural order, potentially diluting the sacred qualities.

If waters from one catchment are transported into another catchment, these spiritual forces are mixed. This is often seen in wastewater systems, where water collected in one catchment is piped to another for community use, and the wastewater is discharged into a third catchment. This practice holds significant implications for Māori and others who adopt a traditional approach to ecosystem or environmental management. (Minisitry for the Environment, 2003)

Cultural Disrespect: Ignoring Māori practices can lead to a lack of respect for Māori culture, spirituality, and traditional knowledge systems. This disregard for indigenous perspectives undermines the cultural identity and well-being of Māori communities, eroding their sense of connection to the land and waterways.

Environmental Degradation: Māori have a deep understanding of the interconnectedness of ecosystems and the importance of maintaining the health and integrity of natural environments. Failing to follow Māori practices and their position as kaitiaki of the land and waterways can result in environmental degradation, including pollution of waterways, loss of biodiversity, and degradation of cultural sites.

Loss of Traditional Knowledge: Māori traditional knowledge systems, including practices related to water management, are passed down through generations and are vital for sustaining cultural practices and relationships with the environment. Disregarding Māori practices can lead to a loss of this valuable knowledge, undermining the resilience of Māori communities and their ability to adapt to environmental changes.

Iwi/Hapū/Community Disempowerment: Exclusion of Māori voices and perspectives from decision-making processes related to water management can contribute to a sense of marginalization and disempowerment within Māori communities. This lack of inclusion can perpetuate historical injustices and exacerbate existing disparities in access to resources and opportunities.

Legal and Political Conflict: Failure to recognize Māori rights and interests in water management can result in legal and political conflicts between Māori communities and government authorities due to not acknowledging the Te Tiriti o Waitangi. Disputes over access to water resources, land development projects, and environmental protection measures can lead to protracted legal battles and strained relationships.

Overall, not following Māori practices for water management can have wide-ranging social, cultural, environmental, and legal consequences, highlighting the importance of respecting indigenous perspectives and knowledge in sustainable resource management. Embracing Māori values and principles can lead to more inclusive, equitable, and environmentally sustainable approaches to water management that benefit all members of society.

6 Technology, Operations and Monitoring

Recycled water practitioners from overseas emphasised the level of technical skill required of a regulator. The following sections touch on some of the key issues from our review. A more detailed summary of technical considerations is provided in Appendix B.

6.1 LRVs

A log credit (LRV) approach can be applied to a wide range of scenarios and is more applicable for varying use types than requiring specific processes. Prescribing specific processes makes adapting for technology familiarity and changes in technology more difficult.

To reduce any risks around potable reuse, requirements could be written such that a regulator and their advisors (if required) are involved in the planning and concept design to consider and manage regulatory risks.

Based on the findings from this review, a pragmatic approach is to apply the same LRV requirements for virus, protozoa and bacteria to all recycled water schemes (potentially depending on the source water characterisation), with:

- LRV requirements cumulatively applied across an entire scheme (e.g. 6 log), including:
  - Wastewater treatment, with minimum treatment standards required (e.g. 2 log) such that there is always a minimum level of treatment (also noting that discharges may be required when there is no reuse available).
  - Advanced water treatment (if applicable)), and
  - water use controls (on site measures)
- LRVs requiring a multi-barrier approach for viruses, protozoa and bacteria to provide additional resilience (for example not all protozoa LRVs obtained from a single process unit).

This approach allows a consistent health-based thinking and approach to recycled water schemes where the use of the water is more restricted with reduced treated water quality. This approach removes any conversation around the required log credit removal needed for different water uses.

Chemical considerations also need to be included, and given recycled water will be discharged to the environment as well as for used for community purposes; these should consider both public health and environmental risk factors when determining such limits. The balance between national and site-specific considerations needs to be carefully considered in the development of any future regulations.

6.2 Managing Risks/Scale/Complexity

Recycled water systems have a high-risk profile. Applying a continuum approach, where health risks are managed through both the treatment and the use of recycled water, can provide practicable options for recycled water schemes. For example, high quality recycled water will have limited restrictions, whereas a typical wastewater discharge will have more significant use restrictions including the crop type and irrigation type used. This approach could be applied to all wastewater discharges, with a change in thinking from disposal of wastewater to reuse of wastewater in many instances.

South Australian recycled water scheme operators have highlighted the importance of both a supply and use management plan for recycled water, and that the value of these documents has increased when the overall document length was reduced from 400 pages to approx. 60 to 80.

Just like drinking water safety plans, these documents are very important to understand, manage and monitor risks and improvements to a water scheme. Further consideration could be given towards making

these documents more integrated with existing digital tools such as Hinekōrako and water quality reporting so that issues can be seen and reviewed by a supply/use and regulatory perspective.

Critical control points are another method for managing risks. The definition of a critical control point should be clearly defined, with a requirement that any process claiming a log credit has one, where direct and indirect (online monitoring) testing can alarm and take an appropriate control action.

Particularly for complex systems, where a multi-barrier treatment approach is required, the LRV could also be calculated throughout a treatment system based on individual process performance.

7 Contaminants of Emerging Concern

Contaminants of emerging concern refers to chemical or microbial contaminants that are not included in a current regulatory framework. These contaminants may be known or unknown including:

- Well known to be of concern but largely avoided for both testing or clinical health studies,
- Not detected previously in wastewater (we did not know to look, or because we did not have the technology to be able to detect), or
- Increasing in concentration, and have negative impacts on human or environmental health.

They include metabolised compounds such as endocrine disrupters, chemical compounds like PFAS, and microbiological compounds like COVID-19.

New Zealand has relatively low levels of environmental PFAS due to the lack of PFAS manufacture in New Zealand, and although there are a few places were higher levels of PFAS have been detected around airports (for example), levels in New Zealand waterways so far are low. (Univeristy of Auckland, 2024) (University of Auckland, 2022) A study in 2022 by ESR found low concentrations of PFAS in some shallow groundwater systems. Of the 131 wells tested, 11% detected PFAS. All the PFAS detected were below the New Zealand Maximum Acceptable Values (MAV) for drinking water. (Close & Banasiak, 2023) However, this indicates PFAS compounds, sourced from human and industrial activities (e.g., degradation of non-stick, and stain-resistant consumer products; paper food packaging; cosmetics, use of class B fire-fighting foam etc.) are making their way into some shallow groundwater systems (Close & Banasiak, 2023).

PFAS contamination can originate from many different sources including wastewater treatment plants and be released into the environment through air, water or improper disposal. Much of the PFAS from WWTPs ends up in the solids stream, but it can also be present in the liquid phase discharge. Source management and isolation and treatment of high-risk areas is recognised as a value approach in the USA (Hunter, McNamara, & Moss, Proactively Planning for PFAS, 2024), and New Zealand needs some collective thought as to how this could be applied.

Microplastics have become prevalent in all municipal and industrial wastewater streams due to the widespread use of plastics in modern society. (Macdonald, Rule, Fahrenfeld, & Sturm, 2022) However, conventional secondary and tertiary treatment processes are very successful at removing a range of microplastics, WWTPs removing microplastics with removal efficiencies in the 75% to 100% range for conventional WWTPs. (Macdonald, Sturm, & Fahrenfeld, 2020) While microplastics concentrations in effluent are lower than in influent indicating that they are effectively being removed from the liquid stream in WWTPs, they are not being digested – and so they need to go somewhere. Where they are removed from the liquid stream, they end up in the biosolids, and become a pollution problem associated with the solids' disposal method as opposed to the discharge of the wastewater.

In the USA, the different states water reuse regulations have different requirements regarding contaminants of emerging concern, leading to inconsistencies in how these contaminants are managed. In Australia, the ADWG include monitoring advice for contaminants of emerging concern. The AGWR classes hazards as 'conventional' or 'emerging' (Table 2.2 AGWR) so contaminants of emerging concern are included in the hazard identification and thus, outline procedures for identifying and managing risk associated with these contaminants. The individual states recycled water guidelines often include specific requirements for monitoring and managing these contaminants.

Identification and quantification of new contaminants of concern is difficult. Water quality laboratories don't necessarily have the expertise or ability to detect specific compounds at the levels they exist in the environment. Sometimes universities are better equipped to do this testing with newly developed methods, however the initial results are not likely accredited. If the regulatory system requires certification of labs, then each time a new

contaminant is identified, then the laboratory must update its certification to include this, and any testing done by universities may not be certifiable.

The importance of specific contaminants of emerging concern may depend on the use of the water. For some industrial uses with low risk of human exposure, contaminants of emerging concern are less of a risk than for agricultural reuse or potable reuse.

New contaminants are being found all the time, and even five years ago the types and concentrations of contaminants of emerging concern being discussed were different to the ones causing the most concern today. Any recycled water regulations need to be able to respond and adapt to new contaminants through an adaptive regulatory structure to maintain health of the public and the environment. For many such compounds, unlike Bacteria / Virus / Protozoa removal, the wastewater industry (in particular) globally has not invested sufficiently to develop a sound understanding of the levels of removal / destruction / transformation of these complex compounds that can be achieved in each of the commonly employed unit treatment processes at primary, secondary and tertiary treatment levels.

The development of technologies, or demonstrating that existing technologies for the removal of contaminants of emerging concern, takes time, and this should be considered in the application of additional requirements into any regulatory framework.

8 Discussion on Regulating Recycled Water in New Zealand

Recycled water systems are inherently complex due to a combination of technological, regulatory, social, cultural, economic / financial, public health and environmental factors. The regulatory landscape alone can add significant complexity, if, as there are overseas, varying standards and regulations across districts creating a patchwork of rules that can be challenging to navigate. Multiple regulatory agencies, from local to federal levels, are often involved, and policies are continually evolving. Technologically, these systems require advanced treatment processes and the development of new infrastructure, including treatment plants, distribution networks, and storage facilities along with stringent water quality monitoring. Socially, recycled water schemes must address public safety concerns, distrust, perceptions, and cultural beliefs, all of which add layers of complexity to their implementation and acceptance.

The following section highlights the key findings from the previous sections for Taumata Arowai to consider in the development of recycled water standards in New Zealand.

8.1 A New Zealand Recycled Water Framework

The key learnings from the experiences in the USA and Australia are that this process takes time, and it is worthwhile getting it right. Practitioners in the USA considered that stronger national guidance from the beginning would have been beneficial for the industry by more proactively encouraging adoption of recycled water as an alternative water source. Both the USA and Australia regulate water at a state level and in New Zealand a decision would need to be made whether or not to continue down a similar path with regional councils regulating recycled water uses, and the extent to which they are capable of doing this (from a skill and resource perspective) and can set conditions around those discharges. The alternative is for the limits and consent conditions for recycled water use to be set at a national level, which would be preferable from a public health and standardisation perspective.

There are a number of parties that will have interests in the development of recycled water regulations in New Zealand. Only some of these parties will be involved in the application and administration of any regulations.

The development of recycled water regulatory framework will be influenced (to some extent) by the changes to the resource management system, and the development of any wastewater performance standards.

8.1.1 Regulatory Scope

There are many potential sources of recycled water, and many ways in which recycled water may be used in New Zealand. From discharge to productive or non-productive land, groundwater injection, direct or indirect potable reuse and ultra-high purity industrial use. Each source and use type has a different risk-profile, and a regulator would need to consider the extent to which different use types have different limits and/or rules applied to them.

A primary driver for recycling water is beneficial use of treated municipal wastewater effluent. Reuse of wastewater to land for irrigating crops (particularly non-food crops) and parks is a relatively low risk activity when suitable usage controls are in place. A staged implementation of recycled water regulations could be implemented, to first address this driver, and then adapt for more complex and higher risk activities over time as New Zealand becomes more accepting (socially and technically) of unrestricted and potable reuse applications. As outlined in Figure 8-1, there is a hierarchy of end uses, water quality, regulatory complexity and associated risk for different water recycling scenarios from restricted to unrestricted uses. Note that there is also an industrial use class that has higher treatment requirements than direct potable.

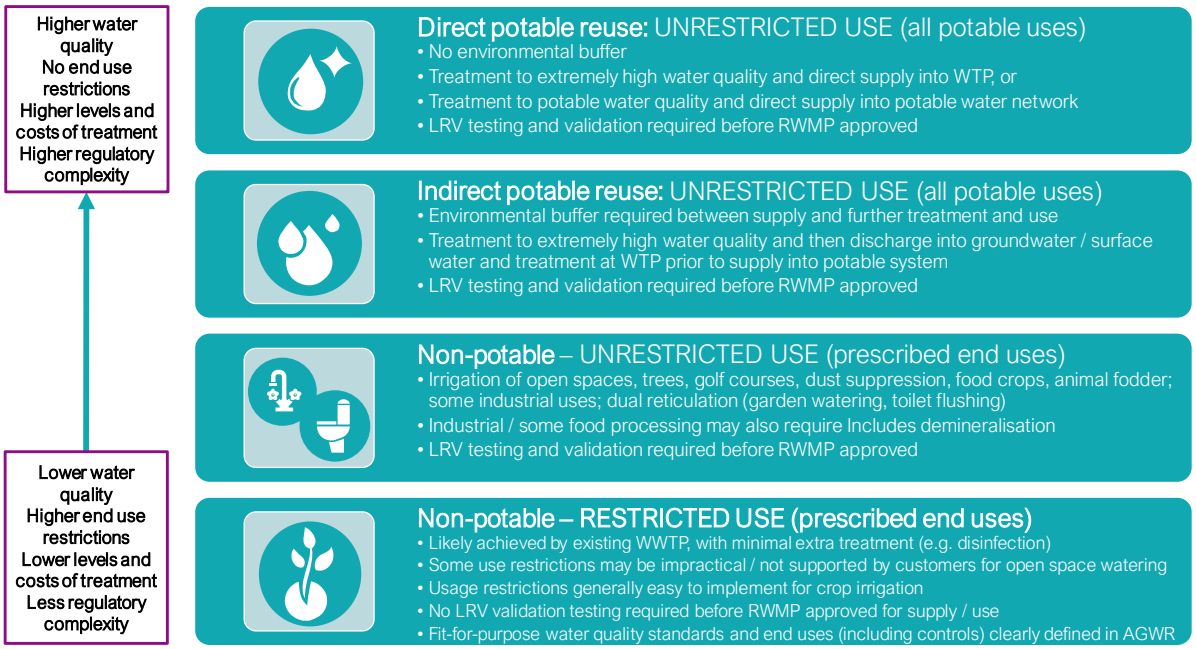

Figure 8-1 Hierarchy of recycled water quality, end uses and regulatory complexity.

A staged approach would have the advantage of breaking the regulatory process into smaller regulatory steps, that could be implemented in shorter timesteps. However, it is important to consider the 'end-state' of recycled water regulation (i.e. working towards direct potable reuse) such that reuglations are easily adapated to these varying use types. Guidelines or regulation documents for lower risk classes should be framed in a way such that there is a clear progression to the ultimate objective.

A staged approach in order of risk also allows technical skills to be built, both within the regulator, the public and water and health professionals. In this context, consideration could be given initially to restricted uses of non-potable recycled water, to enable a first step in the transition to broader water recycling (including potable) strategy implementation. As outlined in Figure 8-2 (adapted from AGRW, 2006), many uses are possible with secondary treatment and lagoons (required for detention time) and/or disinfection to achieve the required water qualities. We note that this is an example only and that a sound risk-based framework is required to develop appropriate controls.

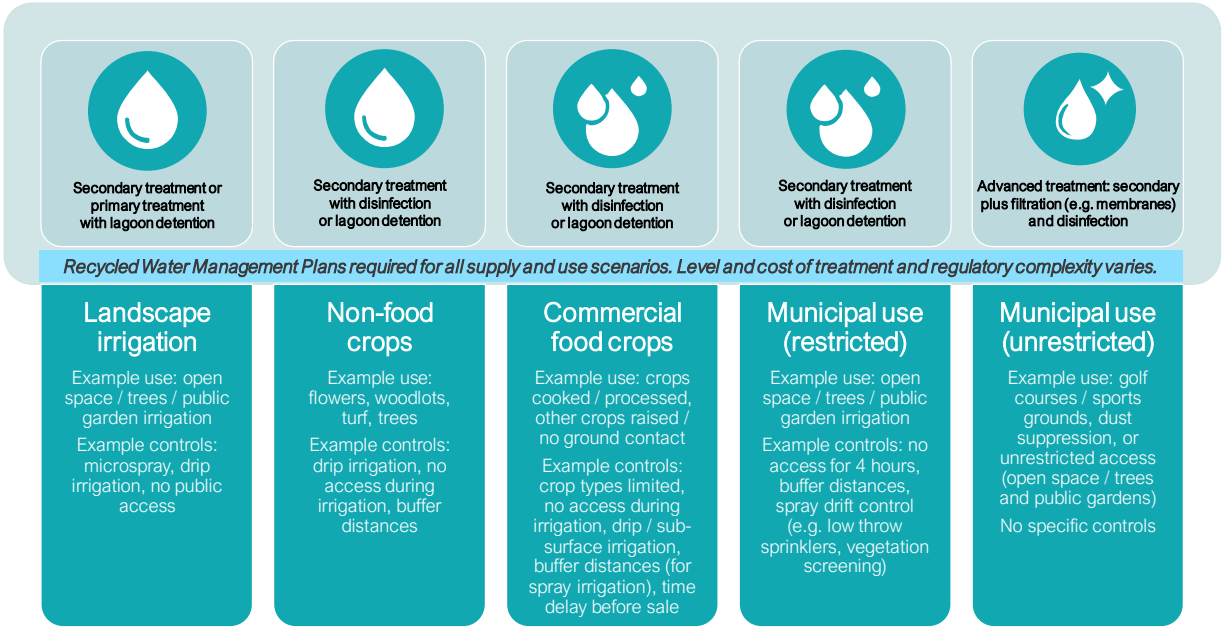

Figure 8-2 Potential first stage of water recycling regulations in New Zealand

Important considerations in any initial recycled water standards would be the definition of:

- Source water types appropriate for application of recycled water guidelines (stormwater, grey water, industrial wastewater, and/or municipal wastewater)
- End uses and recycled water quality objectives (health based and environmental / other), taking into consideration the risk profile across the continuum from source water through treatment to storage, distribution and reuse, and end user controls / usage restrictions to be defined.
- Supply and use risk management/safety plans, and the definition of mandatory inclusions prior to approval of a new recycled water scheme
- International market acceptance of New Zealand products

The Water Services Act only covers wastewater networks (and network operators) that are operated by, for, or on behalf of one of the following:

- A local authority, council-controlled organisation, or subsidiary of a council-controlled organisation:
- A department, or
- The New Zealand Defence Force.

This may leave a gap where other types of recycled water sources do not fit within the regulatory system. When a framework is developed, consideration should be taken to avoid creating unintended barriers to recycled water sources and use because of the mechanism through which the document (standards/guidelines) is introduced. For example, Tamworth was discussed in Section 3.2, where an industrial source of recycled water is caught in a regulatory gap because the recycled water standards do not account for industrial sources and create a barrier for this sort of reuse.

8.1.2 Regulatory Framework

The details of regulatory mechanisms for recycled water in New Zealand have not been specifically investigated at this time, and will somewhat depend on the intended scope as discussed in the previous section, but there are several options available for establishing a regulatory framework in NZ, including:

- The status quo i.e. the ad hoc adoption of parts of overseas guidelines (typically suggested by individual scheme proposers) by Regional Councils on a case-by-case basis. This has the potential for missed opportunities for recycling water as it is seen as too difficult to introduce and to implement as well as

creating the situation where different standards for recycled water exist all over the country and these are being proposed by consent applicants rather than being set by a regulatory body.

- Incorporating national standards for recycled water within the existing resource management framework, similar to the way the existing National Environmental Standards are applied This could be as:
    - Part of the Wastewater Treatment Performance Standard
    - Separate to the Wastewater Performance Standard
- Developing guidelines similar to the Guidelines for the Safe Application of Biosolids to Land in New Zealand. These are optional guidelines which local councils can choose to adopt in their regional plans and set permissions for certain activities e.g., Application of class XX biosolids to land is a permitted activity.
- Creation of a National Environmental Standard for Recycled Water similar to the NES for Freshwater or Sources of Human Drinking Water
- Establishing a bespoke framework (similar to the drinking water regulations)
- Incorporating recycled water (for potable use) into the drinking water regulations

Table 8-1 provides a high-level comparison of these regulatory mechanisms and the pros and cons of each. A full assessment of these options is not part of the scope of this report. Incorporating recycled water standards into the under-development Wastewater Treatment Performance Standards, or creating similar but separate recycled water standards would be the simplest approach for Taumata Arowai, but may not be able to adequately cover the increased human health risks associated with recycled water in the forms of the sorts of comprehensive treatment rules, risk management procedures and testing which are features of international recycled water applications.

Table 8-1 Comparison of potential recycled water regulatory mechanisms for New Zealand

Regulatory Option	Who sets standard	Who regulates	Pros	Cons
Status quo	Regional Councils	Regional Councils under the RMA	• Well understood system, no changes required	• Existing barriers to recycled water use remain • Lack of technical expertise in Regional Councils • Inconsistent application across country • Regulation likely limited to water quality standards
Incorporate recycled water into Wastewater Performance Standard	Taumata Arowai (for municipal wastewater sources)	Regional Councils under the RMA	• WW Discharge work is already underway • Consistent approach nationally • Minimal disruption to current approach, phased introduction • Mandatory application for municipal wastewater, optional adoption for other wastewater discharges	• Perpetuates the negative perception of reuse of wastewater • May delay development of Wastewater Performance Standards or add complexity • May not be adequate to support industrial or domestic reuse purposes • Depending on scope of standard, may not cover all aspects of risk management for example unlikely to require a risk management plan to be developed • Regulation likely limited to water quality standards
Create separate recycled water standards applied under RMA similar to Wastewater Performance Standards	Taumata Arowai (for municipal wastewater sources)	Regional Councils under the RMA	• Could build on Wastewater Performance Standards • Consistent approach nationally • Minimal disruption to current approach, phased introduction • Mandatory application for municipal wastewater, optional adoption for other wastewater discharges	• May not be adequate to support industrial or domestic reuse purposes • Depending on scope of standard, may not cover all aspects of risk management for example unlikely to require a risk management plan to be developed • Regulation likely limited to water quality standards
Recycled Water Guidelines	Taumata Arowai (for municipal	Local Authorities as part of district plans	• Ability to set more comprehensive rules and standards • Consistent approach nationally	• Optional adoption, councils may choose to make local changes in the application • May not be adequate to support industrial or domestic reuse purposes

Regulatory Option	Who sets standard	Who regulates	Pros	Cons
	wastewater sources)		• Moderate disruption to current approach, phased introduction • Robust technical approach and evidence based • More focussed approach to engagement processes	• Local authorities may lack the skills to regulate
NES for Recycled Water	MfE in conjunction with Taumata Arowai	Local Authorities as part of district plans	• Ability to set more comprehensive rules and standards • Consistent approach nationally • Moderate disruption to current approach, phased introduction • Robust technical approach and evidence based • Mandatory adoption	• May not be adequate to support industrial or domestic reuse purposes • More complex regulatory mechanism • Local authorities may lack the skills to regulate
Bespoke Recycled Water Framework	Taumata Arowai (for municipal wastewater sources)	Taumata Arowai	• Ability to set more comprehensive rules and standards • Consistent approach nationally • Robust technical approach and evidence based • Mandatory adoption • Stronger regulatory approach	• Greater disruption to current system • More complex regulatory mechanism • May not be adequate to support industrial or domestic reuse purposes
Incorporate recycled water into the drinking water regulations	Taumata Arowai (for municipal wastewater sources)	Taumata Arowai	• Existing regulatory mechanism • Consistent approach nationally • Robust technical approach and evidence based • Mandatory adoption • Stronger regulatory approach	• Would only apply to potable reuse, separate mechanism required for non-potable reuse • Adds complexity to current drinking water regulations • May not be adequate to support industrial or domestic reuse purposes

The role of a recycled water regulator requires further consideration to balance public health and environmental risks. Due to the complexity and adaptability to changes for these systems, from experience overseas it is considered that a higher degree of regulator involvement, from early in scheme development, is good practice.

Australian and USA recycled water experts have all consistently noted that a success factor for recycled water schemes is having an active regulator who is involved in the scheme development and ongoing operation. This allows for the regulator to understand the journey and safeguards in place, how risks are being managed and also to provide input into how systems may be viewed. It also reduces the reliance on external experts who do not always have the same motivation as a regulator to create a clear regulatory pathway. This would only be possible in New Zealand with a more complex regulatory approach.

8.2 Iwi and Hapū

There is a gap in understanding about iwi and hapū views around recycled water. There may be some information in previous consent decision reports, or Taumata Arowai could reach out to iwi and hapū directly to get their views.

Any approach to recycled water regulation in New Zealand would need to give effect to the Te Tiriti o Waitangi and Te Mana o te Wai (currently under revision), particularly involving tangata whenua in decision making. There are opportunities to provide recycled water systems that align with the aspirations and values of iwi and hapū. Working closely with iwi and hapū is fundamental to realising this opportunity and this means allowing the time and resources for this to occur from the beginning of the development process, talking to a wide range of iwi and hapū as views are likely to differ around the motu. This collaborative approach would also ideally be built into the regulatory process at a project level as well.

Before launching into the more in-depth and nuanced cultural issues listed below, an introduction to the concept of recycled water and discussion about the potential benefits and risks associated with it will build understanding and go some way to softening the immediate distastefulness that can be associated with the idea of potable reuse in particular.

Regulations would need to consider:

- Introduction and discussion of the concept and uses of recycled water
- How to maintain the mauri of the water when it is recycled, and/or what end use is appropriate for which source
- Respecting the tapu and noa states for different types of water
- Upholding te Tiriti o Waitangi and including tangata whenua in decision making
- Respecting and incorporating matauranga māori and supporting māori ways of doing things into an approach
- Setting recycled water standards, policies and regulations that protect human and environmental health
- How tangata whenua may exercise kaitiakitanga and mana motuhake through the regulation (and implementation) process.

There may also be other learnings that could be gained from a more comprehensive review of perspectives of first nations people in Australia, Canada and the USA. This could include a literature review, direct discussions with regulators from these jurisdictions or with First Nations peoples themselves.

8.3 Water Literacy and Social Licence

Water literacy has been identified as a key enabler for community acceptance of recycled water schemes in overseas jurisdictions. Given the cultural sensitivity around discharges of human waste, up front discussions with iwi and hapū about the place of recycled water in New Zealand would help to frame up the boundaries and values for a recycled water regulatory framework, as well as provide an opportunity to improve water

literacy. Previous studies of water literacy in New Zealand around recycled water indicate that water literacy could be improved on. For recycled water, consideration would also need to be given to a long-term campaign to improve water literacy for the wider community as well as a project level. Reframing recycled water as a valuable source of water (as opposed to highly treated wastewater) may help with general public acceptance.

A national recycled water literacy campaign would need to include:

- Developing a rationale for why water recycling is important for New Zealand
- Identifying public perceptions and strategies to address these
- Learning from recycled water campaigns elsewhere, and other water communications strategies in New Zealand (for example the Three Waters Reforms).
- Developing a communications strategy. This could include materials targeted at different groups (e.g. school children, iwi and hapū, people that live in cities), and pilot programmes to test strategies
- Developing communications materials

8.4 Technical Advisory Committee

There are a wide range of technical considerations that will need to be made in development of recycled water regulations, beyond what has been discussed in this report. A technical advisory committee could be established to advise on recycled water matters and include representatives from wastewater, drinking water, utilities/suppliers, suppliers, university/research organisations, laboratories, scientists, international experts and regulators to help inform decisions and provide guidance into the recycled water regulations/standards. It is noted that a committee should only be in place for advice, and not to write any guidelines or regulations.

8.5 Economic development opportunities

Placing a circular economy lens on discharge to land highlights that there are opportunities to place high water use industry, or horticulture in close proximity to our WWTPs.

The management and end use of recycled water needs to be considered from an economic sense, with large international food industry giants demanding – somewhat contradictorily - that agricultural, pastoral and horticultural producers waste less water and also that recycled water is not used in certain applications (e.g., irrigation of some farmland).

In the USA, recycled water is frequently used for cooling water in power plants and for other industrial use which is less common in New Zealand. Other considerations can also be in other industries such as wine processing in South Australia where the processing can reduce public health risks.

8.6 Planning for Change

The regulatory framework for recycled water will need to be able to adapt to all manner of changes, and in the design of the regulations, the following should be considered:

- How new contaminants of concern will have clinical research, and be handled by any Laboratory certification system
- How research programmes into the presence and health risk of contaminants in New Zealand will be established and funded
- How regulations will be able to accommodate new or updated technologies
- How regulations will respond to new or novel sources or reuse types

This theme was noted by many international experts interviewed and the adaptability of a regulatory framework for changing learnings in science, technology, source waters, emerging contaminants and ‘new’ water use types is a key success factor in the development of any recycled water regulations such that regulations can remain future fit without continuous updates.

9 Key Messages and Next Steps/Priorities

When the recycled water experts from Australia and the USA were asked what advice they would give to New Zealand in starting out in developing recycled water standards, they all said it is worth taking the time to get it right. In California, the first indirect potable reuse projects were in the 1960's and they are only now approving the regulations 60 years later. There are of course lessons to be learned from the work California has done, and it is not expected that it will take nearly as long for New Zealand, but this will somewhat depend on the perceived urgency and drivers. In many jurisdictions, recycled water regulations have progressed in parallel with specific recycled water projects, and this has helped provide urgency, but hasn't always resulted in comprehensive or well-though through regulations.

For New Zealand in particular, there are important conversations to be had with iwi and hapū about the place of recycled water use in New Zealand, given it appears these conversations have not taken place to date and there is limited other recorded information about specific iwi and hapū perspectives on recycled water use. These conversations allow the Crown's obligations under Te Tiriti o Waitangi to be fulfilled by involving Māori upfront in decision making, and also may place constraints and boundaries around the source and use of recycled water that shape the regulations.

Current recycled water use in New Zealand is centred around the issue of disposing of wastewater. Changing the framing for recycled water to a water source, rather than a waste product, will help to change perceptions and mindsets about it. Development of any communications materials, policies and regulations should carefully consider the terminology used to avoid reinforcing the associated with waste prodcus and instead promote recycled water as beneficial.

Recycled water can come from many different sources and be used for many different purposes, with different risk profiles. There is considerable complexity in regulating such a product, and trying to simplify it to a single profile or standard has the potential for inadequate management of risks, or a system that tries to manage every risk resulting in a very high level of treatment at a high cost.

Staged implementation of recycled water regulations may address the immediate need around disposal of wastewater in the New Zealand context, but at the same time create a manageable pathway for a wider regulatory system and other uses of recycled water in the future. The staging could be aligned with increasing risk level to allow technical skills and experience to be developed in New Zealand in parallel with the development of regulations.

There are several options for creating a recycled water regulatory framework in New Zealand. It's important to have a robust national system for managing human health risks, and the simpler regulatory mechanisms (such as creating recycled water standards similar to the under development Wastewater Performance Standards) outlined in Table 8-1might not be able to achieve this.

Another key learning was not underestimating the expertise and resources required to develop and then implement recycled water regulations. This report has only touched on a few of the many technical considerations that need to be taken into account and Taumata Arowai may wish to consider drawing in technical expertise from around the industry to guide discussions and then development.

This review has highlighted some key workstreams for Taumata Arowai for the development of recycled water standards for New Zealand, these are discussed in the following sections.

9.1 Iwi and hapū

Iwi and hapū perspectives on recycled water are missing from the current dialogue. There are known cultural issues with the fate of human wastewater, and how recycled water fits into this context needs more nuanced discussion with iwi and hapū from around the country. This would also be an opportunity to improve water

literacy in communities. The other side of this question is how can cultural values and aspirations be incorporated into regulation, and there may be examples of this from overseas.

Actions to improve understanding of iwi and hapū views on recycled water, and how cultural aspirations could be incorporated into recycled water regulation might include:

- Comprehensive review of recycled water related consent decisions for iwi and hapū perspectives,
- Planning and initiating iwi and hapū engagement to ask what level of support there is for recycled water use in New Zealand and if there are some uses that would not tolerable under any circumstances
- Investigating incorporation of indigenous perspectives into overseas regulations through literature review and interviews
- Establishing an iwi hapū advisory group

9.2 Regulatory Design

More detailed consideration of the design of the regulatory system for recycled water, including the scope and framework to be applied, is required. Actions for this might include:

- Establishing a programme or road map to outline how New Zealand may reach potable reuse (if that is the desired end goal), and the stages of implementation
- Discussion with water short regional councils such as Waikato, Hawkes Bay, Canterbury and Marlborough to find how they are incentivising alternative water sources
- Investigation of the application of different mechanisms in New Zealand (which could include a more in depth look at other jurisdictions), and their ability to manage human health risks
- Consideration of the role and level of engagement of the regulator
- Defining recycled water terminology for NZ so it is consistent (use types vs classes etc)
- Engagement with other stakeholder agencies and local and regional government
- Establishing a technical advisory group to advise on technical details and determining matters for their consideration
- Engaging with other interested stakeholders – including the wider water industry. This will build education and awareness among the industry. A special interest group could be established.

9.3 Social Licence and Water Literacy

Developing a strategy for increasing water literacy and raising awareness about recycled water amongst targeted groups (such as school children) and also the wider community is a key component of a national recycled water strategy. This could be part of a wider, long-term strategy to improve water literacy throughout the country in partnership with other industry bodies such as WaterNZ. Actions could include:

- Engaging with communities to find out their current knowledge of and concerns about recycled water.
- Engaging with regions where wastewater consent renewals are approaching to promote and engage on recycled water
- Developing a piloted water literacy campaign to trial ideas
- Developing targeting education materials for schools
- Establishing a stakeholder engagement and communications plan,
- Assembling communications materials suitable for the general public and iwi and hapū

10 References and Acknowledgements

10.1 Acknowledgements

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A

Appendix A – Summary of Overseas Regulations

International regulations and guidelines - overview

The tables below provide a summary of legislation and supporting guidelines in Australia and the USA (California), and the respective document owners.
The document owner is also the regulator, except for National guidelines, which are applied, adapted as appropriate and regulated by individual State Government bodies.

Australian water recycling guidelines and regulations (examples)

Document Name	Type	Document Owner	Description
National			
Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 1) 2006	Guidelines	Managed by National Department of Climate Change, Energy, the Environment and Water, compliance regulated by State governments	This document provides: [1] generic framework for management of recycled water quality and use that applies to all combinations of recycled water and end uses [2] specific guidance on the use of treated sewage and greywater for purposes other than drinking and environmental flows An overview document is also available, which provides an introduction for anyone interested in recycling water, gives an idea of the scope and content of the full guidelines, and highlights some of the main issues in water recycling. The guidelines use a risk based framework for managing risks associated with the beneficial use of recycled water (treated wastewater).
Australian Guidelines for Water Recycling (AGWR): Managing Health and Environmental Risks (Phase 2) – Augmentation of Drinking Water Supplies 2008	Guidelines	Managed by National Department of Climate Change, Energy, the Environment and Water, compliance regulated by State governments	Provides specific guidance on identifying and managing risks associated with augmentation of drinking water supplies with recycled water (treated sewage and stormwater). The guidelines focus on the source of water, initial treatment processes and blending of recycled water with drinking water sources.
Australian Guidelines for Water Recycling (AGWR): Managing Health and Environmental Risks (Phase 2) – Managed Aquifer Recharge 2009	Guidelines	Managed by National Department of Climate Change, Energy, the Environment and Water, compliance regulated by State governments	Provides specific guidance on identifying and managing risks associated with storage of recycled water using managed aquifer recharge. The primary focus of this phase 2 document is: [1] protection of aquifers [2] quality of the recovered water in managed aquifer recharge projects using all water sources, including recycled waters
Australian Guidelines for Water Recycling (AGWR): Managing Health and Environmental Risks (Phase 2) – Stormwater Harvesting and Reuse.	Guidelines	Managed by National Department of Climate Change, Energy, the Environment and Water, compliance regulated by State governments	Provides specific guidance on identifying and managing risks associated with stormwater harvesting and reuse. The primary purpose of this document is to provide guidance on managing potential public health and environmental risks associated with the reuse of: [1] roofwater collected from residential buildings (including industrial buildings) [2] urban stormwater from sewered areas, including stormwater collected from drains, waterways and wetlands
Victoria			
Victoria guideline for water recycling - Publication 1910.2 (March 2021)	Guidelines	EPA Victoria	Defines the roles and responsibilities of suppliers, users, and government. They distinguish three classes of recycled water representing the minimum treatment required and associated water quality objectives for defined categories of use. The required level of treatment increases with the potential for higher levels of exposure to recycled water. In addition to minimum levels of treatment, specific uses may also be subject to site management controls to ensure the protection of public health and the environment. Compliance with the guideline provides the basis for exemption of reuse schemes from EPA Victoria works approvals and licensing requirements.
Technical information for the Victoria guideline for water recycling - Publication 1911.2 (March 2021)	Guidelines	EPA Victoria	Provides detailed guidance on assessing recycled water / treatment performance and risks (against health based and environmental / other water quality parameters) as well as guidance on Recycled Water Quality Management Plan (RWQMP) development (for class A water recycling schemes).
Guideline for irrigation with recycled water (2022)	Guidelines	EPA Victoria	Provides information to support designers and operators of irrigation systems using recycled water to assist them in assessing and managing risk
Recycled water use in surface waters guidance (2024)	Guidelines	EPA Victoria	Outlines the permission required and the information you need to provide to EPA Victoria when seeking approval to use recycled water in surface waters.
Guidelines for validating treatment processes for pathogen reduction: Supporting Class A recycled water schemes in Victoria (2013)	Guidelines	Department of Health	Provides guidance to Class A recycled water scheme proponents on the validation of treatment processes to meet microbial water quality objectives.
South Australia			
South Australian Public Health (Wastewater) Regulations 2013	Regulation	Department for Health and Wellbeing (DHW)	Over-arching legislation for wastewater (including reuse). Defines regulatory conditions, roles and responsibilites for wastewater and recycled water (treated wastewater). DHW approval of wastewater treatment and the supply and use of recycled water must be implemented in accordance with the regulations.
SA Health website - recycled water management requirements	Regulatory requirements / tools	SA Health (within Department for Health and Wellbeing)	All applications require a Recyled Water Risk Management Plan (RMP) and design report to obtain approval for supply and/or use of recycled water. Website outlines requirements for obtaining water recycling approvals, provides guidance on planning and design of recycled water systems, and templates for LRV analysis and Recyled Water supply and use RMPs. RMPs should be reviewed every 2 years.
Recycled Water Supply - Risk Management Plan Template	Regulatory requirements / tools	SA Health (within Department for Health and Wellbeing)	Template to obtain approval for supply of recycled water - guides the development of a RMP and preparation of information on: - Treatment of sewage at a Wastewater Treatment Plant - Supply of recycled water for non-potable end use by third parties - Application of LRVs to both wastewater treatment barriers and on-site preventative measures
Recycled Water Supply and Use - Risk Management Plan Template	Regulatory requirements / tools	SA Health (within Department for Health and Wellbeing)	Template to obtain approval for supply of recycled water and use by the supplier of the recycled water - guides the development of a RMP and preparation of information on: - Treatment of sewage at a Wastewater Treatment Plant - Supply of recycled water to connected third parties - Use of recycled water at the WWTP site or at nearby land owned or managed by the Water Industry Entity supplying the recycled water - Application of LRVs to both wastewater treatment barriers and on-site preventative measures
Recycled Water Use - Risk Management Plan Template	Regulatory requirements / tools	SA Health (within Department for Health and Wellbeing)	Template to obtain approval for use recycled water - guides the development of a RMP and preparation of information on: - Use of the recycled water supplied from a WWTP - On-site preventative measures
LRV endorsement table	Regulatory requirements / tools	SA Health (within Department for Health and Wellbeing)	Template for Water Industry Entities to obtain in principle approval for LRVs during the concept design phase of recycled water scheme development, and review of existing wastewater tratment plants that are proposed to be used for the production and supply of recycled water.

International regulations and guidelines - overview

The tables below provide a summary of legislation and supporting guidelines in Australia and the USA (California), and the respective document owners.
The document owner is also the regulator, except for National guidelines, which are applied, adapted as appropriate and regulated by individual State Government bodies.

Australian water recycling guidelines and regulations (examples)

Document Name	Type	Document Owner	Description
Queensland			
Public Health Act 2005 - Public Health Regulation 2018	Regulation	Department of Regional Development, Manufacturing and Water	Over-arching legislation for public health risk management. Include definition of water quality standards for recycled water (from treated wastewater) for potable and non-potable uses.
Water Supply (Safety and Reliability) Act 2008	Regulation	Department of Regional Development, Manufacturing and Water	Over-arching legislation for water supply risk management. it provides a regulatory framework for providing water and sewerage services, including functions and powers of service providers; and a regulatory framework for providing recycled water (potable and non-potable water quality), primarily for protecting public health.
Water quality guidelines for recycled water schemes 2008 (Department of Regional Development, Manufacturing and Water, 2008)	Guidelines	Department of Regional Development, Manufacturing and Water (previously named Department of Energy and Water Supply) and, Queensland Health	Provides guidance to recycled water providers on the minimum quality of recycled water for prescribed applications and how control measures may impact on what is considered an acceptable water quality
Recycled water management plan and validation guidelines 2008 (Department of Regional Development, Manufacturing and Water, 2008)	Guidelines	Department of Regional Development, Manufacturing and Water (previously named Department of Energy and Water Supply) and, Queensland Health	Recycled water providers that supply recycled water for high-exposure uses are primarily regulated by the Department of Regional Development, Manufacturing and Water. However, Queensland Health is a co-regulator of these schemes and is responsible for setting water quality standards as per the Public Health Regulation 2018. This document provides information to recycled water providers about preparing a Recycled Water Management Plan and validation/verification of treatment processes.
Guideline for low-exposure recycled water schemes (Queensland Health)	Guidelines	Queensland Health	Queensland Health is the primary regulator of low-exposure recycled water schemes. This document assists operators of low-exposure recycled water schemes to meet their obligations under the Public Health Act. The guideline outlines water quality and on-site controls required for low-exposure uses of recycled water.
Guide for preparing a recycled water management plan	Guidelines	Department of Regional Development, Manufacturing and Water (previously named Department of Energy and Water Supply) and, Queensland Health	Template for recycled water providers to use in preparation of a RWMP in accordance with the Queensland Water Supply (Safety and Reliability) Act 2008 (the Act), for the safe use of recycled water. It is used to document planning and management of recycled water schemes. to be used in conjunction with the Recycled water management plan and validation guidelines 2008.
Manual for recycled water agreements in Queensland	Guidelines	Department of Regional Development, Manufacturing and Water (previously named Department of Energy and Water Supply) and, Queensland Health	Information and guidance on the various issues that need to be considered when stakeholders are considering entering into an agreement to supply and/or use recycled water as part of a recycled water scheme.
Recycled water management plan (RWMP) decision tree	Guidelines	Department of Regional Development, Manufacturing and Water (previously named Department of Energy and Water Supply) and, Queensland Health	Guidance on determining when a RWMP is required
Recycled water scheme registration application form	Regulatory requirements / tools	Department of Regional Development, Manufacturing and Water (previously named Department of Energy and Water Supply) and, Queensland Health	Template for Recycled water scheme registration
Recycled water management plan forms	Regulatory requirements / tools	Department of Regional Development, Manufacturing and Water (previously named Department of Energy and Water Supply) and, Queensland Health	Templates for: - Recycled water management plan approval application - Amendment of recycled water management plans
Validation program forms	Regulatory requirements / tools	Department of Regional Development, Manufacturing and Water (previously named Department of Energy and Water Supply) and, Queensland Health	Templates for: - Validation program approval application - Amendment to a validation program

USA water recycling guidelines and regulations (examples)

Document Name	Type	Document Owner	Description
National			**to be updated / expanded**
Guidelines for Water Reuse, 2012 (USEPA, 2012)	Guidelines	USEPA	These guidelines include informatio to support the development of reuse programs and appropriate regulations, and the evaluation, planning, design, operation, or management of water reclamation and reuse facilities. They cover various aspects of water reuse, including treatment methods, quality standards, and regulatory considerations.
Safe Drinking Water Act (SDWA)	Regulation	USEPA: Office of Ground Water and Drinking Water (OGWDW)	The Act authorises the USEPA to establish minimum standards to protect drinking water and requires all owners or operators of public water systems to comply with these primary (health-related) standards. It also establishes minimum standards for state programs to protect underground sources of drinking water from endangerment by underground injection of fluids.
California			
A Proposed Framework for Regulating Direct Potable Reuse in California	Framework		Framework for the development and implementation of Direct Potable Reuse, including application of the goals and principles of public health protection as they pertain to different potable reuse scenarios, the regulatory approach proposed for DPR, and tools to avoid discontinuities in the risk assessment / risk management approach used. The health-protective framework for the regulation of potable reuse projects also includes a schedule for completing recommended research, and a process and timeline for updating the uniform water recycling criteria for surface water augmentation with recycled water.
TITLE 22 Code of Regulations - Division 4. Environmental Health - Chapter 3. Water Recycling Criteria	Regulation	State Water Resources Control Board	Includes definition of water quality requirements and end use restrictions / controls for different end uses of recycled water, including: - Non-potable reuse applications (e.g. irrigation, dual pipe etc) - Indirect Potable Reuse: Groundwater Replenishment – Surface and Sub-Surface Application, Surface Water Augmentation).

International regulations and guidelines - overview

The tables below provide a summary of legislation and supporting guidelines in Australia and the USA (California), and the respective document owners.
The document owner is also the regulator, except for National guidelines, which are applied, adapted as appropriate and regulated by individual State Government bodies.

Australian water recycling guidelines and regulations (examples)

Document Name	Type	Document Owner	Description
Alternative Treatment Technology Report for Recycled Water (2023)		State Water Resources Control Board - Division of Drinking Water	Information on treatment technologies (including specific makes and models) that can be used to comply with filtration and disinfection requirements of Title 22; and the process to be followed (pilot plant etc) for use of any alternative treatment types not pre-approved by the regulator (Division of Drinking Water).
Guidelines for the Preparation of an Engineering Report for the Production, Distribution and Use of Recycled Water (2023)	Guidelines	State Water Resources Control Board - Division of Drinking Water	All recycled water projects must have an engineering report approved by the State Water Resources Control Board – Division of Drinking Water - these guidelines define the requirements for inclusion in engineering reports, including for example: - roles and responsibilites - raw water and treated water quality - technical assumptions

International guidelines - overview: source waters and end uses covered by guidelines

Document Name	Source waters				End uses			
	Stormwater	Grey water	Industrial wastewater	Municipal wastewater	Direct potable	Indirect potable	High quality non-potable	Low quality non-potable
Australia: National								
Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 1) 2006 (document 21)	✓	✓	Only when trade waste discharges into municipal WW system	✓	-	-	✓	✓
Australian Guidelines for Water Recycling (AGWR): Managing Health and Environmental Risks (Phase 2) – Augmentation of Drinking Water Supplies 2008 (document 22)	✓	✓		✓	-	✓	-	-
Australian Guidelines for Water Recycling (AGWR): Managing Health and Environmental Risks (Phase 2) – Managed Aquifer Recharge 2009 (document 24)	✓	✓		✓	-	✓	✓	✓
Australian Guidelines for Water Recycling (AGWR): Managing Health and Environmental Risks (Phase 2) – Stormwater Harvesting and Reuse (document 23)	✓	-	-	-	-	-	✓	✓
Australia: Victoria								
Victoria guideline for water recycling - Publication 1910.2 (March 2021)	✓	✓	✓	✓	-	-	✓	✓
Technical information for the Victoria guideline for water recycling - Publication 1911.2 (March 2021)	✓	✓	✓	✓	-	-	✓	✓
Australia: South Australia								
SA Health website - recycled water management requirements	✓	✓	Only when trade waste discharges into municipal WW system	✓	-	-	✓	✓
Australia: Queensland								
Water quality guidelines for recycled water schemes 2008 (Department of Regional Development, Manufacturing and Water, 2008)	-	✓	Only when trade waste discharges into municipal WW system	✓	-	✓	✓	✓
Guideline for low-exposure recycled water schemes (Queensland Health)	-	✓		✓	-	-	✓	✓
USA: California								
Code of Regulations Title 22 - Division 4. Environmental Health - Chapter 3. Water Recycling Criteria	-	✓	Only when trade waste discharges into municipal WW system	✓	-	✓	✓	✓
A Proposed Framework for Regulating Direct Potable Reuse in California (2019)	-	✓		✓	✓	-	-	-

International guidelines - overview: Recycled water scheme planning, approval and risk management

Document Name	Recycled water scheme planning, approval and risk management				
	Treatment / other technical requirements / guidelines	**Recycled water management plan requirements / guidelines**	**Water quality parameters - health based targets**	**Water quality parameters - environmental / other**	**Monitoring guidelines**
Australia: National					
Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 1) 2006 (document 21)	Guidance notes include treatment types that may be required for / capable of achieving different water quality objectives Not prescriptive regarding design of treatment processes, allows for flexibility by practitioners and State regulatory agencies	Risk management framework includes guidance on what should be included in RWMPs (12 key elements) Not prescriptive, allows for flexibility by practitioners and State regulatory agencies	Wastewater (domestic sewage) LRVs defined for bacteria, protozoa and viruses; health based targets defined for some other parameters; targets vary between end uses	Guidance notes included in AGWR, for adaptation to individual scenarios and regulatory settings in each State - not prescriptive, risk based approach	Guidance notes on baseline (before recycled water scheme planned and designed), validation (before new scheme approved and supply commenced), operational (ongoing, regular) and verification (review of scheme) Not prescriptive, allows for flexibility by practitioners and State regulatory agencies
Australian Guidelines for Water Recycling (AGWR): Managing Health and Environmental Risks (Phase 2) – Augmentation of Drinking Water Supplies 2008 (document 22)	Consistent with AGWR document 21, includes additional considerations for augmentation of drinking water supplies	Consistent with AGWR document 21, includes additional considerations for augmentation of drinking water supplies	DALY approach used for microbial risk management - tolerable risk defined as 10^{-6} DALYs per person per year, consistent with WHO Guidelines for Drinking-Water Quality (2006)	Chemical: various guidelines (e.g. NHMRC, WHO) used as relevant for specific chemicals of interest	Consistent with AGWR document 21, includes additional considerations for augmentation of drinking water supplies
Australian Guidelines for Water Recycling (AGWR): Managing Health and Environmental Risks (Phase 2) – Managed Aquifer Recharge 2009 (document 24)	Consistent with AGWR document 21, includes additional considerations for Managed Aquifer Recharge	Consistent with AGWR document 21, includes additional considerations for Managed Aquifer Recharge	Consistent with AGWR document 21	Guidance notes on risk identification and management (e.g. salinity, nutrients), operational issues	Consistent with AGWR document 21, includes additional considerations for Managed Aquifer Recharge
Australian Guidelines for Water Recycling (AGWR): Managing Health and Environmental Risks (Phase 2) – Stormwater Harvesting and Reuse (document 23)	Consistent with AGWR document 21, includes additional considerations for stormwater harvesting	Consistent with AGWR document 21, includes additional considerations for stormwater harvesting	Stormwater LRVs defined for bacteria, protozoa and viruses; health based targets defined for some other parameters; targets vary between end uses	Guidance notes on risk identification and management (e.g. salinity, nutrients), operational issues	Consistent with AGWR document 21, includes additional considerations for stormwater harvesting
Australia: Victoria					
Victoria guideline for water recycling - Publication 1910.2 (March 2021)	Provides framework for recycled water treatment planning and operation	Provides framework for recycled water risk management	Provides framework for recycled water risk management - classes of recycled water defined (A / B / C), consistent with AGWR document 21, in some cases adpated to Victorian context (*LRVs for Class A aligned with AGWR without adaptation)	Provides framework for recycled water risk management - classes of recycled water defined (A / B / C), consistent with AGWR document 21, risk based approach	Provides framework for preparting a monitoring plan: baseline monitoring ('Where are we now?'), validation monitoring ('Will it work?'), operational monitoring ('Is it working now?') and verification monitoring ('Did it work?')
Technical information for the Victoria guideline for water recycling - Publication 1911.2 (March 2021)	Provides detailed guidance on assessing recycled water / treatment performance and risks, but does not prescribe specific treatment requirements	Provides guidance on Recycled Water Quality Management Plan (RWQMP) development (only for class A water recycling schemes)	Provides detailed guidance on assessing recycled water (health based water quality parameters) and health risks, and developing risk management plans accordingly	Provides detailed guidance on assessing recycled water (environmental water quality parameters) and environmental risks, and developing risk management plans accordingly	Provides guidance on critical control point definition and monitoring Refer also: Guidelines for validating treatment processes for pathogen reduction: Supporting Class A recycled water schemes in Victoria (2013)
Australia: South Australia					
SA Health website - recycled water management requirements	Consistent with AGWR document 21 LRV credits defined for different treatment processes (*higher LRV credits require validation testing) Spreadsheet developed for in principle treatment process approval before planning and design commenced in detail	Consistent with AGWR document 21 RWMPs are mandatory for all supply and use scenarios - approval required by health regulator Recycled Water (supply and/or use) - Risk Management Plan templates on website with guidance notes	Consistent with AGWR document 21 LRV and other health based targets	Consistent with AGWR document 21 Risk based approach used, incorporating site specific conditions and end uses Other stakeholders / regulatiors involved as required (e.g. EPA for soil / groundwater salinity mgt, primary industry agency for helminth reduction prior cattle to fodder irrigation)	Consistent with AGWR document 21 Separate statewide validation guidelines under development One main water authority in SA for most of state's reuse, has own processes established for baseline, operating, vaidation and verification testing (risk based approach used in-line with AGWR)

International guidelines - overview: Recycled water scheme planning, approval and risk management

Document Name	Recycled water scheme planning, approval and risk management				
	Treatment / other technical requirements / guidelines	**Recycled water management plan requirements / guidelines**	**Water quality parameters - health based targets**	**Water quality parameters - environmental / other**	**Monitoring guidelines**
Australia: Queensland					
Water quality guidelines for recycled water schemes 2008 (Department of Regional Development, Manufacturing and Water, 2008)	Provides framework for planning and operation of recycled water schemes, but does not prescribe specific treatment requirements Refer also Recycled water management plan and validation guidelines (2008) for risk management approach to non-drinking water schemes	Provides framework and key considerations in recycled water management plans and scheme development	For requirements for schemes deemed critical / high exposure by the regulator, refer also Public Health Act 2005 - Public Health Regulation 2018, and AGWR (documents 21-22)	Includes general information on requirements for chemical parameters to be included in RWMP and assessments	Refer also Recycled water management plan and validation guidelines (2008) for risk management approach to non-drinking water schemes
Guideline for low-exposure recycled water schemes (Queensland Health)	Provides framework for planning and operation of recycled water schemes, but does not prescribe specific treatment requirements Recycled water management plan and validation guidelines (2008)	Provides framework for end use controls for different end use types (*low exposure excludes dual-pipe schemes and minimally processed food crops) Refer also templates and associated guidance material developed RWMPs and RW user agreements not mandatory (only recommended)	Defines classes of recycled water (A+ / A / B / C / D), not consistent with AGWR - instead, focussed on E.Coli targets only	n/a	Refer separate Excel spreadsheets developed to support monitoring and data collection for assessment against guidelines
USA: California					
Code of Regulations Title 22 - Division 4. Environmental Health - Chapter 3. Water Recycling Criteria	"Alternative Treatment Technology Report for Recycled Water (2023)" provides information on treatment technologies (including specific makes and models) that can be used to comply with filtration and disinfection requirements of Title 22; and the process to be followed (pilot plant etc) for use of any alternative treatment types not pre-approved by the regulator (Division of Drinking Water).	An engineering report, approved by the State Water Resources Control Board – Division of Drinking Water, is required for for all recycled water projects. Guidelines and requirements are defined in "Preparation of an Engineering Report for the Production, Distribution and Use of Recycled Water (2023)".	Defines classes of recycled water, including treatment and water quality objectives (primarily coliform bacteria, and for some end uses, turbidity and protozoa) and approved end uses. Classes include: Undisinfected secondary recycled water, Disinfected secondary-23, Disinfected secondary-2.2, Disinfected tertiary.	Non-potable: n/a Indirect potable: requirements included for advanced treatment criteria, other regulated contaminants and physical characteristics (e.g. organic / inorganic chemicals, metals, disinfection byproducts, radionuclide chemicals), nitrogen compounds, and priority toxic pollutants defined as applicable.	Monitoring requirements are defined for different classes of recycled water.
A Proposed Framework for Regulating Direct Potable Reuse in California (2019)	Direct potable reuse refers to the planned introduction of recycled water directly into a public water system's potable water pipelines or tanks for distribution to customers ("treated water augmentation"), or the planned introduction of recycled water into a raw water supply that directly feeds a water treatment plant that supplies potable water to a public water system ("raw water augmentation") - the key difference to Indirect potable resuse is the lack of an environmental buffer (e.g. aquifer). This document outlines				

B

Appendix B – Technical Considerations

This section describes the key learnings surrounding the technology use, recycled water facility operation and monitoring requirements. It draws on feedback from interviews and workshops with water industry practitioners in Australia and the USA, and key aspects of the literature reviewed as part of this review. The discussion below is focussed on non-potable reuse, however some aspects should also be considered in potable reuse initiatives.

Scale, Complexity and Risk

Scale

With regard to recycled water quality (for non-potable uses), requirements in Australia and the USA are set based on the end use and level of exposure, rather than the scale of the project, so that management of public health and environmental risks are prioritised.

Scale is a still a key consideration, where a balance of capital investment with operational costs and operational / usage controls is required depending on the size and variability of end uses. For example, advanced treatment tailored to local conditions using pilot plants and comprehensive validation for an entire treatment plant may be required if there is a large number of customers being supplied high quality recycled water for similar end uses.

A more pragmatic approach may be necessary where the volumes are lower, and it may be more prudent to manage the water quality risks through on-site preventative measures rather than investment in additional treatment steps.

On site preventative measures

Depending on site specific conditions and use types, it may be more appropriate to invest in higher levels of treatment to minimise usage restrictions or treat only to the minimum levels necessary for wastewater environmental discharges and ensure higher usage restrictions. Examples of on-site preventative measures are summarised in Table B1 (adapted from AGWR Table 3.5 (Australian Guidelines for Water Recycling (AGWR): Managing Health and Environmental Risks (Phase 1), 2006)). Note that the AGWR states “there is limited information on the effectiveness of these preventive measures and further research is required on this aspect,” (Australian Guidelines for Water Recycling (AGWR): Managing Health and Environmental Risks (Phase 1), 2006) and the table below should be taken as a guide to indicate a possible approach.

Table B1 Exposure reductions provided by on-site preventive measures (adapted from AGWR Table 3.5) (Australian Guidelines for Water Recycling (AGWR): Managing Health and Environmental Risks (Phase 1), 2006)

Control Measure	Reduction in exposure to pathogens
Subsurface irrigation of plants, shrubs or grassed areas	5-6 log
Drip irrigation of raised crops with no ground contact (e.g., apples, apricots, grapes)	5 log
Subsurface irrigation of above ground crops	4 log
Drip irrigation of plants/shrubs	4 log
Drip irrigation of crops with limited to no ground contact (e.g., tomatoes, capsicums)	3 log
No public access during irrigation and limited contact after	3 log
Drip irrigation of crops	2 log
No public access during irrigation	2 log
Withholding period for irrigation of parks/sportsgrounds	1 log
Spray drift control (microsprinklers etc)	1 log
Buffer zones (25-30m)	1 log

In South Australia, the concept of a recycled water quality 'continuum' is used, building on the multi-barrier approach to recycled water quality and exposure risk management that is applied in the AGWR. This 'continuum' approach enables wastewater treatment, advanced water treatment and use to be considered as a whole. The concept of a recycled water quality 'continuum' is used, building on the multi-barrier approach to recycled water quality and exposure risk management that is applied in the AGWR.

A key challenge for recycled water schemes can be affordability, so the continuum approach is beneficial as it enables reduced levels of investment (capital and operating) at the recycled water treatment plant (with more controls on the use of the water) and higher resultant affordability of recycled water supplies accordingly. Careful management of the supply and use of the water is critical for the success of this approach.

Taumata Arowai may wish to consider a similar approach as a means of managing health and environmental risks, affordability constraints and treatment complexities, to enable recycled water use with limited additional capital investment required where appropriate.

An important consideration of this approach, however, is the commitment and willingness of recycled water customers/users to implement, demonstrate and maintain the on-site usage controls and preventative measures that are defined to enable the lower treatment and associated costs.

Complexity

A key consideration in the application of water recycling guidelines is the level of complexity of both the treatment process (in place and/or required) and the reuse scheme and recycled water network (in place / under development).

For example, a small wastewater treatment plant with one to two customers that use recycled water for the same end use will be significantly more straightforward to plan, deliver and regulate than a large, complex system with a higher number of end users, different water quality requirements and varying levels of treatment accordingly. In some cases, a wastewater treatment plant may have multiple process streams and produce multiple different water qualities, for which each stream has its own regulatory requirements and approval. An example of this is the Bolivar wastewater treatment plant in Adelaide, South Australia, which broadly includes:

- Treated effluent suitable for coastal discharge – regulated by the South Australian EPA.
- Treated effluent that has been further treated using dissolved air flotation filtration to produce fit for purpose recycled water for the Virginia Pipeline Scheme (market gardens, food crops and pasture irrigation
- Treated effluent that is further treated through an advanced water recycling plant that includes salinity reducing using reverse osmosis, to produce high quality recycled water for the Northern Adelaide Irrigation Scheme (high-tech, high-value intensive food production reliant on reduced salinity). via a separate trunk main and network, with some integration into the Virginia Pipeline Scheme for hydraulic and quality optimisation - recycled water use is regulated by South Australia Health, however the South Australian EPA and the Department of Environment and Water are also involved in the regulation of aquifer storage and recovery for storage of recycled water.

Key considerations for system complexity may include:

- Smaller, less complex treatment systems are more suited for applications where on-site preventative measures can largely manage the public health risk and the LRVs required for the relevant end-uses can be achieved with moderate treatment.
- Larger, more complex systems are likely more suited for applications where on-site preventative measures are lower or are inadequate for achieving LRVs for bacteria, viruses and protozoa for particular end-uses – needing a higher quality water to be produced via treatment.
- The economics will likely balance where recycled water schemes sit on this continuum.

Risk

A risk-based approach to recycled water system management is recommended through the definition and implementation of multiple risk barriers that either improve recycled water quality and/or reduce exposure to contaminants. Core elements of a risk-based system should include:

- Source water management (e.g., trade waste management, and/or separation of wastewater sources between treatment for discharge only and treatment for reuse)
- Wastewater treatment plant design, redundancy, performance optimisation, monitoring and controls
- Multiple barriers for virus, protozoa, helminth and bacteria removal and/or exposure reduction from source to end use, using the 'Swiss cheese model' for risk management
- Supply controls
- Distribution and end use / on-site controls and preventative measures
- Recycled water safety plans (or management plans) for both the supply and use of recycled water, documenting the barriers, monitoring and controls to be used across the system.
- Emergency response plans / alternative supply plans and alternative discharge locations

Technology Validation

When to apply LRVs and invest in validation testing

As discussed in Section 3, log removal values (LRVs) for Viruses, Protozoa and Bacteria are prescribed for different end uses and associated usage restrictions. Varying approaches are used by regulators in the USA and Australia for the validation of wastewater and recycled water treatment plants to demonstrate and get approval for treatment (supply) and use arrangements.

For example, the AGWR defines the LRVs required for Bacteria (B), Viruses (V) and Protozoa (P) (collectively BVP) for different end uses, and depending on the treatment used (primary, secondary, tertiary, disinfection), gives indicative ranges of LRVs that could be achieved. (Australian Guidelines for Water Recycling (AGWR): Managing Health and Environmental Risks (Phase 1), 2006) It is important to note that these LRVs achievable by treatment are not automatically approved. They are intended only as guides to support the development of preliminary plans and designs for a recycled water treatment facility.

Depending on the end use (and the approach of individual regulators), LRV validation testing and LRV credits will not always be required to enable water recycling. In some cases, approvals can still be granted if the combination of other water quality characteristics (e.g., *E. Coli*, turbidity, BOD, suspended solids) can be demonstrated and adequate usage controls are in place. For example, if using the AGWR, municipal use (e.g., open space irrigation) is possible using secondary treatment and disinfection without LRV credits/validation, if restricted access and usage controls are applied (e.g. no access after irrigation until dry (1-4 hours), minimum 25-30 m buffer to nearest point of public access, subsurface drip irrigation).

As previously mentioned, there is often a trade-off between the level of treatment required (i.e., supply controls) and the level of on-site preventative measures (i.e., usage controls) for public health and environmental protection. A key technological and financial consideration in the design, development, implementation and approval of a new / upgraded recycled water scheme is whether or not the system should be validated for the log removal of viruses, bacteria and protozoa using in situ LRV testing. Whilst highly beneficial, as demonstration of higher water quality targets being met enables less usage restrictions, validation can incur significant costs for the recycled water supply agencies (e.g., water authorities, councils). Depending on the scale and complexity of the recycled water system, and the importance of water quality risks to be managed, the validation testing could cost up to $400,000, and may therefore only be appropriate / necessary in some systems.

In some cases, such as in South Australia, different LRVs can be validated for individual unit processes depending on their performance, with:

- default LRVs for BVP at the lower end of the achievable range for the process.
- A higher LRV for enhanced process operation (where defined, similar to enhanced filter performance for drinking water in NZ), or
- in situ validation testing to achieve a higher LRV up to a defined maximum for an individual process.

For example, SA Health automatically grants default LRVs of 1.0, 0.5 and 0.5 (BVP) for secondary treatment via an activated sludge process. (SA Health, (n.d.)) In the AGWR (Table 3.4), however, it notes that secondary treatment is capable of achieving LRVs of between 1.0-3.0 for bacteria, 0.5-2.0 for viruses, and 0.5-1.5 for protozoa (Giardia, 0.5-1.0 for Cryptosporidium). (Australian Guidelines for Water Recycling (AGWR): Managing Health and Environmental Risks (Phase 1), 2006) If higher LRVs are required for a particular end use, then validation testing for the relevant treatment process will be required to demonstrate this can be achieved. Following validation, the 5th percentile LRV demonstrated during validation can be applied to the treatment barrier.

Health-based or process-based approach

The two main approaches to recycled water standards can be categorized into health-based and process-based approaches, each with its own advantages and challenges. Health based targets are developed using various methods including Disability Adjusted Life Year (DALY) and Quantitative Microbial Risk Assessment (QMRA) to come up with treatment requirements and limits.

For non-potable reuse in Australia, the AWGR defines different LRVs for viruses, bacteria and protozoa for different recycled water end uses, for which individual usage controls are also defined to enable health-based targets to be achieved. (Australian Guidelines for Water Recycling (AGWR): Managing Health and Environmental Risks (Phase 1), 2006)

Although examples of LRVs that can be (hypothetically) achieved are noted, there is no mandated use of any specific technology to meet the water quality objectives. This allows for adaptability in meeting the requirements, which can facilitate easier implementation and more tailored treatment solutions.

In the USA (California), however, a more prescriptive and conservative process-based approach is used whereby requirements for source water quality are defined and specific treatment processes are mandated. Whilst this may avoid the need for high cost in situ validation processes, there is a lack of flexibility that results in a ridged and sometimes challenging implementation framework.

LRV testing and validation approaches

The approach to the approval of LRV ‘credits’ is variable between countries and states. Some general considerations include:

- Some treatment processes (e.g., UV treatment) are validated by the manufacturer. When these treatment units are used as a barrier, no additional in situ validation testing is needed, and LRV credits can be automatically granted if the validation certificate and technical specifications for the treatment unit are provided.
- In some cases, even if LRVs are defined for the end use, no LRV validation testing will be necessary if the required LRV credits can be achieved through a combination of pre-validated treatment processes (e.g., UV disinfection) and usage controls are in place.
- Different testing points across the treatment process train may be required, depending on the end use, ability for different usage controls to be implemented, the resultant water quality targets to be met for approvals and the criticality of different treatment process steps in achieving the total system LRV requirements. For example, validation testing points may be defined before and after primary, secondary

and/or tertiary / advanced treatment (refer), depending on whether one or more treatment units are needed to contribute to the total LRV, and the reliability of each treatment process element.

- In some cases (e.g., South Australia), LRV credits can also be claimed with the regulator for usage controls (e.g., drip irrigation, night irrigation, buffer distances etc), which reduces the level of treatment and validation required to achieve the total system LRVs and enable the desired end use.
- Validation testing is usually only required at the commissioning stage of a new / upgraded recycled water treatment plant / scheme. It is usually done with optimised treatment performance to enable challenge testing in which treatment plant performance can be demonstrated to meet the LRVs, and water quality performance envelopes can be defined. Regular monitoring of the treatment plant against these water quality parameters (e.g., *E. coli*, turbidity, suspended solids – all of which are much easier and cheaper to test) is then undertaken in accordance with frequencies (through recognised validation) approved by the regulator. If the treatment plant performance is maintained with these performance envelopes (including through maintenance and replacement of equipment), no further LRV testing and validation is required.

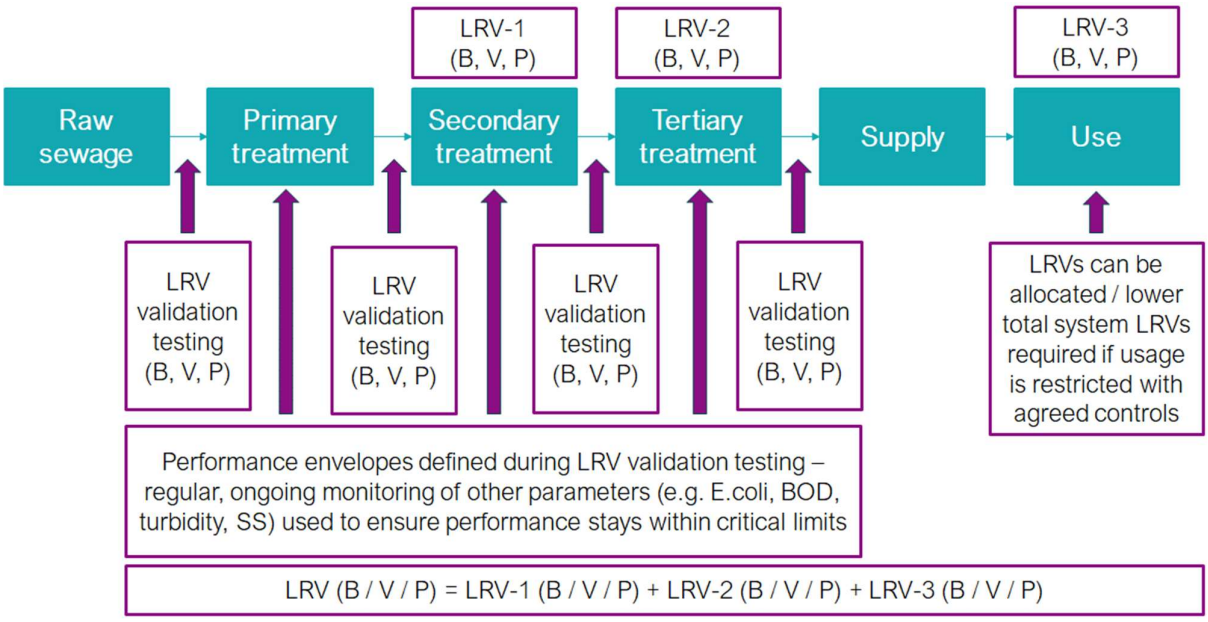

Figure B1. LRV validation testing and calculation (B= Bacteria, V=Virus and P=Protozoa)

An end-to-end system (from source to supply, storage and use) approach is recommended as the basis of a regulatory framework for recycled water. This holistic approach enables greater flexibility for the application of recycled water, and a pragmatic approach to the management of health and environmental risks.

Validation methods - viruses, protozoa and bacteria

Validation testing to demonstrate the removal of Viruses, Protozoa and Bacteria is already used in the provision of safe drinking water, and there is a range of existing methods available for use and consideration by Taumata Arowai. As noted above, some treatment units (e.g., UV and membrane filtration) already have widely used and accepted validation methods and would not require additional testing. In other cases, Taumata Arowai may consider a pathway for validation other treatment processes, to enable default (albeit lower) LRVs to be defined for varying processes (with the equipment supplier or recycled water supplier to complete the validation). Development of validation protocols and guidelines specific to recycled water schemes may also be appropriate, similar to the *Guidelines for validating treatment processes for pathogen reduction Supporting Class A recycled water schemes in Victoria (2013)* (Guidelines for validating treatment processes for pathogen reduction: Supporting Class A recycled water schemes in Victoria, 2013).

Chemical and other contaminants

A priority focus for recycled water quality is bacteria, viruses and protozoa, and validation / demonstration of recycled water treatment plants in achieving these for public health protection, but other important considerations in planning and design of recycled water schemes are chemical and other contaminants and associated requirements for both public health and environmental risk management. Examples include BOD, turbidity, suspended solids, helminths, nutrients (e.g., nitrogen, phosphorus), metals, salinity, organic compounds (for taste and odour and other contaminants of concern, see Section 7), algal toxins, volatile organics and pesticides.

A risk-based approach is recommended for the determination of chemical and other contaminant limits, taking into consideration the receiving environment, soils, groundwater / aquifers and waterways that may be affected by the recycled water use, as well as crops grown for human consumption (raw, cooked, processed, unprocessed). If the recycled water is used to grow fodder for cattle, sheep or other animals, these will also need to be incorporated into the risk assessment.

Whilst typical ranges and guidance on indicative limits are available from literature for chemical and other contaminants, determination of appropriate limits will always need adaptation to local conditions and uses.

This is a significant topic where alignment between the recycled water treatment and environmental discharges should be considered to simplify the development, integration and regulation of recycled water schemes. In this regard, a key consideration will be environmental drivers for wastewater treatment and discharge limits, which should hopefully support recycled water quality limits (e.g., metals) but in some cases misalign with the health / environmental targets. An example of this may be nitrogen and phosphorus, which can be beneficial for irrigation of crops, but may need to be reduced to meet broader environmental discharge objectives.

Engagement with regulators and stakeholders (e.g., health, councils, environmental protection agencies, primary industry representatives and customers) will be important in the determination of recycled water quality parameters and the basis of design for the recycled water scheme. Education, communication and engagement with customers and industry bodies will also be important, preferably from a very early stage, to ensure the requirements and objectives are understood. For example, recycled water irrigation on farms supplying Fonterra will require a specific approach adapted to this industry and will require management through relevant industry bodies and practitioners. It is recommended that Taumata Arowai considers how this may be approached in conjunction with the Ministry for the Environment and Regional Councils, and other stakeholders as appropriate.

Supply and Use Agreements and Risk Safety / Management Plans

The development of supply and use agreements and associated recycled water (quality / safety) management plans should start early in the planning for new / upgraded recycled water schemes, to ensure:

- *Customer objectives for recycled water quality are met* – Knowledge of potential end uses in the recycled water scheme boundary is important in the early stages of planning and design, to ensure the water quality is fit for purpose.
- *Recycled water pricing is accepted by customers* – The willingness to pay for recycled water can be a significant challenge, and negotiations of supply quality, quantity, availability and price can often be lengthy and complex.
- *Usage controls / on-site preventative measures are accepted by customers* – It is imperative that any restrictions (e.g., drip irrigation, drying time before public access, buffer distances) are both understood and agreed to before decisions are made. There will often be a trade-off to be optimised between the recycled water quality supplied from the treatment plant (i.e., LRVs to be achieved through treatment), and the LRVs / health risk management to be achieved through on-site usage controls by the customers. In general, for higher LRVs achieved through treatment, the level of investment required for new /

upgraded treatment elements and associated recycled water prices will be higher, but the usage restrictions will be lower – and vice versa.

Recycled water supply agreements are typically focussed on commercial aspects, including pricing, quantity and quality, and are negotiated between the recycled water supplier (e.g., council) and the end user. The operation of the system is underpinned by supply and use recycled water management plans (RWMPs), which document:

- Roles and responsibilities of the regulator
- Roles and responsibilities of the recycled water supplier
- Roles and responsibilities of the recycled water customer
- Treatment, production and supply of recycled water that is fit-for-purpose (typically up to the boundary of the treatment plant / storage) for the proposed end-uses
- Detailed information on the validation of the treatment processes used for the recycled water scheme and quality supplied
- Treatment process control and monitoring requirements to manage the production of recycled water that is fit-for-purpose for the proposed end-uses
- Contingency plans and incident management protocols for quality that does not meet the prescribed limits

RWMPs are developed by the supply agency (e.g., council, water authority) and customers, and must be formally approved by the relevant regulator before recycled water supply can commence. A key challenge can be the lack of technical capacity of some customers, so assistance is often provided by the supply agencies to ensure the usage and technical requirements are understood, accepted and realistic for different customer end use arrangements.

RWMPs are considered highly valuable documents for suppliers, customers and regulators to ensure the objectives are met and sustained. They should be functional and purposeful to support the operation of and management of recycled water schemes. They should also be concise, to ensure they are used and do not overwhelm customers, but also as regular review and updates (ideally every 2 or so years) should be undertaken to ensure the information is kept up to date. Resourcing constraints for regulators, suppliers and customers can sometimes prohibit this, however.

Monitoring

Monitoring requirements

There is a range of monitoring required with any recycled water scheme:

- **Source monitoring** – Understanding the wastewater source is of significance importance with recycled water systems. Baseline monitoring is important for the planning and design of recycled water treatment plants and assumptions regarding LRVs that might be achieved with different treatment options. A robust source characterisation process to identify risks should be considered for al recycled water facilities. This characterisation should consider both health based and environmental contaminants of concern, and specific reset points should be identified to manage significant changes in a wastewater catchment, for example a new industrial plant discharging into the network. Ongoing source water monitoring is also important, to ensure any high-risk sources (e.g., landfills, some industry) that could influence the treatment plant performance are identified, as some contaminants may necessitate costly infrastructure for removal.
- **Baseline monitoring** – Developing an understanding of the current wastewater / recycled water treatment plant performance is vital for determining appropriate and realistic design parameters and recycled water quality than be achieved. This is typically undertaken for the final effluent and potentially several points across the existing treatment plant. Receiving environment (e.g., soils, groundwater,

waters) monitoring will often also be important
water.

- **Validation testing** – As outlined above, validation testing is undertaken during commissioning of a new / upgraded treatment plant to demonstrate the infrastructure performance is capable of meeting the required recycled water quality objectives. Depending on the scale, complexity and risks associated with recycled water quality objectives and end uses, validation testing may include LRV testing for bacteria, viruses and protozoa, and/or an agreed range of other water quality parameters that can be used to define health and environmental performance envelopes for the system. This is undertaken for the final product water and across treatment processes which contribute to the LRV credit required for the scheme.
- **Verification (ongoing) monitoring** – Ongoing monitoring of the treatment process and receiving environment in accordance with the requirements specified in the supply / use approvals (RWMPs) is critical to ensure regulatory requirements and recycled water quality criteria are met, that the performance limits are not compromised, and that public health and environmental risks are managed. The scope and frequency of testing for different parameters should be proportionate to the scale and complexity of system, and the water quality risks associated with different end uses. An ongoing monitoring program will often include surrogates for bacteria, viruses and protozoa (e.g., *E. coli)* and broader water quality parameters that indicate the overall performance and resilience of the system (e.g., BOD, turbidity, suspended solids).

Testing methods

There is a need to be aware that analytical and online methods change and there should be a mechanism for the approval of recognised approaches, likely by acknowledging other internationally recognised standards - e.g., USEPA.

Direct testing is required to validate and prove that the system is performing as it is required. This can be approached as the final effluent quality and validation of overall performance, and/or to show pathogen removal across individual processes. A balance could be considered here in the monitoring requirements.

Indirect testing online analysis (including microbiological) is a continuously evolving field with new analysers and tests becoming available. Regulations should allow for this flexibility with the simple addition of new sampling and accreditation requirements into the regulatory framework.

Surrogate analysis should be included with direct and indirect testing used across multiple processes and critical control points. These should be regulated such that suppliers are on top of minor changes and can reduce risk greatly. (e.g., conductivity, turbidity, UVT).