Taranaki Regional Council

AGENDA
Policy & Planning

Tuesday 4 February 2025 10.30am

Policy and Planning Committee

04 February 2025 10:30 AM - 12:00 PM

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Taranaki Regional Council

AGENDA Policy & Planning

Date: 4 February 2024

Subject: **Policy and Planning Committee Minutes – 15 October 2024**

Author: M Jones, Governance Administrator

Approved by: A D McLay, Director - Resource Management

Document: TRCID-1492626864-234

Recommendations

That Taranaki Regional Council:

a) takes as read and confirms the minutes of the Policy and Planning Committee meeting of the Taranaki Regional Council held in the Taranaki Regional Council chambers, 47 Cloten Road, Stratford on Tuesday 15 October 2024

b) notes the recommendations therein were adopted by the Taranaki Regional Council on Tuesday 29 October 2024.

Appendices/Attachments

Document 3314556: Policy and Planning Committee Minutes – 15 October 2024

MINUTES
Policy & Planning

Date:	15 October 2024	
Venue:	Taranaki Regional Council Boardroom, 47 Cloten Road, Stratford	
Document:	3314556	
Present:	C S Williamson	Chairperson
	S W Hughes	
	B J Bigham	zoom
	D M Cram	
	C L Littlewood	ex officio
	M Ritai	Iwi Representative
	L Gibbs	Federated Framers
	G Boyde	Stratford District Council
	B Haque	New Plymouth District Council (joined meeting at 10.40am)
Attending:	A D McLay	Director – Resource Management
	M J Nield	Director – Corporate Services
	A J Matthews	Director – Environment Quality
	F Kiddle	Strategy lead
	L Hawkins	Policy Manager
	T Gordon	Programme Manager, Freshwater
	C Woollin	Communications Advisor
	N Chadwick	Executive Assistant
	M Jones	Governance Administrator

One media representative in attendance

The meeting opened at 10.32am

Apologies: Were received and sustained from Councillor Filbee – South Taranaki District Council, Councillor McIntyre, Councillor Walker, Councillor Jamieson, P Moeahu and E Bailey.

Williamson/Boyde

1. Confirmation of Minutes Policy and Planning 3 September 2024

Resolved

That the Taranaki Regional Council:

a) took as read and confirmed the minutes of the Policy and Planning Committee of the Taranaki Regional Council held at 10.45 on 3 September 2024 at Taranaki Regional Council 47 Cloten Road Stratford

b) noted the recommendations therein were adopted by the Taranaki Regional Council on Tuesday 24 September 2024.

Hughes/Littlewood

2. Improving timelines of jury trials submission

2.1 F Kiddle provided an overview of the NZ Government's discussion document on improving the timelines of jury trials, seeking endorsement of the draft submission.

Resolved

That the Taranaki Regional Council:

a) received the memorandum titled Improving timeliness of jury trials submission

b) endorsed the submission with an amendment that Council's preferred option is that Resource Management Act 1991 (RMA) proceedings are excluded from jury trial requirements all together, if this is not possible, increase the threshold to three years

c) determined that this decision be recognised not significant in terms of section 76 of the Local Government Act 2002

d) determined that it has complied with the decision-making provisions of the Local Government Act 2002 to the extent necessary in relation to this decision; and in accordance with section 79 of the Act, determined that it does not require further information, further assessment of options or further analysis of costs and benefits, or advantages and disadvantages prior to making a decision on this matter.

Gibbs/Cram

3. Crown Minerals Amendment Bill Submission

3.1 F Kiddle provided an overview of the Crown Minerals Amendment Bill.

Resolved

That the Taranaki Regional Council:

a) received the memorandum titled Crown Minerals Amendment Bill Submission

b) endorsed the submission contained in Appendix One

c) determined that this decision be recognised not significant in terms of section 76 of the Local Government Act 2002

d) determined that it has complied with the decision-making provisions of the Local Government Act 2002 to the extent necessary in relation to this decision; and in accordance with section 79 of the Act, determined that it does not require further information, further assessment of options or further analysis of costs and benefits, or advantages and disadvantages prior to making a decision on this matter.

Hughes/Cram

4. Freshwater Implementation Update October 2024

4.1 L Hawkins provided a freshwater update for October 2024.

Resolved

That the Taranaki Regional Council:

a) received the October 2024 update on the Freshwater implementation Programme.

Littlewood/Boyde

5. Freshwater Implementation Consultation Feedback and next steps

5.1 L Hawkins presented the analysis and feedback received from the community during the recent consultation process.

(11.29am M Ritai left meeting.)

(11.33am M Ritai re-joined meeting.)

Resolved

That the Taranaki Regional Council:

a) received the memorandum titled Freshwater Community Consultation Feedback and Next Step
b) received the attachment titled Help Shape the Rules – Community Engagement Report
c) noted that a presentation will be provided to the Committee at the meeting to take the members through the content of the consultation report and proposed next steps
d) supported the next steps and overall direction being taken by staff, as summarised in this memorandum, to progress further targeted engagement, investigation and policy development to support the drafting of the Land and Freshwater Plan
e) determined that this decision be recognised not significant in terms of section 76 of the Local Government Act 2002
f) determined that it has complied with the decision-making provisions of the Local Government Act 2002 to the extent necessary in relation to this decision; and in accordance with section 79 of the Act, determined that it does not require further information, further assessment of options or further analysis of costs and benefits, or advantages and disadvantages prior to making a decision on this matter.

Hughes/Cram

There being no further business the Committee Chairperson, C S Williamson, declared the meeting of the Policy and Planning Committee closed at 11.53am.

Policy and Planning

Committee Chairperson: ____________________________________

C S Williamson

MEMORANDUM
Policy & Planning

Date: 4 February 2025

Subject: **Government Submissions Omnibus**

Author: F Kiddle, Strategy Lead

Approved by: A D McLay, Director - Resource Management

Document: TRCID-1492626864-211

Purpose

1. To seek approval to lodge submissions on two proposed Government bills and to inform Taranaki Regional Council of two relevant submissions made by other bodies.

Executive summary

2. The Governments reform agenda is progressing at speed, with a number of bills and discussion documents released towards the end of 2024.
3. The *Resource Management (Consenting and Other System Changes) Amendment Bill* (RM Amendment Bill) proposes a number of changes to the *Resource Management Act 1991* (RMA). The Council's proposed submission:
    a. Supports the changes to the compliance and monitoring regime, especially the increase in fines, lowering of the term of imprisonment below the jury trial threshold, and cost recovery for permitted activity monitoring.
    b. Supports most of the changes to resource consenting. Except it does call into question the value of the proposed new 1-year time limit for processing renewable energy consents.
    c. Supports the Government's intent of fixing the issues with section 70 to allow councils to permit discharges in catchments where significant adverse effects on aquatic life are occurring as long as provision is made for the discharge to reduce its effects over time. However, it does highlight an area where drafting may need improvement.
    d. Can accept proposed new powers of ministerial intervention if the Minister is first required to consider the potential costs imposed on councils.
4. The *Local Government (Water Services) Bill* is the final legislative piece of the Governments local water done well programme. While most of the Bill does not relate to Council functions, a number of changes will impact freshwater management. The most important one is the removal of Te Mana o te Wai from existing water services legislation. This risks creating a significant regulatory gap whereby Taumata Arowai creates wastewater and stormwater environmental performance standards but has no obligation to consider environmental effects in doing so.
5. The Taranaki Mayoral Forum has also submitted on the *Offshore Renewable Energy Bill*. This submission provides broad support for the policy direction in the Bill. It then moves on to highlight the range of other enabling factors that need to be addressed regarding offshore wind. These include port

infrastructure, environmental consenting alignment, and initial explorations of potential price stability mechanisms.

6. Finally, Te Uru Kahika, the umbrella organisation for regional government, has submitted on the Regulatory Standards Bill discussion document. This detailed submission expresses concern that the proposals in the document may lead to worse legislation overall. Particular issues are the lack of focus on the public good and management of externalities, lack of consideration of Treaty of Waitangi/Tiriti o Waitangi matters, and uncertainty on if the proposed Bill would apply to local government or not.

Recommendations

That the Taranaki Regional Council:

a) receives the memorandum titled *Government submissions omnibus*
b) endorses the submission in Attachment 1 on the *Resource Management (Consenting and Other System Changes) Amendment Bill*
c) endorses the submission in Attachment 2 on the *Local Government (Water Services) Bill*
d) notes the submission in Attachment 5 from the Taranaki Mayoral Forum on the *Offshore Renewable Energy Bill*
e) notes that if Council has additional matters it wishes to raise on the *Offshore Renewable Energy Bill* not canvased in the Taranaki Mayoral Forum submission, there is a short window to lodge a separate submission ahead of submissions closing on 6 February
f) notes the submission in Attachment 7 from Te Uru Kahika on the *Regulatory Standards Bill discussion document*
g) determines that this decision be recognised as not significant in terms of section 76 of the Local Government Act 2002
h) determines that it has complied with the decision-making provisions of the Local Government Act 2002 to the extent necessary in relation to this decision; and in accordance with section 79 of the Act, determines that it does not require further information, further assessment of options or further analysis of costs and benefits, or advantages and disadvantages prior to making a decision on this matter.

Background

7. The Government's reform agenda is picking up pace. The end of 2024 saw a flurry of bills and discussion documents that will have significant impacts on both regional councils and Taranaki.

Resource Management (Consenting and Other System Changes) Amendment Bill

8. The *Resource Management (Consenting and Other System Changes) Amendment Bill* (RM Amendment Bill) proposes a range of targeted amendments to the *Resource Management Act 1991* (RMA). The objective of the Bill is to deliver on National Party commitments and coalition agreements for renewable energy and infrastructure, housing, and the primary sector. The policy proposals also aim to improve natural hazards and emergency recovery regulations, as well as improvements to simplify the planning system.
9. Key matters covered in the Bill for Council include:
    a. Providing a one-year time limit for processing resource consents for renewable energy generation. It includes provision for extending this to two years in certain circumstances, including where requested by a Treaty settlement entity, iwi authority or recognised customary rights group.

b. Setting the consent duration of renewable energy and certain long-lived infrastructure consents at 35 years, with some exemptions possible.
c. Extending the expiry of existing coastal permits for ports by 20 years out to 30 September 2026. This is balanced against a new requirement for consent authorities to review the conditions of these permits.
d. Amending section 70 of the RMA to allow councils to permit discharges in catchments where significant adverse effects on aquatic life are occurring as long as provision is made for the discharge to reduce its effects over time.
e. A new power for the Minister for the Environment to direct a council to change a plan to give effect to national direction.
f. Addressing the overlap between the RMA and the Fisheries Act 1996 regarding marine protection.
g. Giving the Minister for the Environment the ability to approve industry organisations to deliver freshwater farm plan certification and audit services. Councils then have an obligation to monitor the performance of the services delivered by these organisations.
h. Providing much greater ability for a council to decline land use consents, or apply conditions, to mitigate natural hazard risk.
i. Multiple changes to the compliance regime, including increasing fines, reducing the maximum period of imprisonment below the jury trial threshold, allowing cost recovery of permitted activity monitoring, and allowing consideration of compliance history in consent decisions.
j. Multiple changes to resource consent processing, including new tests before further information can be requested, the ability to return an application if further information is not provided in a timely manner, and a new requirement to not hold a hearing if a consent authority considers it has sufficient information to determine an application.

10. Attachment 2 contains the legislative statement for the Bill, which provides a more detailed overview of the Bill. It also contains a link to the full Bill.
11. Submissions close on 10 February 2025.

Local Government (Water Services) Bill

12. The *Local Government (Water Services) Bill* (Water Services Bill) is the final legislative piece of the Governments local water done well programme. The Bill provides:
    a. The arrangements for the new water services delivery system.
    b. A new economic regulation and consumer protection regime for water services.
    c. Changes to the water quality regulatory framework and Taumata Arowai.
13. Most of the Bill is not related to regional council functions. However, it does propose the full removal of Te Mana o te Wai from the *Water Services Act 2021* and the *Taumata Arowai–the Water Services Regulator Act 2020*. The proposed new *Local Government (Water Services) Act* also does not include reference to Te Mana o te Wai. Instead, it sets an objective for all water services providers to ensure water services do not have adverse effects on the environment.
14. The Bill also extends the current provisions regarding wastewater environmental performance standards to stormwater as well. Currently Taumata Arowai can set wastewater performance standards that effectively replace any policies or rules in a regional plan. Regional councils are simply required to now implement the performance standards in resource consenting. Under the Bill, Taumata Arowai could do the same for stormwater performance standards.
15. A full summary of the Bill is contained in Attachment 4.
16. Submissions close on 23 February 2025.

Offshore Renewable Energy Bill

17. The *Offshore Renewable Energy Bill* establishes the permitting and decommissioning regime to enable the development of offshore renewable energy. This is particularly focused on offshore wind, but also includes technologies such as wave and tidal energy. The core of the regime is that projects will require two permits:
    a. Feasibility permits will give the exclusive right to apply for a commercial permit in the relevant area.
    b. Commercial permits will enable construction and operation of offshore renewable energy infrastructure (alongside relevant environmental consents).

    Feasibility permits will be offered in rounds, with the Government giving priority to projects that are most likely to be delivered successfully, and at a pace and scale to deliver the greatest benefits to New Zealand. Commercial permit assessments will focus on final checks before construction begins. Applicants are required to consult with relevant iwi, hapū and Treaty settlement entities throughout the permitting process.
18. The decommissioning regime in the Bill seeks to ensure infrastructure is satisfactorily removed at the end of its life, without costs being passed to the Crown. Applicants are required to provide financial security to cover the full cost of decommissioning. This is built up over time to reflect the key risk periods of construction and towards the end of the asset's life.
19. The Bill does not address environmental matters. This instead will be handled under the RMA, Exclusive *Economic Zone and Continent Shelf (Environment Effects) Act 2012* (EEZ Act), and – if the developer chooses to apply – Fast-track Approvals Act 2024. It also does not impose any royalty regime.
20. Attachment 6 contains an overview of how the proposed Act would function.
21. Submissions close on 6 February 2025.

Regulatory Standards Bill discussion document

22. The Government also released a discussion document on the proposed Regulatory Standards Bill. The document canvases three discussion areas. These are the setting of principles as a benchmark for good regulation, mechanisms to assess legislation against the principles, and a mechanism for the independent consideration of regulation.
23. The discussion document proposes principles that primarily focus on the effect of legislation on existing interests and liberties, good law-making process, and regulatory stewardship. There is a strong focus in the principles on protections for personal liberty, security and property. The discussion document specifically proposes that the Bill would not include a principle related to the Treaty of Waitangi/Te Tiriti o Waitangi.
24. Under the proposed approach, new regulatory proposals would be required to be assessed for consistency with the principles. Where a policy proposal or a draft Bill is assessed as inconsistent with any of the principles, the responsible Minister would be required to make a statement justifying why they are proceeding with the proposal despite these inconsistencies. Existing legislation would also need to be assessed against the principles.
25. Finally, the discussion document proposes creating a Regulatory Standards Board. The Board would be able to consider complaints about inconsistency of existing regulation with the principles and would deliver non-binding, recommendatory findings. The Board would also be able to undertake reviews at its own behest, or at the direction of the Minister for Regulation. Members of the Board would be appointed by the Minister for Regulation.
26. Attachment 8 contains the full discussion document.

Issues

27. The below list sets out the key issues associated with each consultation document or bill for the Council:
    a. The RM Amendment Bill will impact how the Council process resources consents, carries out compliance and monitoring activities, and develops resource management policy.
    b. The Water Services Bill will impact freshwater quality through how water services providers take from and discharge to water.
    c. The establishment of an offshore renewable energy industry could have significant impacts on both the regional economy and coastal environment.
    d. The Regulatory Standards Bill could significant shape how Government develops regulation that then Council needs to implement.

Discussion

RM Amendment Bill

28. Overall, the RM Amendment Bill provides a number of tangible improvements to the resource management regime. The proposed submission in Attachment 1 focuses on key matters to Council and does not seek to comment on all aspects of the Bill. The key points in the submission are:
    a. Support for the proposed compliance changes.
    b. Support for most of the proposed consenting changes. The exception to this is the proposed 1-year time limit for deciding on renewable energy consents. We question if this new requirement is needed, as existing timelines in the RMA means consents should be granted within 1 year unless an applicant requests an extension.
    c. Support for the intent behind the changes to section 70. However, our submission suggests further work is needed to ensure the change works as intended.
    d. Acceptance with amendment of the proposed new ministerial powers of intervention. We request that before the Minister directs a council to undertake a plan change, they need to consider the cost of this work.
    e. Calling for sufficient time for public engagement in the development of new freshwater farm plan regulations.
29. While they do relate to regional council functions, we propose to not submit on the provisions in the Bill regarding coastal permits for ports and the RMA-Fisheries Act overlap. Submitting on the former could be a perceived conflict of interest for Council considering our ownership of Port Taranaki. Submitting on the latter is not recommended as we do not currently regulate fisheries activities under our coastal plan.

Water Services Bill

30. Attachment 3 contains a proposed targeted submission on the Water Services Bill. Our key concern is the removal of references to Te Mana o te Wai in existing legislation means Taumata Arowai would have no legislative obligation to consider environmental effects when setting environmental stormwater and wastewater performance standards. This is a significant regulatory gap. At the very least, the removal of Te Mana o te Wai in the *Water Services Act 2021* and the *Taumata Arowai–the Water Services Regulator Act 2020* needs to be replaced with a new reference to managing adverse effects and protecting the environment.
31. Taumata Arowai should also specifically be required to give regard to the *National Policy Statement for Freshwater Management* (NPS-FM) in the creation of wastewater and stormwater environmental

performance standards. This would ensure these standards do not undermine achieving the objective of the NPS-FM.

32. Our final key concern is that the current drafting of some regional council provisions in the Bill are too broad. The Bill includes provisions for how a regional council that provides water services can transfer these to a new water services entity. Current drafting might also capture Council's supply of water to Pukeiti. This type of use, where it is small scale and there is no onwards supply, should be exempt.

Offshore Renewable Energy Bill

33. Considering the potential impact of any offshore wind industry on the region, the Taranaki Mayoral Forum has lodged a submission on the Bill. The submission was drafted with support from the four councils. The full submission is in Attachment 5. It supports the high-level policy directions taken in the Bill.
34. The submission then highlights a range of additional matters that need to be addressed beyond the Bill if a suitable enabling environment for offshore wind is to be provided. These are:
    a. Work to better integrate consenting across the RMA and EEZ Act.
    b. Providing a robust regime for the management of competing uses of the marine environment.
    c. Solving the chicken and egg problem whereby ports need surety from developers before they invest in new infrastructure, while developers need surety that port infrastructure exists before they commit to a project.
    d. Undertaking exploratory work into price stability mechanisms, such as contracts for difference.
35. If upon review of the Taranaki Mayoral Forum submission, Council considers there are additional matters to raise, there is still time to do this. Based on any feedback from the Council, officers can draft a new submission and lodge it prior to submissions closing at the end of 6 February 2025.

Regulatory Standards Bill discussion document

36. Te Uru Kahika, the umbrella organisation for regional councils, has produced a detailed submission on the *Regulatory Standards Bill discussion document*. The full submission is contained in Attachment 7. Key points are:
    a. Support for the intent of improving regulatory quality, but highlighting the risk that the Bill as described in the discussion document could result in an increase in poor legislation.
    b. Disagreement with the proposed principles of regulatory performance being narrowly cast in terms of individual liberties. Any principles need to take a broader view and also recongise wider societal benefits and the importance of managing externalities.
    c. That the level of focus on individual liberties may not adequately accommodate the collective rights and interests of iwi and hapū. And that the current set of principles would not require any declaration of inconsistency with the Treaty/te Tiriti.
    d. That it is unclear if the Bill is intended to apply to local government or not. Local regulations should be placed outside the Bill, as local government's regulatory standards are already comprehensively set in legislation like the RMA.
    e. Greater care is needed to ensure the Regulatory Standards Board does not become a partisan instrument.
    f. There are opportunities in developing a Regulatory Standards Bill, including promoting greater stability in the regulatory regime, setting evidential standards, and emphasising the importance of considering implementation costs.
37. This discussion document is the first step in developing the full Regulatory Standards Bill. When the Bill is finally introduced into the House, Council officers will seek further direction on a potential submission from Council.

Options

38. For the RM Amendment Bill and Water Services Bill submissions, Council can endorse the submissions as drafted, endorse the submissions with amendment, or not endorse the submissions. Considering the importance of the Bills to Council operations, it is important the Council's voice is heard in the legislative process. Accordingly, either adopting the submission as drafted or with amendment is recommended.

Significance

39. This decision is assessed as not significant with regards to the Significance and Engagement Policy. It will have no impact on levels of service, incur more than $10,000,000 budgeted or $5,000,000 of unbudgeted expenditure, or involve the transfer of ownership or control of a strategic asset. More broadly, final decision making authority rests with the Government.

Financial considerations—LTP/Annual Plan

40. This memorandum and the associated recommendations are consistent with the Council's adopted Long-Term Plan and estimates. Any financial information included in this memorandum has been prepared in accordance with generally accepted accounting practice.

Policy considerations

41. This memorandum and the associated recommendations are consistent with the policy documents and positions adopted by this Council under various legislative frameworks including, but not restricted to, the *Local Government Act 2002*, the *Resource Management Act 1991* and the *Local Government Official Information and Meetings Act 1987*.

Climate change considerations

42. The potential mitigation benefits offered by offshore wind is a key consideration in assessing support for the *Offshore Renewable Energy Bill*. Offshore wind energy in particular has considerable potential to lower New Zealand's emissions in the medium to long term.
43. The other matters covered in this memorandum are not likely to affect or be affected by climate change.

Iwi considerations

44. This memorandum and the associated recommendations are consistent with the Council's policy for the development of Māori capacity to contribute to decision-making processes (schedule 10 of the *Local Government Act 2002*) as outlined in the adopted Long-Term Plan and/or Annual Plan. Similarly, iwi involvement in adopted work programmes has been recognised in the preparation of this memorandum.

Community considerations

45. This memorandum and the associated recommendations have considered the views of the community, interested and affected parties and those views have been recognised in the preparation of this memorandum.

Legal considerations

46. This memorandum and the associated recommendations comply with the appropriate statutory requirements imposed upon the Council.

Appendices/Attachments

1. Document TRCID-1553446934-22: Resource Management (Consenting and Other System Changes) Amendment Bill submission

2. Document TRCID-1553446934-29: Legislative statement for Resource Management (Consenting and Other System Changes) Amendment Bill

3. Document TRCID-1553446934-32: Local Government (Water Services) Bill submission

4. Document TRCID-1553446934-30: Local Government (Water Services) Bill overview

5. Document TRCID-1553446934-38: Taranaki Mayoral Forum Submission Offshore Renewable Energy Bill

6. Document TRCID-1553446934-33: Offshore Renewable Energy Bill overview

7. Document TRCID-1553446934-36: Te Uru Kahika submission on Regulatory Standards Bill discussion document

8. Document TRCID-1553446934: Regulatory Standards Bill discussion document

Taranaki Regional Council

4 February 2025
Document: TRCID-1553446934-22

Environment Committee

Committee Secretariat
Environment Committee
Parliament Buildings
Wellington

Via email: en.legislation@parliament.govt.nz

Submission on Resource Management (Consenting and Other System Changes) Amendment Bill

Introduction

1. Taranaki Regional Council (Council) welcomes the opportunity to submit on the Resource Management (Consenting and Other System Changes) Amendment Bill (the Bill). Overall, the Bill will provide a number of tangible improvements to the resource management regime and should be commended for this. As detailed below, there are however some aspects of the Bill that could be improved.

Compliance and enforcement

2. The Council is particularly supportive of the proposed compliance changes. This includes the following proposals:
    a. the ability to fix new administrative charges for various compliance matters;
    b. the ability to consider past noncompliance in resource consent decision making;
    c. the Environment Court being able to suspend a consent for noncompliance;
    d. increasing the maximum fines for offences;
    e. decreasing the maximum term of imprisonment so that jury trials are no longer an option; and
    f. making insurance against fines or infringement fees unlawful.

    Overall, we consider these changes will support increased levels of compliance and thereby improve environmental quality. Being able to cost recover for permitted activity monitoring will also greatly facilitate the development of planning regimes that lean more on permitted activity status.

Resource consents

3. Regarding changes to the resource consent process, we support the following proposals:
    a. the requirement that the applicant provide information at a level of detail proportional to the nature and significance of the activity;
    b. new tests that must be met before further information requests can be made;
    c. the ability for the applicant to request to see draft consent conditions and that the consent authority can only take into account their comments for technical or minor matters;
    d. the ability to return applications where an applicant fails to respond or takes too long to provide requested information; and
    e. the ability to decline resource consent applications due to significant natural hazard risk.
4. We do however, question the need for setting a one-year deadline for the processing of renewable energy and wood processing applications. Existing timeframes under the RMA mean that decisions should be made within a year unless an applicant agrees to a longer timeframe. An exception to this

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may be when there is a need for substantial additional information. However, either this information is legitimately needed to process the application, or it is not and the proposed new further information tests would prevent it being requested in the first place. Rather than leading to more renewable energy, the change is likely to just result in more resource consent applications being rejected as incomplete.

5. We are cautiously supportive of the new requirement that a consent authority must not hold a hearing if it has sufficient information to consider an application. While this will help stop frivolous submitters forcing a hearing, it is a further erosion of the public's role in the resource consent process. We also note that clause 100(3) should be expanded to require consultation with relevant iwi or other Māori groups where related to a joint management agreement or mana whakahono ā rohe. Currently this clause just refers to Treaty settlements.

Resource management policy

6. The Council welcomes the Government addressing the issues with section 70 of the Resource Management Act 1991. Change is necessary to ensure councils can put in place appropriate permitted activity standards that allow for freshwater improvement over time. For example, through freshwater farm plans. We support the approach of allowing for a permitted activity where the rule requires a contribution to reductions over time.
7. We are however concerned parts of the new drafting of section 70 may be difficult to implement. Specifically, the proposed new requirement in clause 70(3)(c) to state a time period within the permitted activity rule for which a reduction of effects must be achieved. Such direction would usually be reserved to policy direction, not permitted rule standards. Including a time bound component to a rule standard will make it difficult for plan users to be certain that they can meet permitted activity classification. This concern could be addressed by amending clause 70(3)(c) to refer to a period of time specified in the plan, rather than the rule itself.
8. With amendment, we can accept the proposed new power for the Minister for the Environment to direct a local authority to prepare or modify a plan to be consistent with national direction. Our concern is that this could lead to significant un-planned expenditure for councils. Accordingly, we request amendment to specify matters the Minister must consider before making such a direction. In particular, the Minister should consider the expected cost of the plan change, and if changes to the council's long-term plan would be required before work could commence.

Freshwater farm plans

9. Finally, we support the Government's intent of making the freshwater farm plan system more cost effective. We see value in a nationally consistent pathway for industry organisations to carry out certification and auditing functions. However, there needs to be robust criteria to guide the Minister's decision making. Accordingly, we note that the most significant detail will come in regulations. We request that sufficient time be provided to allow robust public engagement in their development.
10. We wish to be heard in support of this submission.

Yours faithfully

S J Ruru
Chief Executive

Legislative statement for Resource Management (Consenting and Other System Changes) Amendment Bill

First Reading, December 2024

Legislative Statement presented in accordance with Standing Order 272

Overview

The Resource Management (Consenting and Other System Changes) Amendment Bill (RM (COSC) Bill) proposes targeted amendments that align with the longer-term replacement of the RMA.

The objective of the Bill is to deliver on National Party commitments and coalition agreements for renewable energy and infrastructure, housing, and the primary sector. The policy proposals also aim to improve natural hazards and emergency recovery regulations, as well as improvements to simplify the planning system.

Infrastructure and energy – key policy proposals

One-year time limit for processing resource consents for renewable energy generation

The Bill provides certainty for renewable energy projects by requiring that applications for these consents are decided within one year of being lodged.

It proposes certain parties can request the one-year time limit be extended. Councils must grant the extension (of not more than one additional year) if requested by an applicant, and may grant an extension, if requested by a Treaty settlement entity, iwi authority or a recognised customary rights group.

Councils must also grant the extension if the consent is the establishment of a new hydro or geothermal energy activity, and the request is from a Treaty settlement entity, iwi authority, or a recognised customary rights group.

Maximum consent duration for renewable energy and certain long-lived infrastructure consents, and longer lapse period for renewable energy consents

The Bill provides certainty about consent duration by requiring that resource consents for renewable energy generation and certain types of long-lived infrastructure have a 35-year duration by default. Limited exemptions are provided for the applicant, to uphold treaty settlements and other arrangements, and to enable national direction to specify a different duration.

The Bill targets long-lived infrastructure that delivers public benefit and is expected to last at least 50 years. This includes telecommunications networks, electricity transmission and gas transmission, as well as ports, roads, and railways.

The Bill proposes to extend the default lapse period for consents for renewable energy activities from 5 to 10 years.

Proposals for Ports

Port operators rely on coastal permits issued under section 384A of the RMA. These occupation permits will expire in September 2026 and operators would need new consents prior to this date to continue operating. The Bill proposes to extend section 384A coastal permits by a further 20 years, to 30 September 2046.

Consent authorities may review the conditions of these permits and apply new conditions or modify existing conditions, but must not change the size or location of the permit area or otherwise prevent the permit holder from carrying out their commercial activities.

The Bill proposes the country's 13 major port authorities be included in the definition of 'network utility operator' enabling them to designate the landward part of existing coastal ports and possible extensions to them. Inland ports would also be able to be designated. Designations are able to override the existing district plan rules in the area they apply.

This proposal also enables these port operators to acquire land under the Public Works Act.

Increase certainty for requiring authorities

The Bill provides more efficient and less costly processes for requiring authorities by simplifying the assessment of alternatives test and other requirements. This includes changes to:

a) specify that notices of requirement must be proportionate to the nature and significance of work being carried out, and

b) enable designating authorities, where they have an interest in land sufficient to give effect to a proposed designation, to 'describe' alternative locations and methods for the activity in a similar manner to existing resource consenting processes. This reduces existing requirements to justify the need for the designation and undertake detailed assessment of alternatives.

The Bill also increases the default lapse period of designations from 5 to 10 years. This allows requiring authorities more time to progress projects.

Section 70 of the RMA amended

The RMA prescribes how regional councils must manage discharges to land or water. Section 70 of the RMA limits the kinds of permitted activity rules councils can make for discharges to land or water. Councils are seeking clarity on how to interpret and apply section 70 in their regional plans.

The Bill proposed to amend section 70 of the RMA to clarify that discharges can be permitted where they will contribute to a reduction in effects over time. This amendment aligns with changes to section 107 delivered through the Resource Management (Freshwater and Other Matters) Amendment Act 2024.

Housing – key policy proposals

Ratification vote to keep, change or remove the Medium Density Residential Standards

Under the RMA, councils in Auckland, Hamilton, Tauranga, Wellington and Christchurch are required to incorporate the Medium Density Residential Standards (MDRS) into most residential zones in their plans. The resulting plan changes are in various stages of completion by these councils.

The Bill requires councils to vote on whether to keep, change or remove the MDRS within one year of the enactment of the Bill.

Councils can use the Streamlined Planning Process to remove or modify the MDRS

The Bill amends the SPP, removing the requirement for councils to apply to the Minister to use the SPP to remove or alter the MDRS. Councils would be able to:

a) Progress a plan change using the SPP to remove or alter the MDRS and give effect to the revised National Policy Statement on Urban Development) (NPS-UD), which will include the 30 Year Housing Growth Targets, or
b) Withdraw the plan change that incorporated the MDRS and then use the SPP to progress a plan change to give effect to the revised NPS-UD, which will include the 30 Year Housing Growth Targets.

The Bill also amends the decision-making process for under the SPP. The key features are:

a) The Minister for the Environment (the Minister) will no longer be the final decision maker on plans made under SPP.
b) Councils will be the final decisions maker of these plans (under SPP) and can decide to accept or reject each of the SPP panel's recommendations.
c) Where recommendations are rejected, the council must decide an alternative solution. Rejected recommendations can be appealed to the Environment Court.
d) The Minister can appoint up to half the members of an SPP panel.

Minister for the Environment has new intervention powers

The Bill provides the Minister with two new intervention powers to ensure compliance with national direction. The Bill amends the RMA to:

a) allow the Minister to direct the type of planning process a council uses to prepare a plan change, and
b) enable the Minister to direct a council to prepare or amend a document required by national direction (eg, housing and business development capacity assessments required by the NPS-UD).

Farming and the primary sector

Addresses the overlap between the RMA and the Fisheries Act 1996

Both the RMA and the Fisheries Act 1996 (the Fisheries Act) can be used to control the effects of fishing on biodiversity and other related values. The interface is complex.

The Bill:

a) requires that councils include a broader set of considerations in their evaluation reports (section 32) when proposing a rule that controls fishing – including whether the proposed rules may exclude fishing, or increase the cost of fishing, and whether there is other legislation (eg, the Fisheries Act) that might also limit fishing.
b) directs regional councils must provide their section 32 evaluation reports to the Director General of the Ministry for Primary Industries (MPI) where they have included a proposed rule to control fishing in a regional coastal plan. Regional councils cannot notify proposed rules that control fishing unless the Director General of MPI concurs with the section 32 evaluation.
c) specifies that rules that control fishing may only be permitted or prohibited and may only be included at the time a plan is notified, not added later as a part of the plan change process.

Consent conditions for aquaculture activities can be changed or cancelled

The Bill enables changes to consent conditions for aquaculture activities. The regulatory settings to enable changes to consent conditions will need to be specified through national direction.

The Minister for the Environment can approve industry organisations to deliver farm plan certification and audit services

Currently regional councils are responsible for approving industry body organisations to deliver farm plan certification and audit services.

The Bill amends Part 9A to allow the Minister to approve industry body organisations to deliver farm plan certification and audit services. The Bill gives regional councils tools to monitor the performance of industry body organisations in delivering these services.

Emergency response and natural hazards

Introduces a new regulation-making power for responding to natural hazards and other emergencies

The Bill introduces a new regulation-making power for the Minister to respond to natural hazards and other emergencies and enable recovery efforts in affected areas. The Bill outlines how and when the regulation-making power can be used, and the scope of regulations that can be created under this power.

Clarifies councils' ability to decline land use consents, or apply conditions, to mitigate natural hazard risk

The Bill introduces criteria under which consenting authorities can decline or impose conditions on a land use consent because of natural hazard risk. The Bill outlines an assessment of natural hazard risk that councils must complete when granting a land use consent for an area subject to natural hazard risk. The Bill specifies the types of conditions that can be imposed to mitigate natural hazard risk.

Currently, rules in a plan generally have legal effect only once the plan has become operative. The Bill amends the RMA so plan rules that relate to natural hazards have immediate legal effect from the date of plan notification.

RM system improvements

Compliance regime amended

The Bill amends the compliance regime to deter offences by:

a) increasing penalties for offences under the RMA from $300,000 for individuals and $600,000 for companies to $1 million for individuals and $10 million for companies,
b) removing the ability to insure against penalties for non-compliance,
c) enabling electronic service of documents via email,
d) enabling better cost recovery for councils, and
e) enabling consideration of a person's compliance history in consent decisions.

Makes technical amendments to DOC functions to improve management of discharges

The Bill amends the Conservation Act 1987 to enable a defence for discharging contaminants to apply in every instance where the discharge was authorised under the

RMA. These are technical amendments to DOC functions to improve their ability to manage discharges.

Some consenting processes are clarified

When applying for consent, councils can request further information from the applicant to better understand the proposal. The Bill seeks to clarify that these information requests must be proportionate to the nature and significance of a proposal.

In some cases, an applicant doesn't respond to a request for further information, so the Bill proposes to allow councils to return an application if no response is provided by an agreed date.

The Bill amends the RMA to ensure that councils cannot hold a hearing where they have sufficient information to decide an application.

It proposes to enable applicants to request to review consent conditions before a decision is issued.

The Bill also provides councils with the ability to recover costs incurred for reviewing consent conditions, when consent review is required by national direction.

Heritage can be delisted more efficiently

The Bill proposes councils are able to use the Streamlined Planning Process to remove heritage listed buildings and structures from district plans.

Development of the Bill

The Bill delivers on key coalition agreement and manifesto commitments.

Cabinet agreed the scope of the RM (COSC) Amendment Bill in June 2024. Detailed policy decisions were delegated to the Minister Responsible for RMA Reform and relevant portfolio ministers.

The select committee process will be an important means of consulting on the proposals, as drafted.

Further information

Key documents can be found here —

- The Bill on the Legislation website : Resource Management (Consenting and Other System Changes) Amendment Bill 105-1 (2024), Government Bill Contents – New Zealand Legislation
- Regulatory impact analysis and proactively released Cabinet papers can be found here: https://environment.govt.nz/what-government-is-doing/cabinet-papers-and-regulatory-impact-statements/rm-consenting-and-other-system-changes-amendment-bill
- The departmental disclosure statement can be found here: https://disclosure.legislation.govt.nz/bill/government/2024/105

Taranaki Regional Council

14 January 2025
Document: Document ID Pending

Finance and Expenditure Committee

Committee Secretariat
Finance and Expenditure Committee
Parliament Buildings
Wellington

Local Government (Water Services) Bill

1. Thank you for the opportunity to comment on the Local Government (Water Services) Bill (the Bill). The Bill will have significant implications for the management of freshwater resources, and accordingly is highly relevant to the functions of regional councils.
2. Taranaki Regional Council (Council) is concerned about the proposed removal of Te Mana o te Wai from the Taumata Arowai–the Water Services Regulator Act 2020 and the Water Services Act 2021. Te Mana o te Wai is currently the principal vector for those carrying out water services functions to consider environmental matters. Considering Taumata Arowai can create wastewater and stormwater performance standards that replace provisions in a regional plan under the Resource Management Act 1991 (RMA), the removal of the obligation to consider environmental matters is a significant regulatory gap.
3. This problem is somewhat avoided in the proposed Local Government (Water Services) Act. Clause 15(1) still sets an objective for water service providers to provide water services that do not have adverse effects on the environment. A similar provision needs to be inserted into the Taumata Arowai–the Water Services Regulator Act 2020 and the Water Services Act 2021. The definition of 'environment' should also match that used in the RMA. This will ensure it captures the wider social, economic, aesthetic and cultural components of the RMA definition. We also note the role water services play in providing positive outcomes across this wider conception of the environment.
4. Specifically in the creation of wastewater and stormwater environmental performance standards, Taumata Arowai should also be required to give regard to the National Policy Statement for Freshwater Management (NPS-FM). These standards are integral to the achievement of the purpose of the NPS-FM. It is important that the standards do not undermine the NPS-FM. We note transitional provisions would be required for the period before a new NPS-FM is in effect.
5. We are also concerned that the current drafting of the regional council provisions regarding the transfer of responsibilities in the Bill are too broad. It is appropriate that these apply to regional councils that are heavily involved in the provisions of water services. However, the current drafting may capture regional councils who supply water to their own small facilities. Accordingly, we seek an exemption where such a regional council water supply only exists to service council facility and there is no onwards delivery of a water supply service.
6. We also wish to highlight a duplication risk in the Bill. Subpart 5 of the proposed Water Services Act requires water service providers to make drinking water catchment plans to control activities in the catchment that pose a risk to drinking water. This potentially duplicates the functions of regional councils, including under the Resource Management (National Environmental Standards for Sources of Human Drinking Water) Regulations 2007. Between these regulations and regional plan provisions, regional councils also regulate the potential impacts of activities on drinking water.

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7. To resolve this matter, we suggest that consultation should be required with the relevant regional council in the formation of any drinking water catchment plan. This help ensure any conflicts are managed and duplication avoided.
8. Finally, we welcome the inclusion of transitional provisions clarifying how wastewater and stormwater environmental performance standards apply to resource consent applications under consideration when those standards come into effect. To avoid considerable cost to applicants and councils, we request the forthcoming wastewater environmental performance standards do not come into effect until these transitional provisions are in place.
9. We do not wish to be heard in support of this submission.

Yours faithfully

S J Ruru
Chief Executive

Te Tari Taiwhenua
Internal Affairs

December 2024

LOCAL WATER DONE WELL

Factsheet: Local Government (Water Services) Bill overview

This factsheet provides an overview of key aspects of the Local Government (Water Services) Bill, and is designed to help readers to navigate through different parts of the Bill.

It replaces the Factsheet: *Local Government Water Services Bill overview* shared in August 2024, based on the provisions of the Bill as introduced in December 2024.

The Bill sets out the enduring settings for the new water services system. It is the third piece of legislation in the Government's three-stage process for implementing Local Water Done Well.

What is Local Water Done Well?

Local Water Done Well is the Coalition Government's plan to address New Zealand's long-standing water infrastructure challenges. It recognises the importance of local decision making and flexibility for communities and councils to determine how their water services will be delivered in the future. It will do this while ensuring a strong emphasis on meeting economic, environmental and water quality regulatory requirements.

What are the proposed changes?

The Local Government (Water Services) Bill (the Bill) establishes the enduring settings for the new water services system. Changes are proposed to the water services delivery system and to the water services regulatory system. It is the third piece of legislation in the Government's three-stage process for implementing Local Water Done Well.

Overview of the Bill

The Bill provides for:

- arrangements for the new water services delivery system;
- a new economic regulation and consumer protection regime for water services; and
- changes to the water quality regulatory framework and the water services regulator.

It contains standalone provisions and amendments to a number of other Acts.

It is intended that the Bill will be divided by the select committee or at the committee of the whole House stage into separate Bills, as follows:

- Parts 1 to 4, Part 6, and Schedules 1 to 4 will become the Local Government (Water Services) Bill.
- Part 5, and Schedules 5 to 12 will become the Local Government (Water Services Repeals and Amendments) Bill.

Part 1: Preliminary provisions

This part includes:

- the purpose of the Act;
- the interpretation clause, containing definitions of all the key terms used in the Bill.

One of the key terms is "water service provider". This incorporates:

- territorial authorities;
- water organisations – if responsibilities have been transferred to an organisation through a transfer agreement;
- regional councils, if they provide any water services.

"Water services" is defined as meaning any or all of the following: water supply services; stormwater services; wastewater services. Each of these terms is also defined.

Part 2: Structural arrangements for water services provision

This Part incorporates a number of clauses concerning the structural arrangements for the provision of water services.

- **Subpart 1** provides for territorial authorities' responsibility for the provision of water services in their districts and the different methods by which they can structure service provision arrangements. It covers:
    - the key role of water organisations as being, along with territorial authorities, water service providers;
    - how responsibilities, infrastructure, and other matters can be transferred to water organisations through transfer agreements (which include the content set out in Schedule 2);
    - the objectives, financial principles, and obligations of water service providers;
    - how water service providers can contract for the provision of services on their behalf or enter into joint arrangements with other water service providers;
    - the decision-making process that must be followed by a territorial authority that proposes to make a change to the structure of water services provision.
- **Subpart 2** provides for the different ways a regional council may provide water services, for those regions in which the regional council also provides water services. This may be relevant in relation to urban stormwater services, for example.

- **Subpart 3** provides for the establishment, ownership, and governance of water organisations. These organisations must be companies, and must be wholly owned by:
    - one or more local authorities; or
    - one or more local authorities and the trustees of one or more consumer trusts; or
    - the trustees of one or more consumer trusts.

Further details on the structural arrangements for water services provision can be found in the factsheet: *Water service delivery arrangements*.

Regardless of the future water service delivery arrangements councils choose to use, existing responsibilities, commitments and obligations between iwi/Māori and the Crown under the Local Government Act 2002 (LGA02), and under Treaty settlement legislation will continue to apply.

Part 3: Provision of water services – operational matters

This Part of the Bill covers a range of operational matters that relate to the provision of water services. It gives water organisations powers that already apply to local authorities through other legislation, including charging powers. It also contains new requirements relating to managing water networks that will apply to all water service providers.

- **Subpart 1** enables water organisations to set and collect charges for water services (if they are the water service provider for those services), and contains related matters. (This subpart does not apply to Watercare.)
- **Subpart 2** enables water organisations to require development contributions for growth-related capital costs through a modified version of the development contributions regime in the LGA02.
- **Subpart 3** enables territorial authorities to make water services bylaws for their districts for the purposes of regulating connections to water services networks.
- **Subpart 4** provides for the power of a water service provider to enter land and carry out work in relation to water services infrastructure.
- **Subpart 5** sets out requirements relating to drinking water catchment plans.
- **Subpart 6** sets out requirements relating to trade waste plans.
- **Subpart 7** sets out obligations on water service providers that have responsibility for the management of stormwater networks (including overland flow paths and watercourses), and related matters. It provides for:
    - stormwater risk management plans;
    - stormwater network bylaws;
    - obligations of owners of private land that has an overland flow path or a watercourse crossing over or beneath it;
    - integrated management of stormwater networks, through (voluntary) service agreements.
- **Subpart 8** covers the discharge of sewage and trade wastes.

Part 4: Planning, reporting, and financial management

This Part of the Bill sets out a new planning and accountability framework for water services, which is fit for purpose for the new water services delivery system and supports an enhanced focus on water services.

- **Subparts 1 and 2** provide for a cycle of planning, performance, and reporting that promotes accountability to consumers of water services and to shareholders in water organisations. The cycle includes requirements that:
  - the shareholders of each water organisation must prepare and adopt a statement of expectations for the water organisation;
  - each water service provider must prepare and adopt a water services strategy, an annual budget, and a water services annual report. (Schedules 3 and 4 set out the detailed content requirements for water services strategies and water services annual reports, respectively.)
- **Subpart 3** provides for additional planning, reporting, and performance requirements for water service providers that are water organisations.
- **Subpart 4** sets out financial matters that apply to water organisations, including provisions relating to operating revenues, borrowing in foreign currency, and income tax.

Further details on the new planning and reporting framework for water services, and the associated amendments to the LGA02, can be found in the factsheet *Planning and accountability for local government water services.*

Part 5: Amendments to other Acts

Part 5 of the Bill includes the substantive amendments to other Acts, to give effect to the decisions the Government made in June and July 2024 – including the new regulatory regime for water services.

- **Subpart 1** amends civil defence legislation.
- **Subpart 2** amends the Commerce Act 1986.
- **Subpart 3** amends the Income Tax Act 2007.
- **Subpart 4** amends Local Government Act 2002 (Ministerial powers to act in Part 10, and definition of council-controlled organisation is section 6).
- **Subpart 5** amends the Local Government (Water Services Preliminary Arrangements) Act 2024.
- **Subpart 6** amends the Receiverships Act 1993.
- **Subpart 7** amends the Resource Management Act 1991.
- **Subpart 8** amends the Act previously called Taumata Arowai–the Water Services Regulator Act 2020.
- **Subpart 9** amends the Water Services Act 2021.

Further details on the main amendments are provided below and in separate factsheets. Additional consequential amendments to other legislation (including to the LGA02) are in Schedule 12.

Part 6: Miscellaneous provisions

Subparts 1 to 3 of this Part of the Bill contain a new framework for water services bylaws, including new functions and graduated enforcement tools.

- **Subpart 1** provides territorial authorities with powers to make water services bylaws, and enables the delegation of functions or powers that relate to the administration or enforcement of a water services bylaw to a water service provider operating in the district. It also requires the initial and ongoing review of water services bylaws.
- **Subpart 2** covers compliance and enforcement matters, including providing for infringement offences, compliance officers, and compliance powers.
- **Subpart 3** provides for a range of offences and penalties relating to water infrastructure and water services networks.

Subpart 4 requires the Minister of Local Government to commission a review of the water services system, no sooner than 54 months after the commencement of this Act. The review must examine and report on the overall operation and effectiveness of the water services legislation and local government arrangements for providing water services.

Further details on the amendments to other Acts

New economic regulation regime

The Bill amends the Commerce Act 1986 to provide for regulation of water services by the Commerce Commission (the Commission).

Subpart 2 of Part 5 of the Bill sets out a new regime for water services, based on the existing economic regulation regime in Part 4 of the Commerce Act (which currently applies to electricity lines services, gas pipeline services, and airport services).

Under the new economic regulation regime for water services, the Commission will have a range of regulatory options, including:

- information disclosure regulation;
- revenue threshold regulation;
- quality regulation;
- performance requirement regulation;
- price-quality regulation.

The Commission will also enforce a new “ring-fencing” rule, under which regulated suppliers will be required to spend the revenue they receive from providing water services on providing those services (see clause 3 of new Schedule 7). Pecuniary penalties will be available if the rule is breached.

Alongside the economic regulation regime, the Bill sets up a consumer protection regime that will enable the Commission to collect and analyse information relating to consumer protections, such as service quality and customer engagement. If information gathered reveals that issues exist, the Bill contains a range of tools to allow consumer protections to be strengthened.

Please refer to the factsheet, *Economic regulation and consumer protection*, for further details.

Amendments affecting the Water Services Authority–Taumata Arowai and the drinking water quality regulatory framework

In line with the Government's intention that government agencies have an English name first, the Bill amends the Taumata Arowai–the Water Services Regulator Act 2020 (and related legislation) to refer to the 'Water Services Authority–Taumata Arowai'.

The Bill makes changes to the water quality regulatory framework and to how the Water Services Authority (the Authority) regulates drinking water suppliers. It includes changes to the Water Services Act 2021 to reduce the regulatory burden of the drinking water quality regime and improve proportionality in the application of regulatory powers.

The Bill also amends the Authority's operating principles (in the Taumata Arowai–the Water Services Regulator Act). The Authority will be required to consider the costs of regulatory compliance for drinking water suppliers, in particular mixed-use rural water suppliers, and ensure the regulation is proportionate to the scale, complexity, and risk profile of each supply. The Authority will also be required to proactively engage with suppliers and network operators to ensure there is a path to compliance that takes into account the risk profile and capacity of each supply.

In addition, the Bill amends the Water Services Act to require the Authority to include specific information on mixed-use rural water suppliers in its annual drinking water regulation report and its drinking water compliance, monitoring, and enforcement strategy.

Change in approach to Te Mana o te Wai

The Bill repeals the requirements in water services legislation to give effect to Te Mana o te Wai.

A new single standard for wastewater and stormwater environmental performance

The Bill amends the Water Services Act and the Resource Management Act to provide for a single standard for wastewater and stormwater environmental performance. This will ensure regional councils implement a single approach to resource consents, with a mechanism for exceptions.

Regional councils will be unable to set additional requirements either higher or lower than the standard. Wastewater and stormwater environmental performance standards will be made by Order in Council.

Please see the factsheet, *Wastewater and stormwater environmental performance standards*, for further details.

National engineering design standards

The Bill introduces a mechanism for establishing mandatory national engineering design standards to ensure consistent standards for the design and construction of water network infrastructure. National engineering design standards will be made by Order in Council.

Please see the factsheet, *National Engineering Design Standards*, for further details.

Ministerial powers to address problems facing local government water service providers

Subpart 4 of Part 5 of the Bill amends Part 10 of the LGA02: *Ministerial powers to act in relation to local authorities*. The amendments:

- enable the powers in Part 10 to be used in relation to all water service providers (water organisations, as well as local authorities), and shareholders in water organisations (including trustees and consumer trusts);
- expand the definition of a 'problem' to cover a range of situations that may be relevant in a water services context (including significant and persistent non-compliance with the economic regulation regime in the Commerce Act);
- provide for two new Ministerial bodies that can be considered in a water services context: a Crown facilitator – water services, and Crown commissioners – water services.

These changes are designed to apply on an enduring basis, if problems or potential problems emerge over the longer term.

Amending the definition of CCO in the LGA02 to include water organisations

Subpart 4 of Part 5 of the Bill amends the definition of council-controlled organisation in section 6 of the LGA02.

It adds a new provision, so that "council-controlled organisation" also includes a water organisation within the meaning of section 4 of the Local Government (Water Services) Act 2024, if:

- the organisation is owned by 1 or local authorities; or
- the organisation is owned by 1 or more local authorities and the trustees of 1 or more consumer trusts, and the local authorities hold more than 50% of the shares and voting rights in the organisation.

This helps to clarify where a water organisation is also a CCO.

Schedule 1 of the Bill includes a transitional provision for existing water services CCOs, which become water organisations upon enactment.

Other Local Water Done Well legislation

Local Water Done Well is being implemented in three stages, each with its own piece of legislation.

The Water Services Acts Repeal Act (enacted in February 2024) repealed the previous Government's water services legislation and restored continued council ownership and control of water services.

The Local Government (Water Services Preliminary Arrangements) Act (enacted in September 2024) established the Local Water Done Well framework and the preliminary arrangements for the new water services system. The Act includes:

- Requirements for councils to develop Water Services Delivery Plans (by 3 September 2024).
- Requirements for councils to include in those Plans baseline information about their water services operations, assets, revenue, expenditure, pricing, and projected capital expenditure, as well as necessary financing arrangements, as a first step towards future economic regulation.
- Streamlined consultation and decision-making processes for setting up council-controlled organisations that deliver water services, and joint local government arrangements, both of which are currently provided for in the Local Government Act.
- Provisions that enable a new, financially sustainable model for Auckland Council's CCO, Watercare.
- Interim changes to the Water Services Act that means the Te Mana o te Wai hierarchy of obligations in the National Policy Statement for Freshwater Management (NPS-FM) will not apply when the Authority sets wastewater standards.

As outlined in this factsheet, the third Bill – the Local Government (Water Services) Bill – will establish the enduring settings for the new water services system.

Next steps

There will be an opportunity to provide submissions on the Local Government (Water Services) Bill at select committee.

The Department of Internal Affairs will prepare further guidance material to support the implementation of Local Water Done Well, following the enactment of the Bill. This is expected to be in mid-2025.

Further information

The Local Government (Water Services) Bill is available at www.legislation.govt.nz.

Information about the parliamentary process and timeline for the Bill, including how to make a submission to the select committee, is available at www.parliament.govt.nz.

For further information about Local Water Done Well, including guidance and information for councils, visit www.dia.govt.nz/Water-Services-Policy-and-Legislation

Questions? Contact waterservices@dia.govt.nz

Te Kaunihera-ā-Rohe o Ngāmotu New Plymouth District Council | Taranaki Regional Council | Te Kaunihera ō Taranaki ki Te Tonga South Taranaki District Council | Te Kaunihera ā Rohe o Whakaahurangi Stratford District Council

Our Reference
F22/55/007-D25/2062

Taranaki Mayoral Forum

23 January 2025

Taranaki Mayoral Forum Submission: Offshore Renewable Energy Bill

1. The Taranaki Mayoral Forum welcomes the introduction of the Offshore Renewable Energy Bill (the Bill) and the commitment of the Government to its advancement. Through its people, natural resources – including world-class offshore wind resources – and location, Taranaki has the potential to be a centre of renewable energy excellence. An effective and efficient offshore wind regime is a core component of unlocking this.

2. We support the Bill and the direction it takes on key policy matters. In particular:
   a. The proposed two-step permitting model. The feasibility permit stage will provide developers with the surety needed to undertake robust investigations to inform commercial permitting and environmental consents.
   b. The strong focus on ensuring there are robust decommissioning provisions and associated financial securities. In developing these securities, we note the importance of a system that allows a developer to build up the security over the life of the asset.
   c. That the Bill does not duplicate the Resource Management Act 1991 (RMA) and the Exclusive Economic Zone and Continental Shelf 2012 Act (EEZ Act) by including environmental related matters. It is appropriate environmental considerations are dealt with through these other more specific frameworks.
   d. The requirement for prospective developers to consult closely with mana whenua throughout the process.
   e. The flexible model for the declaration of safety zones around offshore renewable energy infrastructure. It is important that safety zones are appropriate to the specifics of the development.
   f. That the regime does not include any provision for royalties. The offshore renewable energy industry in New Zealand is still nascent. Royalties or other revenue gathering mechanisms would serve to disincentivise investment.

3. We also wish to emphasize there are other enabling factors that require attention if New Zealand's offshore wind potential is to be realised. Without addressing these other barriers, there is a real risk the work on the Bill is wasted.

4. We are supportive of more integrated consenting pathways across the RMA and EEZ Act. The Fast Track Approvals Act will provide one pathway for such consideration. However, considering the scale and novelty of offshore wind in New Zealand, providing developers efficient and effective options outside the fast track regime is essential. This will better give applicants and communities the space to assess the environmental impacts of offshore wind.

5. A critical gap in New Zealand's marine regime remains how competing uses of marine space are determined. Under the Bill, a feasibility permit grants the holder the exclusive right to apply for a commercial permit for offshore renewable energy infrastructure. Yet it would seemingly be possible for another activity, such as seabed mining, to be granted consent to operate within the same area. Further work is required to provide a robust mechanism for resolving these conflicts.

6. We wish to also emphasise the crucial nature of port infrastructure. The Government needs to ensure there is an appropriate enabling environment for long-term and strategic port development. There is also the issue of port operators needing certainty from developers before investing in new infrastructure. While developers need certainty from port operators that the right infrastructure exists before they and others invest. Government could play an important role in resolving this chicken and egg issue.

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7. Finally, The Taranaki Mayoral Forum calls on the Government to keep an open mind on potential price stability mechanisms. Tools such as contracts for difference can play an integral role in giving investors the confidence to commit the substantial capital needed to finance offshore wind facilities. These tools are relatively immature in New Zealand, and further work is needed to explore them. If after robust investigation such tools were found to be economically warranted, their application would not be needed for many years hence.

8. The potential benefits of offshore wind are not about what they can offer New Zealand today. It is about ensuring New Zealand has a secure, equitable and sustainable energy sector in ten years' time. The Bill is a welcome and commendable step on this journey. We look forward to working with the Government as the Bill progress and in addressing the other matters raised in this submission.

9. We wish to be heard in support of this submission.

Yours faithfully

Mayor Neil Volzke (Forum Chair)
Stratford District Council

Mayor Phil Nixon
South Taranaki District Council

Mayor Neil Holdom
New Plymouth District Council

Charlotte Littlewood
Taranaki Regional Council Chairperson

Offshore Renewable Energy – Overview of Regulatory Regime

The proposed regime will:
- give developers greater **certainty to invest**
- allow the selection of developments that **best meet New Zealand's national interests**
- **manage the risks** to the Crown and the public from offshore renewable energy developments.

The regime covers all forms of offshore renewable energy. Offshore wind is the most developed technology.

INDICATIVE OFFSHORE WIND PROJECT TIMELINE

OFFSHORE RENEWABLE ENERGY PROJECTS WILL REQUIRE TWO PERMITS

1. FEASIBILITY PERMITS WILL GIVE GREATER CERTAINTY TO UNDERTAKE FEASIBILITY STUDIES

FEASIBILITY PERMIT

Feasibility permit assessments will give priority to projects that are most likely to be delivered successfully, at a pace and scale to deliver the greatest benefits to New Zealand

7-year duration

Comparative assessment

Gives the exclusive right to apply for a commercial permit in the relevant area

Government opens application round
- **Developer identifies site** Legislation will allow for government to identify sites in future
- **Developers engage with iwi/hapū before applying**
- **Minister can issue guidance on area**, e.g. <250km² (but no legislated limits)

Regulator (MBIE) assesses application

Regulator:
- **notifies and consults publicly**
- **engages with relevant Māori groups** on Treaty Settlement impacts
- **assesses application**
- **ranks applications** where there are overlaps or overall limits

Permit granted
- **Regulator makes recommendation**
- **Minister grants permit**
- Feasibility permits will be subject to **"use it or lose it"** provisions

2. COMMERCIAL PERMITS WILL ENABLE CONSTRUCTION AND OPERATION

COMMERCIAL PERMIT

Commercial permit assessments will focus on final checks before construction begins

40-year duration

Pass/fail assessment
(non-comparative)

Enables construction and operation of offshore renewable energy infrastructure
(alongside relevant consents)

Developer applies
- **Developer applies when ready** (within 7 years of being granted feasibility permit)
- **Developer can reduce the size of the area** (minor extensions may be considered)

Regulator (MBIE) assesses application

Regulator:
- **notifies application**
- **engages with relevant Māori groups** on Treaty settlement impacts
- **assesses application** (non-comparative and only where not covered by other legislation)

Permit granted
- **Regulator makes recommendation**
- **Minister grants permit**
- Applicants provide **feasibility data** to the regulator

COSTS WILL BE RECOVERED

- The regulator will recover the **costs of administering the regime** through fees and levies.
- The government will not collect **royalties**, as this would deter investment and the costs would flow through to consumers.

PERMITS MAY BE CHANGED

- **Permits may be varied, transferred, surrendered and revoked**, with agreement from the Minister.
- The Minister may also agree to a **change of permit holder.**
- A range of **offences and penalties** apply for breaches of the legislation and permit conditions.

DECOMMISSIONING

Decommissioning obligations apply to generation and transmission infrastructure.

Financial security will be required to cover full decommissioning costs. Financial security would build up to reflect key risk periods, i.e. construction and towards the end of asset life.

Trailing liability will be limited to the previous permit holder. It will continue until financial security has fully accrued, or the Minister for Energy agrees to release the obligation.

PROJECTS WILL ALSO REQUIRE ENVIRONMENTAL (AND OTHER) APPROVALS

Developers will need:
- **Resource consents under the RMA or its successor** (e.g. for transmission cables running through the territorial sea and onshore infrastructure)
- **Marine consents under the EEZ Act for activities in the EEZ** (e.g. for turbines)
- Other relevant approvals, e.g. under the Overseas Investment Act 2005 and Maritime Transport Act 1994.

Offshore renewable energy projects will only be eligible for environmental consents, including through the fast-track approvals process, if they hold a feasibility permit (to avoid land banking outside the regime).

Note: Opportunities to align commercial permits and consent processes under a one-stop shop may be considered at a later stage (outside the scope of the Bill).

SAFETY ZONES

Safety zones can be declared around offshore renewable energy activities to manage risks to people and infrastructure.

Te Uru Kahika Regional and Unitary Councils Aotearoa

MINISTRY FOR REGULATION
PO BOX 577
WELLINGTON 6140

VIA EMAIL TO: RSBconsultation@regulation.govt.nz

13 JANUARY 2025

REGULATORY STANDARDS BILL

Te Uru Kahika (Regional and Unitary Councils Aotearoa) thanks the Ministry for Regulation for the opportunity to comment on the proposed Regulatory Standards Bill.

Te Uru Kahika is the collective voice of New Zealand's sixteen regional and unitary councils. It is underpinned by an extensive network of subject-matter experts. Together, we play a vital role in championing best practice, information sharing and collaboration across regional government. We also work with central government to deliver better outcomes for local people and their environment.

This feedback draws on our collective expertise to present a perspective on behalf of regional government as a whole. Regional and unitary councils may make individual submissions, reflecting their own local circumstances. Should our positions diverge on specific points, we respect the authority of councils to express their own views. Where differences arise between regions, we trust this supports you in understanding the complexity of the issues being considered.

Councils are both subject to regulation and themselves exercise regulation-making powers. This submission focuses on a small number of points taking into consideration both of those dimensions.

We applaud the intent to improve the quality of New Zealand's regulatory system. We see opportunities for regulatory standards to support better efficiency and effectiveness within our areas of work. At the same time, it is not clear whether the proposed Bill is intended to apply to councils' regulation making: if so, we have concerns about the workability of the proposed regime. We also harbour serious concerns that a narrow focus on libertarian principles will unbalance New Zealand's future legislation to the detriment of social and environmental outcomes. Rather than resolve the problem the Bill suggests needs to be addressed – namely, improving New Zealand's regulatory performance – we suggest that the Bill as currently described would result in an increase in poor legislation.

THE ISSUE TO BE RESOLVED

Processes already exist to ensure the robustness of regulation (for example, Regulatory Impact Statements). Certainly, they do not always produce optimal results – but issues often arise when existing mechanisms are side-stepped for expediency. We consequently remain unconvinced that regulating to improve the quality of regulation is the best way forward.

Of greater concern to us is the use of this Bill to pre-empt the content or purpose of other legislation. For example, proposed restrictions on the taking of property are not a principle of legislative quality, but a matter of policy. (And a matter already covered, for example, by the Public Works Act.)

Individual rights are protected under the Bill of Rights Act. Should the Government wish to strengthen protection of economic liberties, that may be the better place to do so.

PRINCIPLES SHOULD BE BALANCED

We disagree with regulatory performance being cast narrowly in terms of individual liberties and property rights. We believe principles relating to the *design and content of regulation* must take a broader view, taking into account wider societal benefits and the management of externalities. Protection of existing interests needs to be balanced against the interests of future generations. If that cannot be achieved, the principles should be removed from the Bill altogether.

Regulation exists to balance the interaction between individual freedoms to act and the impact of those actions on others. Taxation, policing, environmental protection are all examples of “society” imposing limits on individual freedoms. Without such a framework, society would not function – or, certainly, would not function in a way that cared or provided security for its members.

Constraints on individual liberty must be approached with great care (and the protection of individual rights will always be a consideration in law making) – but the social, environmental and macroeconomic benefits of good regulation are also relevant and should be factored into any guiding set of principles. The omission of the public good from the Bill’s principles or its framing, as in the 2021 version of the Bill, as a secondary consideration creates a serious imbalance. This would, in our view, be as likely to contribute to social inequity and environmental degradation as to drive productivity improvements. We cannot support such an approach.

Public good (including environmental health)

With its focus on individual rights, the proposed Bill fails to provide a cohesive and balanced approach to the public good. This should encompass both collective value (e.g. waterways that are suitable for swimming) and intrinsic value (e.g. biodiversity and the protection of threatened species).

Weighing the public good will always be nuanced and respond to social preferences. But the fundamental premise – that there are public goods upon which society is founded – cannot be omitted or relegated to secondary consideration in a Bill as wide-ranging as this one. It is not a question of whether private or public interests predominate, but of how they are balanced.

Our responsibilities give regional and unitary authorities a strong connection to environmental sustainability and the resource use aspects of this discussion. We would argue that any principle that recognises public rights and interests should be drafted to encompass a broad understanding of public/societal good.

If the proposed provisions in relation to liberties (clause 6(1)(b) of the 2021 Bill) are to be retained, at a minimum the words “or is necessary in the public interest" should be added.

Treaty of Waitangi considerations

We also note that a focus on individual liberties and property rights may not adequately accommodate the collective rights and interests of iwi and hapū. Principles such as equity, along with active protection and redress, are important to ensure consistency with Te Tiriti. We are concerned that the narrow set of design principles currently proposed does not require Ministers to consider or disclose inconsistencies with the Treaty. Further, a bias in the principles against retrospective action may actively impede redress for Māori through future Treaty settlements.

These issues have been raised by officials in regulatory and Treaty impacts statements and, in the spirit of good regulatory practice, should be addressed.

In terms of *good law-making* and *regulatory stewardship*, we suggest that guiding principles should encompass the use of evidence, administrative efficiency, whether the regulation can practically be implemented and achieves its stated purpose.

If the principles in the proposed Bill are to shape all regulation in future, its provisions around design and content must be politically neutral and reflect the issues that regulation sets out to address. Failure to achieve this may see regulatory standards politicised, undermining the transparency and rigour that the framework seeks to establish.

ASSESSMENT OF LOCAL REGULATIONS

It is unclear to what extent regulatory powers delegated to local government are to be subject to the provisions of the proposed Bill. We ask that local regulations be placed clearly outside the scope of this Bill.

Regional and unitary authorities are already subject to stringent reporting and audit requirements under the Local Government Act, the Resource Management Act, the Climate Change Response Act, and other legislation. Introducing new requirements that duplicated or conflicted with them would run counter to the intent of the Bill. Instead, to avoid additional cost and bureaucratic inefficiency, we recommend that existing processes be improved. Reform already underway within the Local Government and Resource Management portfolios offers a mechanism to do so.

If local regulations were to be within the scope of this Bill, it would be important to ensure integration with existing processes for making them and reporting on their performance. The processes described in the *showing whether regulations meet standards* section of the discussion document relate only to central Government agencies. It is appropriate that overarching responsibility for regulatory performance sit with the responsible minister and central agency. If consistency requirements are to apply explicitly to local regulations, however, responsibilities should mirror delegations for the regulations themselves so that assessments do not become a barrier to efficient and timely decision making.

The role of the Environment Court in relation to policy statements and plans under the Resource Management Act (or similar local regulations once the Resource Management Act is replaced) would also need to be considered. While the Court could be required to have sufficient regard to the principles in setting regulation, review of the Court's decision by a Regulatory Standards Board may present complications.

APPOINTMENT OF THE REGULATORY STANDARDS BOARD

Given the breadth and quasi-judicial nature of the proposed Regulatory Standards Board's role, we believe greater care is required to ensure it does not become a partisan instrument. Neither regulatory quality nor the interests of general public, taxpayers and businesses would be well-served by the uncertainty that would be created were all existing law subject to politically motivated review with every change of Government.

We note that Taituarā in its submission has suggested several ways the necessary political separation could be achieved.

We also suggest the Board will require a broader range of expertise than "law and economics" if it is to perform its role in keeping with the stated intent of promoting good regulation (to help achieve "economic, environmental and social outcomes, support the effective operation of markets, and protect communities from harm"). The Board will require at a minimum expertise in regulatory implementation, policy evaluation, and Te Ao Māori.

OPPORTUNITIES FOR BETTER REGULATION

Poorly designed national regulations often translate to costs for councils charged with implementing them and frustration for local ratepayers, businesses and communities. We see opportunities for the proposed Bill to remove barriers to better performance at a regional level.

A feature of our current regulatory environment is frequent, and at times rushed, changes to operative regulation. The National Policy Statement for Freshwater Management, for example, has been amended roughly every three years since it was introduced in 2011. Medium-density residential standards were introduced, then made optional. Amendments to the Resource Management Act are frequent; it was repealed, and then the replacement legislation itself repealed. Councils can find themselves having to redo work, at ratepayers' expense, when overarching legislation changes. Ambiguous legislation can lead to additional costs as its interpretation is tested through the courts.

A Regulatory Standards Bill could assist in several ways:

- It could underscore the importance of robust evidence to underpin decision making. Haste and a lack of evidence in national policy creates significant downstream costs and compliance burdens.
- It could codify consideration of implementation as part of regulatory design. Implementation is often overlooked, left to last, or left to others (including regional and unitary authorities). A solution that looks good on paper may be contentious or unworkable in practice. Stock-access regulations, and the definition of wetlands and significant natural areas in freshwater and biodiversity regulations respectively are examples. Ideally, the cumulative impact of regulation – and capacity within the system to implement multiple changes at once – should be taken into account.
- Regulators could be required to consider the cost of administering new regulations. Analysis by Government agencies often consciously omits costs imposed on local government. This unfunded mandate is a driver of increasing council rates around the country.
- Regulatory stewardship provisions could place greater weight on monitoring and evaluation. Done well, this could both help to ensure poorly performing regulation is improved and dampen changes to regulations that have not had time to take effect.

FURTHER CONTACT

Thank you again for the opportunity to comment on the Regulatory Standards Bill.

On any matters arising from this submission, contact should in the first instance be made with:

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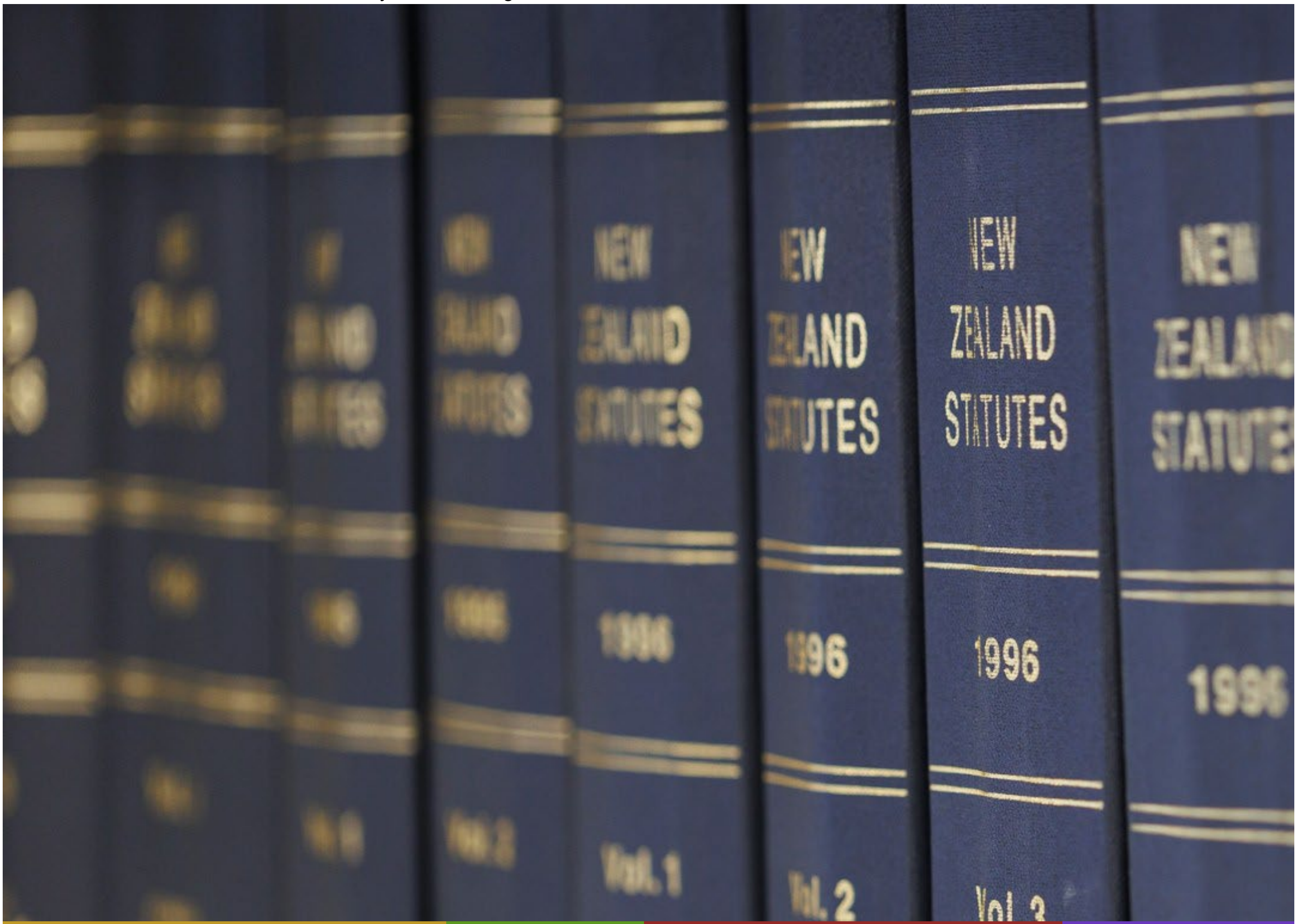
Nāku iti noa, nā

LIZ LAMBERT
ON BEHALF OF REGIONAL CHIEF EXECUTIVE OFFICERS
TE URU KAHIKA | REGIONAL AND UNITARY COUNCILS AOTEAROA



Have your say on the proposed Regulatory Standards Bill

November | 2024

Ministry for Regulation
Te Manatū Waeture

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Minister’s foreword

Most of New Zealand's problems can be traced to poor productivity, and poor productivity can be traced to poor regulations. To address this, the Coalition Agreement between ACT and National commits to policies aimed at rebuilding the economy and enhancing productivity. Establishing the Ministry for Regulation (the Ministry) and introducing the Regulatory Standards Bill (the Bill) are key initiatives to help the government achieve these goals

The Bill is the culmination of nearly 25 years of work. I would like to acknowledge those who have paved the way for regulatory reform in 2024, particularly Dr Bryce Wilkinson, whose book "Constraining Government Regulation" laid important groundwork for this Bill. Special thanks also go to Dr Graham Scott, Jack Hodder KC, and other members of the Regulatory Responsibility Taskforce, who refined the Bill in 2009. In 2021, I brought the Bill forward as a Member's Bill, but it was voted down by the previous government. Today, we are taking the opportunity to make real progress on regulatory reform.

The Bill aims to establish high-quality regulatory standards to help ensure that regulation keeps up with societal change, and drives productivity, by codifying principles of good regulatory practice. The aim is for future regulatory proposals, as well as existing regulations, to comply with these principles, unless lawmakers justify why they are failing to meet the standard.

The Bill also establishes a Regulatory Standards Board (the Board). The Board will assess complaints about existing regulation that is inconsistent with the principles, issuing non-binding recommendations and public reports.

Where a statement of inconsistency is made by the Board, the governing Minister must respond to justify deviation from principles. The findings, justification arguments, and relevant documents will be made publicly available to ensure transparency.

The Bill also provides the framework under which the Ministry will operate, empowering it to act in an advisory capacity, promoting good regulatory practice across all sectors. It seeks to bring the same level of discipline to regulatory management that the Public Finance Act brings to public spending, with the Ministry playing a role akin to that of the Treasury.

Under the proposed Bill, government agencies will have duties to maintain, review, and update their regulatory systems. An effective regulatory system ensures that its regulatory "stock" remains effective and responsive to change.

Ultimately, this Bill will help the Government achieve its goal of improving New Zealand's productivity by ensuring that regulated parties are regulated by a system which is transparent, has a mechanism for recourse, and holds regulators accountable to the people.

Hon David Seymour
Minister for Regulation
31 October 2024

What is being consulted on?

This discussion document sets out a proposal to introduce a Regulatory Standards Bill.

The Coalition Agreement between the New Zealand National Party and ACT New Zealand includes a commitment to legislate to improve the quality of regulation, ensuring that regulatory decisions are based on principles of good law-making and economic efficiency, by passing the Regulatory Standards Act as soon as practicable.

The proposed Regulatory Standards Bill would aim to bring the same discipline of regulatory management as New Zealand has for fiscal management by providing:

- a benchmark for good regulation through a set of principles of responsible regulation (see **Discussion area one**)
- mechanisms to transparently assess the consistency of new legislative proposals and existing regulation with the principles (see **Discussion area two**)
- a mechanism for independent consideration of the consistency of existing regulation, primarily in response to stakeholder concerns (see **Discussion area three**).

It would also include provisions to support the Ministry for Regulation in its work to improve the quality of regulation (see **Discussion area four**).

The proposed Bill itself has not yet been drafted so your views are being sought on a proposal on what it should contain.

What is not in scope?

For this consultation, feedback is not being sought on:

- the Ministry for Regulation or its functions
- other proposed or current Government policies relating to regulation
- issues with specific regulations or agencies
- funding decisions.

Questions for discussion

The discussion document sets out a range of questions in relation to the proposal, which are intended as a guide for you to provide feedback. However, you do not have to answer all – or any – of these questions.

Supporting information

Some supporting information that may help you form your views on the proposal is listed below.

Regulatory Impact Statement

The Ministry for Regulation has produced an interim regulatory impact statement, which provides the Ministry's analysis of available options and their relative impacts, including the proposal set out in this discussion document. You can download a copy from the Ministry?s website.

Preliminary Treaty Impact Analysis

The Ministry for Regulation has produced a preliminary Treaty Impact Analysis, which provides the Ministry's initial analysis of the Treaty impacts of the proposal set out in this discussion document. You can download a copy from the Ministry?s website.

The Report of the Regulatory Review Taskforce

The Regulatory Review Taskforce was set up to provide its view on what a Regulatory Standards Bill should contain, and reported its findings to the Government in 2009. The proposal in this document is largely based on that proposal. You can find the Taskforce's report on the Treasury?swebsite.

Other useful supporting information

In 2010, the Institute of Policy Studies at Victoria University of Wellington published a special edition of its Policy Quarterly journal, setting out the different views of a number of experts on the draft Regulatory Standards Bill proposed by the Regulatory Taskforce. This Vol. 6 No. 2 (2010) edition can be found at https://ojs.victoria.ac.nz/pq/issue/view/515.

In 2011, the Regulatory Standards Bill drafted by the Taskforce was introduced to Parliament and considered by the Commerce Select Committee. The reports of the Committee along with public submissions on the Bill can be found on Parliament?s website.

Consultation process

Consultation on the proposal to introduce a Regulatory Standards Bill is open from 19 November 2024 until 13 January 2025.

You can provide a submission:

- through the engagement hub on the Ministry's website
- emailing your submission to RSBconsultation@regulation.govt.nz, or
- mailing your submission to Ministry for Regulation, P O Box 577, Wellington 6140.

This discussion document has questions that you can use to complete your submission.

As noted above, the questions are not compulsory. You can answer as many as you want or share your own thoughts about the proposed Bill.

Please send any questions on the submissions process to RSBconsultation@regulation.govt.nz.

What will happen with feedback?

The information provided in submissions will be used to help determine the final shape of the Bill that will be introduced into the House next year.

There will be a further chance to submit on a draft Bill during the Parliamentary Select Committee process in 2025.

Submitters may be contacted directly if clarification of any matters in the submissions is required.

Release of information

The Ministry for Regulation will publish a summary of submissions on its website. Submissions remain subject to request under the Official Information Act 1982. Please clearly indicate in the cover letter or e-mail accompanying your submission if you have any objection to the release of any information in the submission, and which parts you consider should be withheld, together with the reasons for withholding the information. The Ministry will take such objections into account and will consult with submitters as it considers necessary when responding to requests under the Official Information Act.

Private information

The Privacy Act 2020 establishes certain principles with respect to the collection, use and disclosure of information about individuals by various agencies, including the Ministry for Regulation. Any personal information you supply to the Ministry in the course of making a submission will be used only for the purpose of assisting in the development of advice in relation to this consultation, for contacting you about your submission, or to advise you of the outcome of the consultation, including any next steps. The Ministry may also use personal information you supply in the course of making a submission for other reasons permitted under the Privacy Act (e.g. with your consent, for a directly related purpose, or where the law permits or requires it).

We will proactively remove identifying information from the published summary of submissions. Any request under the Official Information Act 1982 that includes identifying information will need to be considered in line with that Act. Please clearly indicate in your submission if you consider your name, or any other identifying information, should not be released under the Official Information Act and why, and we will take that into account in the event of a request.

The Ministry will retain personal information only as long as it is required for the purposes for which the information may lawfully be used.

Where any information provided (which may include personal information) constitutes public records, it will be retained to the extent required by the Public Records Act 2005. The Ministry may also be required to disclose information under the Official Information Act, to a Parliamentary Select Committee or Parliament in response to a Parliamentary Question.

You have rights of access to and correction of your personal information, and further details on how to contact us are on the Ministry's website.

Questions

1. What is your name?
2. Are you submitting in a personal capacity, or on behalf of an organisation, iwi, or hapū?
3. If you are submitting on behalf of an organisation, iwi, or hapū what is the name of that organisation, iwi or hapū?

4. Where in New Zealand are you primarily based?
5. Please provide us with at least one method of contacting you, in case the Ministry needs to discuss your submission further.

Background

Why is good regulation important?

Good **regulation** can help governments to achieve their desired economic, environmental and social outcomes, support the effective operation of markets, and protect communities from harm.

Done poorly, however, regulation can impose costs, limit freedoms, stifle innovation, and give rise to other unintended consequences – or it can simply fail to achieve its intended objectives.

Governments should therefore make careful choices about when they regulate, and any resulting regulation should be designed, implemented, and monitored so that it achieves its objectives, and its benefits outweigh its negative impacts.

'Regulation' versus 'legislation'

This discussion document uses 'regulation' to encompass any government intervention that is intended to direct or influence people's behaviour, or how they interact with each other. 'Regulation' therefore includes, but is not limited to, legislation.

Legislation includes primary legislation (i.e. law made by Parliament) or secondary legislation (where Parliament delegates its law-making power - usually to the Governor-General acting on the advice and with the consent of the Executive Council, a regulator, a Minister or a government agency).

The term 'regulation' is also distinct from the term 'regulations' which is used to describe a particular type of secondary legislation made under the delegated authority of an Act.

How good is New Zealand's regulation?

New Zealand's approach to regulation has not always been consistent with best practice.

For instance, in its 2023 *Briefing for the Incoming Attorney-General*, the Legislation Design and Advisory Committee (LDAC), which has responsibility for promoting good quality legislation in New Zealand, noted a tendency towards using legislation in cases where it was not strictly required, or where it covered matters already addressed in existing legislation[1].

Unneeded or poor-quality legislation can arise through deficiencies in the policy development process, including a failure to fully consider the impacts of regulatory proposals on regulated parties and regulators. This is often exacerbated by a truncated or rushed legislative process. Issues can also result from poorly implemented regulation.

In addition, New Zealand has a large stock of outdated or no longer fit-for-purpose legislation. Back in 2014, the Productivity Commission noted that two-thirds of regulator chief executives reported they had to work with legislation that is outdated or not fit-for-purpose.[2] This creates inefficiencies for regulators, imposes unnecessary costs on regulated parties, and means that **regulatory systems** cannot easily adapt to technological, demographic, or other change, or easily respond in emergency situations.

Regulatory systems

Regulatory systems comprise a set of rules, organisations and activities that share a common policy objective (e.g. health and safety). Regulatory systems are not limited to primary and secondary legislation, but include a range of activities including the delivery of services, education, monitoring and enforcement, and dispute resolution. The Government is responsible for around 180-200 regulatory systems.

[1] LDAC (2023). *Briefing for the Incoming Attorney-General*, pp. 12-13
[2] Productivity Commission (2014). *Regulatory Institutions and Practices*, p. 224

New Zealand's regulatory performance has also stagnated or worsened over time, according to results from recent international surveys[3]. While those results are partly due to changes in the scope and methodology of surveys over time, or characteristics particular to New Zealand, such as its small size and relatively less formal constitutional arrangements, they indicate that there may be considerable room for improvement.

What are the current arrangements to promote regulatory quality?

Requirements for responsible Ministers and agencies

There are two main requirements for Ministers and agencies currently in place that are designed to improve the quality of proposed legislation.

- All regulatory proposals taken to Cabinet for approval must be accompanied by a **Regulatory Impact Statement** (RIS), unless an exemption applies. A RIS is a document produced by the responsible government agency and provides a high-level summary of the problem being addressed, the options and their associated costs and benefits, the consultation undertaken, and the proposed arrangements for implementation and review.
- Most legislation introduced to the House must be accompanied by a **disclosure statement**, intended to promote good practices for the development of that legislation by requiring agencies to set out relevant background material, outline the quality assurance processes undertaken by the agency and note any significant or unusual provisions. Disclosure statements are currently only provided under administrative arrangements. Part 4 of the Legislation Act 2019 (which provides for new disclosure requirements) has not yet come into force.

All RISs and disclosure statements are published to allow for public scrutiny.

There are no specific requirements relating to the ongoing review and maintenance of legislation and the operation of regulatory systems, beyond a broad duty for Chief Executives in the Public Service Act 2020 in relation to proactively promoting stewardship of the agency's legislation (see section 12(1)(e)(v) of the Public Service Act 2020).

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[3] For instance, New Zealand's relative ranking in the OECD's Product Market Regulation Indicators survey has declined across the 2018 and 2023 results.

Various guidance has been published to support these requirements, including the *Government Expectations for Good Regulatory Practice*[4] and *Starting out with regulatory stewardship*[5].

New Zealand is also party to several international agreements (including Free Trade Agreements) that contain expectations for good regulatory practice, including publishing descriptions of our good regulatory practice mechanisms and processes, public consultation on proposed regulatory measures, and impact assessments of regulatory proposals.

Regulatory oversight arrangements

Regulatory oversight arrangements help make sure that regulation is of good quality and Ministers and agencies are meeting relevant expectations – just as there are assurance and audit arrangements in place for agencies' financial performance (for instance, the Treasury's scrutiny of new spending proposals).

Regulatory oversight

Regulatory oversight involves the establishment of mechanisms and institutions to oversee, support, and implement regulatory policy to promote better regulatory quality. It can include setting up dedicated structures (such as the Ministry for Regulation), or processes, guidance and requirements.

First and foremost, **Parliament** plays an important role with respect to oversight of regulatory quality. In addition to its broad role in holding the Executive (including Minsters and agencies) to account, Parliamentary select committee processes ensure that proposed legislation is subject to appropriate Parliamentary and public scrutiny.

One Select Committee, the Regulations Review Committee, examines all secondary legislation and may also examine proposed secondary legislation-making powers in bills. The Committee considers whether the secondary legislation ought to be drawn to the special attention of the House on one or more grounds. The Regulations Review Committee also investigates complaints about the operation of secondary legislation and may report on the complaints to the House.

[4] This can currently be found on the Treasury's website
[5] This can currently be found on the Treasury's website

How Parliament holds the Executive to account

New Zealand's constitutional framework is based on parliamentary sovereignty, which means Parliament is supreme over the other branches of government – the Executive and the Judiciary. Parliament's primary roles are to legislate and to maintain public trust in government by holding the Executive to account. The Executive sets the legislative priorities and supports the law-making process, but Parliament is ultimately responsible for producing good quality laws through effective scrutiny.

Parliament holds the Executive to account through a range of structures and procedures. These include scrutiny by members of Parliament during question time, Select Committee processes, the work of Officers of Parliament such as the Auditor-General, Parliamentary agencies such as the Office of the Clerk, and the government's own accountability systems.

In addition, the Ministry for Regulation is responsible for some oversight and quality control arrangements to help ensure new regulatory proposals meet required standards:

- It administers the requirements for quality assurance of RISs, which must all be independently assessed against set quality assurance criteria. In most cases, this assessment is led by the responsible agency – however, the Ministry for Regulation can decide to be involved in quality assurance for particularly complex, significant proposals, or where there are concerns about the agency's capacity to carry out robust quality assurance.
- It can audit the robustness of quality assurance processes put in place by agencies.
- It monitors compliance with Cabinet's impact analysis requirements.
- It has established a second opinion advice role, where it provides separate advice on the quality of regulatory proposals put forward by other agencies – in the same way that the Treasury scrutinises proposals with fiscal implications.

Other entities also play a role in helping ensure legislation introduced to the House is of a high quality, supporting the Attorney-General as senior law officer in carrying out their particular responsibility for maintaining the rule of law:

- The Parliamentary Counsel Office (PCO) is responsible for drafting Government bills and amendments to them, drafting much of New Zealand's secondary legislation, and publishing all introduced bills, Acts and the secondary legislation it drafts. PCO's objective is to promote high-quality legislation that is easy to find, use, and understand, and to exercise stewardship over New Zealand's legislation as a whole.

- The Legislation Design and Advisory Committee (LDAC) promotes quality legislation by engaging with agencies early in the development of policy and legislation to resolve problems in the design of legislation and to identify potential public and constitutional law issues. It also publishes and maintains the Legislation Guidelines[6], which are endorsed by Cabinet, and makes submissions to select committee where key legislative design issues arise.
- The Ministry of Justice is responsible for scrutinising proposed legislation to assess whether it is consistent with the New Zealand Bill of Rights Act 1990 (BORA). BORA protects and promotes human rights and fundamental freedoms in New Zealand.
- The Office for Māori Crown Relations – Te Arawhiti administers the Treaty Provisions Oversight Group which is available to meet with agencies to support the development of legislative provisions.

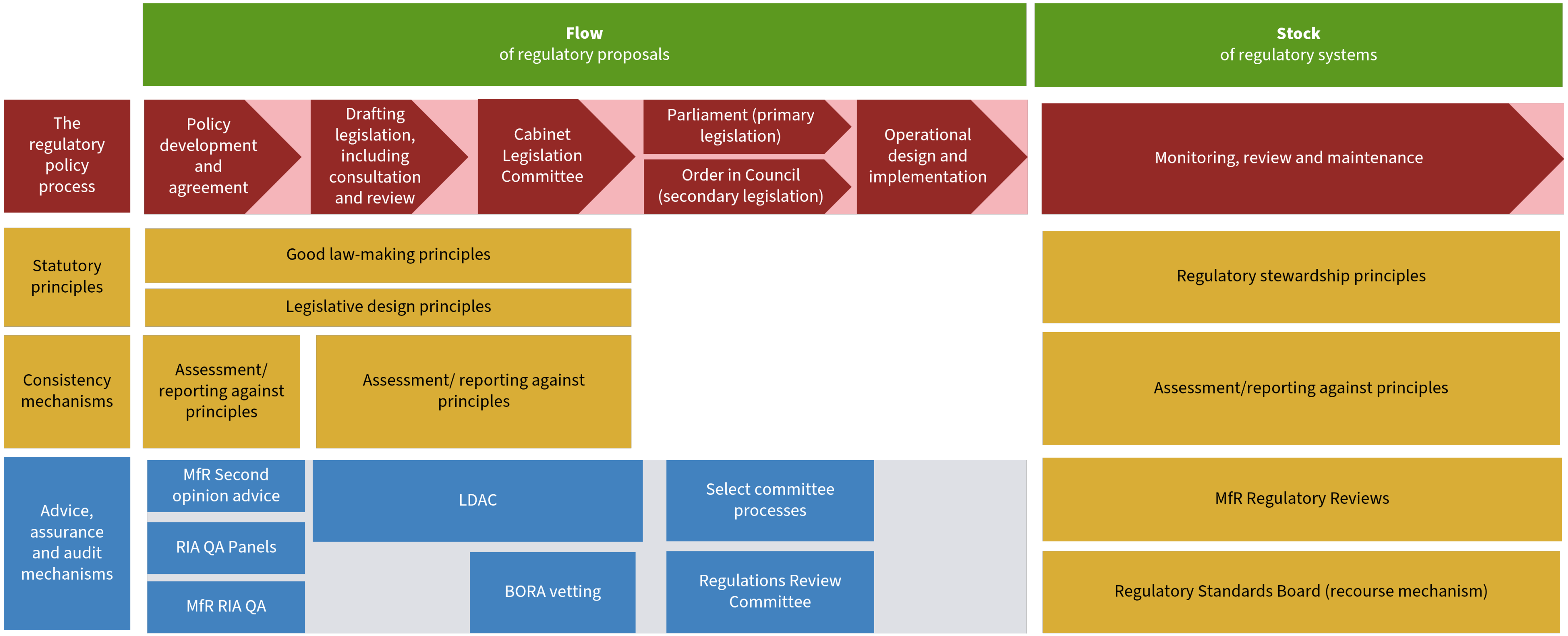
There are fewer regulatory oversight arrangements within the Executive in relation to the performance of existing regulation. However, the Ministry for Regulation has responsibility for:

- improving the functioning of regulatory systems by undertaking regulatory reviews of specific regulatory systems or sectors
- raising the capability of regulators to design, operate and govern regulatory systems effectively.

The diagram below sets out how all these aspects of regulatory oversight fit together.

[6] These can be found on LDAC's website.

How regulatory oversight mechanisms fit together



Key: Blue boxes are existing mechanisms. Yellow boxes are components of the proposed Bill

RIA – Regulatory Impact Analysis
OIA – Official Information Act

LDAC – The Legislation Design and Advisory Committee
BORA – New Zealand Bill of Rights Act 1990

Why a Regulatory Standards Bill?

New Zealand's current regulatory oversight arrangements as outlined in the previous section are under-developed compared with many other countries. In particular, New Zealand tends to rank low relative to other countries in relation to oversight and quality control of regulation.[7] Some issues with our current approach include that:

- agencies' performance in relation to RIA requirements can be patchy, with many RISs not fully meeting requirements. In addition, there are increasing levels of non-compliance with RIA requirements, and the devolved nature of the quality assurance process can make it more difficult to test the robustness of assessments made by agencies. The Ministry for Regulation is currently leading work to help address some of these issues
- there are few checks and balances in place in relation to the performance of existing regulation, or monitoring of agencies's **stewardship** of their regulatory systems
- while there are standards for regulation set out in a number of different places (e.g. the *Government Expectations for Good Regulatory Practice* and the *Legislation Guidelines*) there is no one, single place to find these standards
- aspects of our oversight arrangements, including the relatively informal nature of these arrangements along with limited accountability mechanisms, mean that we need to make some improvements to better comply with our international obligations in relation to good regulation.

Regulatory stewardship

Regulatory stewardship is the governance, monitoring and care of regulatory systems. It aims to ensure that all the different parts of a regulatory system work well together to achieve its goals, to keep the system fit for purpose over the long term and to deliver value for money for taxpayers.

[7] OECD (2021). *OECD Regulatory Policy Outlook*

The idea of a Regulatory Standards Bill – to strengthen regulatory oversight and improve the quality of regulation through legislative means – was first proposed in 2006, when the Regulatory Responsibility Bill was introduced as a private member's Bill, but did not progress past its first reading in Parliament.

In 2009, the Government established the Regulatory Responsibility Taskforce to consider what should be in a Regulatory Standards Bill.

In its report, the Taskforce expressed a view that:

> [t]he fundamental nature of the principles contained in the [Legislation] Guidelines, and patchy compliance by policy-makers with the guidelines and the regulatory impact analysis requirements, signals the need for a coherent, mandatory, regulatory quality regime. Analysis of the scale and scope of a problem, the various options for addressing it, whether legislation is required (and whether existing laws are sufficient) should be the first things examined by policymakers. Yet all too often they are the last. The Taskforce members are satisfied that the constitutional principles require additional and effective mechanisms to motivate early, and transparent, consideration of proposals against them. They should have legislative force.[8]

The Taskforce therefore proposed a draft Bill to set principles in legislation and require regulation to be assessed against these standards.

The Taskforce's Bill formed the basis of the Regulatory Standards Bill that was introduced as a private Member's Bill in 2021 (which similarly did not progress at the time).

While the components of the proposed Regulatory Standards Bill outlined in this discussion document share many similarities with the Taskforce's draft Bill and the 2021 Regulatory Standards Bill, there are also some key differences, including that this proposal includes:

- amendments to some of the principles in the 2021 Bill to better align them with broadly accepted principles and practices
- establishment of a Regulatory Standards Board rather than giving a role to the courts in finding legislation inconsistent with the principles

[8] Regulatory Responsibility Taskforce (2009). *Report of the Regulatory Responsibility Taskforce*, p. 16

- new powers and expectations to give effect to the Ministry for Regulation's regulatory oversight role.

This discussion document seeks feedback on each of these components of the proposed Bill.

Questions

6. What are your overall views on the quality of New Zealand's regulation?
7. What are your overall views on the current arrangements in place to promote high quality regulation?
8. Do you ever use RISs to find out information about proposed government regulation? If so, how helpful do you find RISs in helping you make an assessment about the quality of the proposed regulation?
9. Do you ever use disclosure statements to find out information about a Bill? If so, how helpful do you find disclosure statements in helping you make an assessment about the quality of the Bill?
10. What are your views about the effectiveness of the regulatory oversight arrangements currently in place?
11. What are your views on setting out requirements for regulatory quality in legislation? Are there any alternatives that you think should be considered?

Discussion area one: Setting standards for good regulation

How would standards for good regulation be set?

It is proposed that the Bill would set out a set of principles that the Government would consider when developing legislative proposals or exercising stewardship over regulatory systems. The principles would be in primary legislation, consistent with the Taskforce's view that this was necessary to give the principles sufficient weight.

These **principles of responsible regulation** would act as a set of criteria against which new regulatory proposals or existing regulation could be assessed.

The principles would be broad and expressed at a high level. The Bill would require the Minister for Regulation to release guidelines that would set out in more detail how the principles should be interpreted and applied.

What would the principles cover?

It is proposed that the Bill include principles based on the Taskforce's recommended principles, as set out in the 2021 Bill.

These principles are selective rather than comprehensive – for instance, they do not cover all the principles set out in the *Legislation Guidelines*. Instead, as the Taskforce noted, they "focus primarily on the effect of legislation on existing interests and liberties and good law-making process."[9]

In some cases, the wording of the principles differs slightly from the ones in the 2021 Bill – these reflect changes made to better align some of the principles with how they are currently formulated in the *Legislation Guidelines* or elsewhere in legislation. However, other principles reflect new formulations of legal principles.

It is also proposed that the Bill include some new principles focused on the review and maintenance of existing regulation, given that many issues arise when legislation is poorly implemented, or is no longer fit for purpose.

The proposed principles fall into three broad categories:

- principles relating to the design and content of legislation
- principles relating to good law-making

[9] Regulatory Responsibility Taskforce (2009), p. 38

- principles relating to regulatory stewardship.

What would the principles not cover?

There are some principles in the *Legislation Guidelines* that are not proposed to be covered in the Bill.

For instance, even though there is some overlap with rights set out in the BORA, the proposed Bill would not cover all of these rights.

In addition, it is not proposed that the Bill would include a principle relating to the Treaty of Waitangi/Te Tiriti o Waitangi.

What would the specific principles be?

The proposed principles are set out below.

Legislative design principles

Rule of law

- The importance of maintaining consistency with the following aspects of the rule of law:
    - the law should be clear and accessible
    - the law should not adversely affect rights and liberties, or impose obligations, retrospectively
    - every person is equal before the law
    - there should be an independent, impartial judiciary
    - issues of legal right and liability should be resolved by the application of law, rather than the exercise of administrative discretion.

Liberties

- Legislation should not unduly diminish a person's liberty, personal security, freedom of choice or action, or rights to own, use, and dispose of property, except as is necessary to provide for, or protect, any such liberty, freedom, or right of another person.

Taking of property

- Legislation should not take or impair, or authorise the taking or impairing of, property without the consent of the owner unless:
    - there is good justification for the taking or impairment
    - fair compensation for the taking or impairment is provided to the owner
    - compensation is provided to the extent practicable, by or on behalf of the persons who obtain the benefit of the taking or impairment.

Taxes, fees and levies

- The importance of maintaining consistency with section 22 of the Constitution Act 1986 (Parliamentary control of public finance).
- Legislation should impose, or authorise the imposition of, a fee for goods or services only if the amount of the fee bears a proper relation to the costs of efficiently providing the good or service to which it relates.
- Legislation should impose, or authorise the imposition of, a levy to fund an objective or a function only if the amount of the levy is reasonable in relation to both:
    - the benefits that the class of payers are likely to derive, or the risks attributable to the class, in connection with the objective or function
    - the costs of efficiently achieving the objective or providing the function.

Role of courts

- Legislation should preserve the courts' constitutional role of ascertaining the meaning of legislation.
- Legislation should make rights and liberties, or obligations, dependent on administrative power only if the power is sufficiently defined and subject to appropriate review.

Good law-making

- The importance of consulting, to the extent practicable, the persons or representatives of the persons that the Government considers will be substantially affected by the legislation.
- The importance of carefully evaluating:

  - the issue concerned
  - the effectiveness of any relevant existing legislation and common law
  - whether the public interest requires that the issue be addressed
  - any options (including non-legislative options) that are reasonably available for addressing the issue
  - who is likely to benefit, and who is likely to suffer a detriment, from the legislation.
- Legislation should be expected to produce benefits that exceed the costs of the legislation to the public or persons.
- Legislation should be the most effective, efficient, and proportionate response to the issue concerned that is available.

Regulatory stewardship

- Legislation should continue to be the most effective, efficient, and proportionate response to the issue concerned that is available.
- The system should continue to be fit for purpose for the people, area, market, or other thing that is regulated.
- Unnecessary regulatory burdens and undue compliance costs should be eliminated or minimised.
- Any regulator should have the capacity and the capability to perform its functions effectively.
- Any conflicts or adverse interactions with other regulatory systems should be eliminated or minimised.
- The importance of monitoring, reviewing, and reporting on the performance of the system.

Questions

12. What are your views on setting principles out in primary legislation?
13. Do you have any views on how the principles relate to existing legal principles and concepts?

14. Do you agree with the focus of the principles on:
    - rights and liberties?
    - good law-making processes?
    - good regulatory stewardship?
15. Do you have any comments on the proposed principles themselves?
16. In your view, are there additional principles that should be included?

Discussion area two: Showing whether regulation meets standards

A key part of the 2021 Regulatory Standards Bill contained a requirement for Ministers and agencies to certify new and existing legislation against the principles.

Similarly, this proposal would provide for both new legislation and existing regulation to be assessed against the principles of responsible regulation.

This approach aims to create a strong incentive for agencies and Ministers to ensure that regulation for which they are responsible is consistent with the principles, or that any departure is justified. It also aims to ensure that there is full transparency and accountability where a Responsible Minister chooses:

- to proceed with legislation despite it being inconsistent with the principles (without justification)
- to not address unjustified inconsistencies identified in existing regulation.

By applying the same scrutiny to both new regulatory proposals and existing regulation, the aim is to significantly improve the quality of New Zealand’s stock of regulation over time.

How would new regulatory proposals be assessed?

The proposed approach would set requirements for agencies to ensure that new regulatory proposals are assessed for consistency with relevant principles, and any inconsistencies identified.

These requirements would apply prior to:

- a proposal coming to Cabinet
- primary legislation being introduced into the House, or secondary legislation being made and published.

At either stage, a regulatory policy proposal or draft legislation could be assessed as inconsistent with any of the principles. There would then be two options for the responsible agency and Minister:

- the regulatory policy proposal or the draft legislation could be amended to ensure consistency with the principles (or withdrawn entirely)

- the responsible Minister could make a statement justifying why they are proceeding with the proposal despite these inconsistencies.

To provide transparency, any Ministerial statements, along with the relevant key supporting information generated through the assessment process could be published after a Bill has been introduced, or secondary legislation made (subject to equivalent provisions of the Official Information and Privacy Acts).

How would existing regulation be assessed?

The proposed approach would set new requirements for both Ministers and agencies in relation to the review of regulation for which they are responsible.

These requirements would include a duty for Ministers and agencies to maintain, review and update the regulatory systems for which they are responsible. This duty is discussed further in **Discussion Area Four**.

Under this duty, agencies would be responsible for regularly reviewing their regulation for consistency with the regulatory stewardship principles.

Where a responsible agency identifies any inconsistency with those principles, there would be two options for the agency and the responsible Minister:

- an agency could commit to amendment of the regulation within a specified time (for instance, by adding it to a forward plan for regulatory amendments)
- the responsible Minister could make a statement justifying why they are choosing not to remedy these inconsistencies.

Again, to help ensure full transparency, the Bill would require the publication of any Ministerial statements, along with the relevant key supporting information generated through the assessment process (subject to equivalent provisions of the Official Information and Privacy Acts).

How would processes for assessing consistency be set?

Under the proposed approach, the Bill would only set out the high-level expectations of agencies and Ministers. It would not set out detailed processes.

Instead, under the proposed approach, the Minister for Regulation would be required to issue guidelines in relation to the assessment of consistency of proposed and existing regulation. These guidelines would set out:

- further information on how the principles should be interpreted and applied
- what steps agencies and Ministers should take to ensure that they consider the principles when developing new proposals or reviewing their regulation, and any processes they should follow
- the information that should be provided when assessing the consistency of regulation or justifying any inconsistency
- requirements for publication of any information generated through these processes.

What would be exempt from consistency requirements?

There will be situations where it may not be possible or desirable for new or existing regulation to be assessed for consistency with the principles, for instance in emergency situations, or in relation to proposed or existing regulation that has only minor or technical impacts or significance (e.g. much secondary legislation).

The proposed approach would therefore enable the Minister for Regulation to determine which types of regulation are required to comply with consistency requirements. Other regulation not covered by the direction would be exempt.

This would aim to provide some flexibility to recognise specific circumstances, or to ensure agencies and Ministers are focusing on regulation that has the most potential or actual impact on New Zealanders.

The ability to exclude the application of mechanisms to certain proposals will also be important to enable new arrangements to align with **RIS exemptions** where appropriate.

RIS exemptions

Cabinet O?ice Circular CO (20) 2 sets out where a RIS is not required for certain types of government regulatory proposals. These exemptions include where a proposal is minor or technical in nature, in emergency situations, or where the analysis that would be set out in a RIS has been done elsewhere (e.g. where a business case has been produced).

The Crown's commitments under Treaty settlements are reflected in deeds of settlement, which are given effect through legislation. The proposed approach would therefore exclude legislation that gives effect to, or is otherwise related to, full and final Treaty settlements.

How would these arrangements fit with existing processes?

There would be a degree of overlap between the proposed new arrangements for assessing consistency, and some of the existing arrangements for promoting the quality of regulation discussed in the **Background** section above, in particular the requirements relating to RISs and disclosure statements. It will be important that these are aligned and streamlined, to minimise costs and complexity.

Given that RIS requirements and other guidance (such as the *Legislation Guidelines*) are administrative (i.e. they are not required by legislation), new arrangements to align and streamline the new proposal and current RIS requirements can be designed once a Bill has been drafted.

However, requirements for disclosure statements are set out in **Part 4 of the Legislation Act 2019**. While these requirements have not yet been brought into force, they include provisions for the Government to issue standards that would operate in a similar way to the proposed principles – however they would be set out in secondary legislation and affirmed by the House.

Part 4 of the Legislation Act 2019

Part 4 of the Legislation Act requires notices to be issued by the Attorney-General and the Responsible Minister (which we anticipate would become the Minister for Regulation) and agreed by Parliament, that set out what disclosure statements must contain. The notices would specify what information disclosure statements must contain about departures from legislative guidelines and standards, and identify legislative guidelines or standards for this purpose.

Similar to the proposed Bill, this would effectively set quality benchmarks for all legislative proposals, but it would do this in secondary rather than primary legislation. However, Part 4 has not yet been brought into force, and no notices have therefore yet been issued. In the meantime, agencies are still required to prepare disclosure statements, but the requirement is administrative (i.e. a Cabinet requirement) rather than legislative.

Any changes to the disclosure regime would therefore require amendment or repeal of Part 4. This would be worked through in more detail during the drafting of a Bill.

Questions

17. Do you agree that there are insufficient processes in place to assess the quality of new and existing regulation in New Zealand? If so, which parts of the process do you think need to be improved?
18. Do you think that the new consistency checks proposed by the Regulatory Standards Bill will improve the quality of regulation? Why or why not?
19. Do you have any suggested changes to the consistency mechanisms proposed in this discussion document?
20. Which types of regulation (if any) do you think should be exempt from the consistency requirements proposed by the Regulatory Standards Bill (for example, regulation that only has minor impacts on businesses, individuals, and not for-profit entities, legislation that corrects previous drafting errors, or legislation made under a declared state of emergency)?

Discussion area three: Enabling people to seek independent assessment of whether regulation meets standards

The 2021 Bill created a specific role for the courts in applying the principles. This role included:

- preferring interpretations of legislation that were consistent with the principles
- being able to declare legislation inconsistent with the principles in response to applications to the court.

The Taskforce saw these roles as strengthening the application of the principles and providing strong incentives for responsible Ministers and agencies to ensure good quality regulation – to avoid the courts publicly declaring regulation inconsistent with the principles. It also provided a way for individuals or organisations to complain about poor quality regulation.

Current mechanisms for considering complaints about regulation

There are already a range of ways that members of the public can raise complaints about the quality of regulation in New Zealand, or the way that regulation has been applied or enforced. These include:

- the Regulations Review Committee, which focuses on secondary legislation (described earlier in this discussion document)
- the Office of the Ombudsman
- independent Commissions within Government (e.g. the Human Rights Commission, the Health and Disability Commissioner)
- bringing a judicial review case to the courts
- bringing a legal case to a tribunal (e.g. the Employment Relations Authority)
- raising the issue with a Minister or Government agency directly (or with local government and non-government administering agencies)
- creating a petition on the New Zealand Parliament website regarding the regulation.

Proposed approach

The proposed approach would aim to complement current mechanisms for hearing complaints about regulation.

It differs from the 2021 Bill in that it no longer provides a role for the courts. Instead, it proposes that a Regulatory Standards Board be established to consider the consistency of regulation with the principles in response to complaints.

The proposed Board would aim to offer a relatively low-cost, agile way to consider and respond to complaints quickly. It would focus on the consistency of existing regulation with the principles.

What form would the Board take?

The proposed Board would be established as a statutory board that would make non-binding recommendations independent of Ministers and agencies.

It would be made up of members appointed by the Minister for Regulation, and would be supported by a secretariat from the Ministry for Regulation.

The Board would likely be made up of members with a range of skills, including legal and economic expertise.

What would the Board do?

The Board would be able to consider complaints about inconsistency of existing regulation with one or more of the principles, and would deliver non-binding, recommendatory findings.

The Board would consider the operation of regulatory systems (e.g. how well regulation is being implemented) as well as the content and design of legislation.

The Board would also be able to undertake reviews at its own behest, or at the direction of the Minister for Regulation.

After considering an issue, the Board would provide a short report setting out any views on the consistency of regulation with the relevant principle(s), along with any recommendations for addressing this inconsistency.

If there was insufficient information for the Board to come to any conclusion on the consistency of regulation, and the Board thought further investigation was worthwhile, the Board could also recommend that the responsible agency should undertake a review of the whole or particular parts of that regulatory system to assess it for consistency.

If the Board found any inconsistency with the principles, the responsible Minister would be required to respond to that finding, including justifying any decision not to address identified inconsistencies.

All Board findings would be published (subject to equivalent provisions of the Official Information and Privacy Acts) to ensure transparency.

The Board's report could also be presented to the House to help strengthen Parliamentary scrutiny.

What would the Board not do?

The aim is that the Board would not:

- cut across any existing complaint mechanisms
- consider decisions made by Ministers or agencies in relation to individual cases.

The Board would not initially have a role in assessing new regulatory proposals – but this could be reviewed over time.

How would the Board operate?

In order to manage the costs of the Board and the costs to agencies in responding to any complaints, the Board would:

- have some discretion in relation to whether to consider complaints, and what principles to consider in response to any complaints.
- operate 'on the papers' (i.e. it would not hold hearings) and on the basis of reasonably available information.

Questions

21. Have you used any of the existing mechanisms described above to raise issues or bring complaints about the quality of regulation to the Government? If so, did you find them effective?
22. Do you think that New Zealand needs a new structure or organisation to consider complaints about the quality of regulation? Why or why not?
23. If a new structure is created specifically to consider complaints about regulation:

a. do you think a Regulatory Standards Board would be the best mechanism to do this?

b. are there any alternatives that you think would be preferable to the proposed Board for investigating complaints about regulation?

24. Do you have any views on the detailed design of the proposed Board, including how it would operate and the proposed number of members?

25. In your view, what individual skills or experience should Board members have?

Discussion area four: Supporting the Ministry for Regulation to have oversight of regulatory performance

The proposal includes setting some new expectations for Ministers and agencies in the Bill to help improve the quality of regulation by:

- supporting the measures discussed earlier in this discussion document
- helping the Ministry for Regulation to take on a strong regulatory oversight role.

Setting strengthened regulatory stewardship expectations

Under the proposed approach, the Bill would:

- set a broad requirement for agencies in relation to regular review, maintenance and improvement of the legislation they administer. This would clarify and strengthen the legislative stewardship requirements that are already set out in s 12 of the Public Service Act 2020.
- require responsible agencies to develop and publicly report against plans to review their stock of legislation.

The proposed Bill could allow the Minister for Regulation to set further, more detailed requirements on how this should be done - e.g. in relation to the timing of plans and reports and what they must contain.

Given known issues with New Zealand's stock of legislation, encouraging agencies to more actively steward their regulatory systems will be critical to improving the quality of regulation over time.

This approach aims to place clearer and more specific requirements on agencies in relation to regulatory stewardship, and make this activity more transparent. However, it also aims to give agencies significant flexibility to plan and undertake reviews, as it does not mandate a certain number of reviews, or require regulatory systems to be reviewed within a specified time. Despite this, as a result of this proposal, agencies may need to dedicate greater resource to monitoring, evaluating, and reviewing their stock of legislation, which is likely to create costs for agencies.

Supporting the Ministry's regulatory oversight role

The Ministry for Regulation is responsible for conducting regulatory reviews that aim to assess whether regulatory systems are achieving their objectives and are not imposing unnecessary compliance costs, or unnecessarily inhibiting investment, competition and innovation.

Under the proposed approach, the Bill would give the Minister and Ministry for Regulation some powers to help carry out these reviews, with the aim of ensuring that these reviews can be carried out as efficiently and effectively as possible.

In particular, the Ministry will need to obtain information from entities that exercise regulatory functions – both to help decide whether a regulatory review is warranted, and to inform regulatory reviews. While most information would likely be requested and shared co-operatively, there may be some situations, where a statutory power to obtain information may be required. However, any such powers would not override prohibitions or restrictions on the sharing of information already set down in legislation. Entities required to comply with requests for information as part of regulatory reviews are likely to incur costs, which will range depending on the size and complexity of the information request and the entity's existing capacity and capability to comply with the request.

The proposed approach would also aim to increase the impact of reviews by enabling Parliament to consider review reports and to hold the Government to account for its response to the review.

More specifically, under the proposed approach, the Bill would support the Ministry's role in carrying out regulatory reviews by:

- providing for the Minister for Regulation to initiate regulatory reviews and set terms of reference for reviews
- providing information-gathering powers to enable the Chief Executive of the Ministry for Regulation to require information to be provided on request, to support the effective and efficient conduct of reviews, from:
    - public service agencies as defined in section 10(a) of the Public Service Act 2020)
    - statutory Crown entities as defined in section 7(1)(a) of the Crown Entities Act 2004
    - any entity that makes or administers secondary legislation, including local government

  - any entity authorised by an Act to undertake a regulatory function, for example the Reserve Bank and statutory occupational licensing bodies
  - any entity contracted by the government to support the delivery of a regulatory function, also known as third-party service providers
- setting a requirement for the review report to be presented to the House together with the Government's response.

Other proposed provisions to support the Ministry for Regulation's oversight of the quality of regulation include:

- a requirement for the Ministry for Regulation to produce a regular report for the Minister for Regulation to present to Parliament assessing the overall performance of the Regulatory Management System, including a broad assessment of the consistency of regulation against the principles
- a power for the Ministry for Regulation to require provision of information from agencies to support this regular report.

Such provisions would aim to strengthen accountability and transparency throughout the system, and give the Ministry for Regulation a solid statutory basis to carry out its central agency role.

Questions

26. Do you support the proposals in this section for strengthened regulatory stewardship expectations on agencies to be set out in a Bill?
27. Do you agree that there may be some situations where a power for the Chief Executive of the Ministry for Regulation to obtain information will be required to help decide whether a regulatory review is warranted and to inform regulatory reviews?
28. Do you agree that the proposed information gathering powers are justified for the purpose of informing regulatory reviews? Do you think the powers should apply to all the types of entities listed above, or only some?
29. Do you think the information gathering powers are broad enough to enable the Ministry for Regulation to undertake regulatory reviews effectively and efficiently?
30. Do you think any safeguards or procedures should be applied to limit how the information gathering powers are used by the Ministry for Regulation? What safeguards do you think should be put in place?

31. Do you support the proposals in this section in relation to the Ministry for Regulation's broad oversight role?
32. Are there any other measures you think a Bill should contain to support the quality of regulation?

Any other comments?

The Ministry would welcome any further comments you may have on the proposed Regulatory Standards Bill, including in relation to the following:

Questions

33. Do you think the overall proposal will be effective in raising the quality of regulation in New Zealand?
34. Do you think there are other provisions that should be included in the Bill. If so, what would they be?
35. Would you prefer any alternative options to the Bill, including non-legislative options?

What's next?

Your feedback on the proposal contained in this document will help inform further policy development and contribute to drafting a Regulatory Standards Bill.

There will be a further opportunity for you to provide feedback on a Bill if it progresses to select committee.

The proposed timeline for introduction of a Bill is in the first half of 2025.

Questions glossary

Questions **Page 8-9**

1. What is your name?
2. Are you submitting in a personal capacity, or on behalf of an organisation, iwi, hapū?
3. If you are submitting on behalf of an organisation, iwi, hapū what is the name of that organisation, iwi or hapū?
4. Where in New Zealand are you primarily based?
5. Please provide us with at least one method of contacting you, in case the Ministry needs to discuss your submission further.

Questions **Page 19**

6. What are your overall views on the quality of New Zealand's regulation?
7. What are your overall views on the current arrangements in place to promote high quality regulation?
8. Do you ever use RISs to find out information about proposed government regulation? If so, how helpful do you find RISs in helping you make an assessment about the quality of the proposed regulation?
9. Do you ever use disclosure statements to find out information about a Bill? If so, how helpful do you find disclosure statements in helping you make an assessment about the quality of the Bill?
10. What are your views about the effectiveness of the regulatory oversight arrangements currently in place?
11. What are your views on setting out requirements for regulatory quality in legislation? Are there any alternatives that you think should be considered?

Questions **Page 24 -25**

12. What are your views on setting principles out in primary legislation?
13. Do you have any views on how the principles relate to existing legal principles and concepts?
14. Do you agree with the focus of the principles on:
    a. rights and liberties?
    b. good law-making processes?
    c. good regulatory stewardship?
15. Do you have any comments on the proposed principles themselves?

16. In your view, are there additional principles that should be included?

Questions **Page 30**

17. Do you agree that there are insufficient processes in place to assess the quality of new and existing regulation in New Zealand? If so, which parts of the process do you think need to be improved?
18. Do you think that the new consistency checks proposed by the Regulatory Standards Bill will improve the quality of regulation? Why or why not?
19. Do you have any suggested changes to the consistency mechanisms proposed in this discussion document?
20. Which types of regulation (if any) do you think should be exempt from the consistency requirements proposed by the Regulatory Standards Bill, (for example, regulation that only has minor impacts on businesses, individuals, and not for-profit entities, regulation that corrects previous drafting errors, or regulations made under a declared state of emergency)?

Questions **Page 33 - 34**

21. Have you used any of the existing mechanisms described above to raise issues or bring complaints about the quality of regulation to the Government? If so, did you find them effective?
22. Do you think that New Zealand needs a new structure or organisation to consider complaints about the quality of regulation? Why or why not?
23. If a new structure is created specifically to consider complaints about regulation:
    a. do you think a Regulatory Standards Board would be the best mechanism to do this?
    b. are there any alternatives that you think would be preferable to the proposed Board for investigating complaints about regulation?
24. Do you have any views on the detailed design of the proposed Board, including how it would operate and the proposed number of members?
25. In your view, what individual skills or experience should Board members have?

Questions **Page 37 - 38**

26. Do you support the proposals in this section for strengthened regulatory stewardship expectations on agencies to be set out in a Bill?
27. Do you agree that there may be some situations where a power for the Chief Executive of the Ministry for Regulation to obtain information will be required to

help decide whether a regulatory review is warranted and to inform regulatory reviews?

28. Do you agree that the proposed information gathering powers are justified for the purpose of informing regulatory reviews? Do you think the powers should apply to all the types of entities listed above, or only some?
29. Do you think the information gathering powers are broad enough to enable the Ministry for Regulation to undertake regulatory reviews effectively and efficiently?
30. Do you think any safeguards or procedures should be applied to limit how the information gathering powers are used by the Ministry for Regulation? What safeguards do you think should be put in place?
31. Do you support the proposals in this section in relation to the Ministry for Regulation's broad oversight role?
32. Are there any other measures you think a Bill should contain to support the quality of regulation?

Questions **Page 40**

33. Do you think the overall proposal will be effective in raising the quality of regulation in New Zealand?
34. Do you think there are other provisions that should be included in the Bill. If so, what would they be?
35. Would you prefer any alternative options to the Bill, including non-legislative options?

Te Kāwanatanga o Aotearoa
New Zealand Government

regulation.govt.nz

MEMORANDUM
Policy & Planning

Taranaki Regional Council

Date:	4 February 2025
Subject:	**Freshwater Implementation February Update**
Author:	L Hawkins, Policy Manager
Approved by:	A D McLay, Director - Resource Management
Document:	TRCID-1492626864-219

Purpose

1. The purpose of this memorandum is to provide a Freshwater Implementation project update.

Executive summary

2. Set out in this memorandum is an update on the progress of implementing the freshwater package from central government. The memorandum focusses on the key tasks undertaken since the previous Committee meeting, and identifies risks associated with the project and achievement of the project timeframes.
3. The attached report focusses on the key streams of work associated with the freshwater package. This being policy development, implementation of Freshwater Farm Plans, and the communications and engagement timeline.

Recommendation

That the Taranaki Regional Council:

a) receives the February 2025 update on the Freshwater Implementation Programme.

Background

4. This memorandum updates on progress in implementing the Freshwater Package. An implementation programme was previously presented to and approved by the Committee. This report provides an overview on the progress of the work programme, specifically focusing on the previous 6 weeks and those ahead. It provides an opportunity for discussions relating to progress and risks identified.

Discussion

5. The attached report (attachment 1) provides a high level overview of the progress made since the last Committee meeting in October 2024, and identifies those tasks to be undertaken in the coming 6 weeks. It also identifies risks associated with the programme, and a copy of the high level engagement strategy.
6. Key discussion points are included in this covering memorandum to draw attention to key areas of work.

Government direction

7. Since the previous meeting the government has released their second amendment bill to the Resource Management Act (RMA) – *the Resource Management (Consenting and Other System Changes) Amendment Bill.*
8. Content of this Bill and the proposed Council submission is covered in detail in another item on the Committee Agenda. The Committee should note that the Bill proposes changes to s.70 of the RMA- which pertains to the requirements of Council in drafting permitted activity rules and as such this section of the Act is a critical test for policy development for the new plan.
9. No additional direction from the government has yet been received in relation to future freshwater direction. When this is available staff will review and will report back to the Committee on the implications of any changes to content and programme. Staff understand the release of this information is imminent and we are hopeful an update can be presented at the March Committee meeting.

Ongoing consultation

10. In December two hui were held with community and industry reps with regard to the topics of Earthworks and Animal Effluent Discharges. Specifically these discussions focused on the following aspects:
    a. Earthworks – identification of small-scale farm activities, testing risk based approach that could capture elements like slope and soil type, identification of areas where guidance for good management may be needed to support future plan provisions.
    b. Animal effluent discharges - approaches to phase out effluent discharges to water – specifically parameters for a bespoke framework for high rainfall / high altitude farms – including other attributes such as land use capability, soil types and proximity to sensitive receptors.
11. Staff are now working through the feedback received to refine policy options, with future discussion on draft policies planned, along with testing options with tangata whenua.

Tangata whenua engagement

12. Over the past couple of months staff have continued to work closely with the Ngā Iwi o Taranaki Freshwater Pou Taiao position on the drafting of regional wide objectives and policies and discussions on earthworks and animal effluent discharges discussed above.
13. A Wai Steering Group meeting was held in December which covered recent government updates, progress update on plan development topics, and an overview of the programme of works together for 2025. In addition updates to the existing agreement for the Ngā Iwi o Taranaki Freshwater Pou Taiao position to extend to the date of notification of the draft Land and Freshwater Plan for Taranaki were agreed. The updates will enable continued working between staff and the Pou Taiao position, and also provide additional support to Pou Taiao from each iwi authority which also assists engagement with hapū.
14. A detailed work programme for working with tangata whenua in 2025 is currently being prepared and will be shared with the Committee at a future meeting.

Financial considerations—LTP/Annual Plan

15. This memorandum and the associated recommendations are consistent with the Council's adopted Long-Term Plan and estimates. Any financial information included in this memorandum has been prepared in accordance with generally accepted accounting practice. The update to the agreement for the Ngā Iwi o Taranaki Pou Taiao position is in accordance with existing LTP and budget considerations.

Policy considerations

16. This memorandum and the associated recommendations are consistent with the policy documents and positions adopted by this Council under various legislative frameworks including, but not restricted to, the *Local Government Act 2002*, the *Resource Management Act 1991* and the *Local Government Official Information and Meetings Act 1987*.

Climate change considerations

17. This item is administrative in nature. There are *no* climate change impacts to consider in relation to this item.

Iwi considerations

18. This memorandum and the associated recommendations are consistent with the Council's policy for the development of Māori capacity to contribute to decision-making processes (schedule 10 of the *Local Government Act 2002*) as outlined in the adopted Long-Term Plan and/or Annual Plan. Similarly, iwi involvement in adopted work programmes has been recognised in the preparation of this memorandum. Specific considerations for tangata whenua are reported in the content of this memorandum.

Community considerations

19. This memorandum and the associated recommendations have considered the views of the community, interested and affected parties and those views have been recognised in the preparation of this memorandum.

Legal considerations

20. This memorandum and the associated recommendations comply with the appropriate statutory requirements imposed upon the Council.

Appendices/Attachments

TRCID-1492626864-224: Freshwater Implementation Progress Report February 2024

Freshwater Implementation Project Report to Policy & Planning Committee

February 2025

	Progress in the last six weeks	Key tasks in the coming six weeks	Risks

National Policy Statement for Freshwater Management	• Developing draft policy and objectives ready for refinement against expected new NPS-FM direction
	• Meetings with iwi Pou Taiao re key policy directions.
	• Meeting with Wai Steering Group
	• Meetings with key stakeholder groups to refine policy direction.
	  ○ Effluent management framework
	  ○ Earthworks discussion
	• Progress Science programme:
	  ○ Continue existing attribute work
		• Developing draft policy and objectives ready for refinement against expected new NPS-FM direction.
		• Expecting national direction to land in the next 6 weeks – will work on reviewing and responding.
		• Meetings with iwi Pou Taiao re key policy directions – topics including Source water risk management areas, earthworks, managing over allocation.
		• Ongoing discussion Meetings with key stakeholder groups to refine policy direction.
		  ○ Effluent management framework
		  ○ Earthworks discussion
		• Progress Science programme:
		  ○ Continue existing attribute work
			• Medium risk – Partnership with iwi. Risk that the timeframes, complexity of issues and the need to be working in an agile manner to develop the policy framework will impact on the partnership approach being fostered. Amendments to the Pou Taiao Agreement including the setting up of a steering committee to mitigate this risk. Opportunity to consider amendment to programme to providing more time and opportunity to work through policy drafting. Continue to present progress to the Wai Steering Committee. *Also note that the next 6 weeks will likely be focused on central govt direction will also be relevant for iwi*.
			• Medium risk – participation in the community engagement is low. Mitigated through continued promotion of process, community meetings switched to being held at various locations, targeted engagement with industry groups to lessen the load on individuals.
			• High risk –change to direction of the NPSFM with the new government. We can mitigate against this risk by maintaining momentum on policy development, keeping abreast of policy announcements from the government, and taking pause when necessary to confirm approach as policy guidance from the government develops.

Freshwater Farm Plans	• Status quo – as we await further direction from the Government on likely changes to the Regulations etc.	• Status quo – as we await further direction from the Government on likely changes to the Regulations etc.	• Low risk – potential change to direction of FWFP regulations with the new government. The government has signalled the continuation of the FWFP process and Councils should expect an order

			in council, as such this is a low risk. The continuation of the programme will mitigate against any pressure to respond to an OIC when released.

MEMORANDUM
Policy & Planning

Date:	4 February 2025
Subject:	**Request to commence Coastal Plan change**
Author:	L Hawkins, Policy Manager
Approved by	A D McLay, Director - Resource Management
Document:	TRCID-1716858071-59

Purpose

1. The purpose of this memorandum is to set out an issue with the drafting of Policy 43 in the *Coastal Plan for Taranaki 2023* (the Coastal Plan) and to seek approval on commencing a plan change under Schedule 1 of the *Resource Management Act 1991* (the RMA).

Executive summary

2. The intent of Policy 43 is to give a much higher level of RMA protection to discrete 'protected' areas such as marine parks, reserves or their equivalent. The presumption is that disturbance, deposition and extraction activities must not occur in these areas.
3. This is a very high bar that must be satisfied in relation to any use and development activities in such areas.
4. In recent times, officers have become aware of an interaction of Policy 43 with the *Marine Mammals Protection (West Coast North Island Sanctuary) Notice 2008* (Notice), which covers the vast majority of the Taranaki coastal marine area (CMA). This has raised a potential issue with Policy 43 that is too significant to ignore.
5. Officers consider the wording "*…area managed or held under other Acts for statutory protection*" in Policy 43 likely captures the Notice.
6. This was not intended and will likely preclude (or at the very least, make difficult) many appropriate use and development activities that disturb the seabed in the CMA.
7. To remedy this issue, staff recommend commencing a plan change to clarify the intent of Policy 43 by ensuring that the policy targets discrete coastal protected areas as originally intended. Throughout the plan change process, close consultation with iwi will be especially important, noting that initial discussions have already begun.
8. A proposed plan change would involve a Schedule 1 RMA planning process. A plan change is limited to specific amendments or additions to an existing plan.

Recommendations

That Taranaki Regional Council:

a) receives this memorandum entitled Proposed Plan Change to the Coastal Plan for Taranaki

b) notes that the wording of Policy 43 likely applies to the West Coast North Island Sanctuary likely precluding many appropriate use and development activities that disturb the seabed in the CMA

c) agrees to commence a plan change to Policy 43, and other consequential amendments, to address the issue

d) directs staff to engage closely with iwi throughout the plan change process

e) determines that this decision be recognised as not significant in terms of section 76 of the Local Government Act 2002

f) determines that it has complied with the decision-making provisions of the Local Government Act 2002 to the extent necessary in relation to this decision; and in accordance with section 79 of the Act, determines that it does not require further information, further assessment of options or further analysis of costs and benefits, or advantages and disadvantages prior to making a decision on this matter.

Background

9. Taranaki Regional Council (the Council) made the Coastal Plan operative on 4 September 2024 following a significant and comprehensive planning, engagement and consultative process under the *Resource Management Act 1991* (RMA).

10. The purpose of the Coastal Plan is to promote the sustainable management of the coastal environment, including the coastal marine area (CMA). As such, it sets out policies and rules relating to use, development and protection in the CMA.[1] There are 52 policies that provide direction in its implementation, particularly the consenting process.

11. Policies 43 to 47 of the Coastal Plan set out activity-specific policies relating to disturbance, deposition and extraction in the CMA. These policies provide a deliberately nuanced and tiered management approach that takes into account differing values, characteristics, uses, vulnerability or sensitivity, or management needs across the CMA. The most restrictive policy in the Coastal Plan relating to disturbance, deposition and extraction activities is Policy 43.

12. Taranaki has three marine reserves and protected areas that constitute approximately 3.2% of the Taranaki coastline – these are Parininihi Marine Reserve, Ngā Motu/Sugar Loaf Islands Marine Protected Area, and Tapuae Marine Reserve. Policy 43 of the Coastal Plan seeks to provide a high level of protection to these areas plus any other similar type protected marine areas that might be created in the future. Policies 44 to 47, which apply to other areas of the CMA, are less restrictive.

Policy 43

13. Policy 43 of the Coastal Plan reads as follows:

Policy 43: Disturbance, deposition or extraction in marine areas with legal protection

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[1] *The CMA refers to "…the foreshore, seabed, and coastal water, and the air space above the water:*
(a) of which the seaward boundary is the outer limits of the territorial sea;
(b) of which the landward boundary is the line of mean high water springs, except that where that line crosses a river, the landward boundary at that point will be whichever is the lesser of:
(i) one kilometre upstream from the mouth of the river; or
(ii) the point upstream that is calculated by multiplying the width of the river mouth by five."

Disturbance of, or deposition on, the foreshore or seabed or the extraction of natural material must not occur in areas managed or held under other Acts for statutory protection (including Parininihi Marine Reserve, Ngā Motu/Sugar Loaf Islands Marine Protected Area and Tapuae Marine Reserve identified in Schedule 1) apart from that associated with:

(a) recreational activities including boating and anchoring

(b) scientific or educational study or research

(c) the placement and maintenance of boundary marker buoys."

14. The presumption of Policy 43 is that disturbance, deposition and extraction activities must not occur in marine areas with legal protection. This is a very high bar that precludes most activities. The only exceptions in Policy 43 are those listed in (a) to (c), which cover very minor and specific activities that provide public benefits and are not anticipated to have more than minor adverse effects.
15. In the notified *Proposed Coastal Plan for Taranaki*, the original drafting of the Policy only applied to Parininihi Marine Reserve, Ngā Motu (Sugar Loaf Islands) Marine Protected Area, and Tapaue Marine Reserve. The policy intent, as stated in the section 32 evaluation document on the Proposed Coastal Plan, was to provide marine reserves and protected areas with an elevated level of protection from the remainder of the CMA.
16. However, during the submissions process for the Proposed Coastal Plan, the Te Korowai o Ngāruahine Trust requested the Policy be amended so any future areas set aside for similar protection also receive the same treatment.[2] Te Rūnanga o Ngāti Mutunga and Te Atiawa supported this relief in their further submissions. The idea was to 'futureproof' the Coastal Plan should any new marine reserves (or their equivalent) be established over the life of the Plan.
17. The Council accepted the submission point and broadened the Policy to apply to "*areas managed or held under other Acts for statutory protection*" (rather than only stating the three specific sites). Royal Forest and Bird and Port Taranaki had submitted to keep the original wording. However, as noted, in the Council's decisions document on submissions to the Proposed Coastal Plan, it was Council's view that the amendments were only minor and did not change the policy intent.

Discussion

The problem

18. Implementing the plan through the consent process has highlighted concerns relating to the wording of Policy 43, its interpretation, and its application during any consenting process.
19. The issue is in the phrase "areas managed or held under other Acts for statutory protection", which may inadvertently be 'capturing' almost the whole CMA. The phrase captures marine parks and reserves under the *Marine Reserves Act 1971* or their own stand-alone legislation (as intended). However, the phrase is not defined and is very open-ended. Hence, it likely applies to other areas never contemplated to be covered by the Policy.
20. There are many statutes providing protection for a wide variety of marine areas for a wide variety of purposes (refer to Appendix I for an overview of statutes for the management of marine areas across New Zealand). In particular, this includes marine mammal sanctuaries under the *Marine Mammals Protection Act 1978*. The West Coast North Island Marine Mammal Sanctuary extends from Maunganui Bluff in Northland to Taputeranga Marine Reserve on the south coast of Wellington, covering an area

[2] In relation to this Policy (it was Policy 40 in the Proposed Coastal Plan), the Te Korowai o Ngāruahine Trust submission read as follows "...Policy 40 could usefully be expanded so that it can include areas that may be subject to future protection, but have not yet been designated. A general statement to this effect would future proof this policy."

of approximately 20,574 km², including almost the entire Taranaki CMA (refer Appendix II for a full map).[3]

21. The consequential impact of Policy 43 applying to almost the whole CMA (notwithstanding that this was never the intention) is problematic for future disturbance, deposition or extraction activities in the CMA that need a resource consent.
22. The Policy 43 wording "*must not occur*" is highly directive. In RMA practice, this means that any restricted discretionary, discretionary or non-complying resource consent applications involving disturbance, deposition or extraction of the foreshore or seabed in the CMA will, at best, be difficult to grant, or at worst, unable to be.
23. Restriction of some activities, such as ports, may be balanced by highly directive policies in the *New Zealand Coastal Policy Statement*. In these circumstances, a consent may be possible to grant – albeit more complex and costly as it would otherwise be. However, other activities, like offshore wind, do not have similar enabling policies. In these circumstances, a consent for an activity that disturbs the seabed would be unlikely to be granted.

Where to from here

24. The interpretation that Policy 43 might apply to most of the CMA is not what was originally intended either at notification or in responding to the request of the submitter during the hearing process.
25. To clarify the policy intent of Policy 43 officers recommend commencing a plan change to the Coastal Plan. The proposed plan change would be limited to amendments to Policy 43 (and consequential and administrative amendments).
26. A plan change under the RMA refers to the process of amending or replacing rules in a district or regional plan. This can be initiated by Council pursuant to section 79(4) of the RMA (refer **Appendix III**).
27. The key differences between a plan change and a full plan review under the RMA, is that a plan change is limited to specific amendments or additions to an existing plan, while a full plan review involves a comprehensive evaluation and update of the entire plan (see table below).

Plan Change:
Purpose: To make specific amendments or additions to an existing plan
Scope: Limited to particular parts of the plan that need updating or correcting
Process: Follows the standard Schedule 1 process, including public notification, submissions, hearings, and decisions
Timeframe: Generally quicker as it focuses on specific changes rather than a comprehensive review
Examples: Amending Policy 43 to confine its application to protecting to marine parks and reserves (or their equivalent)
Full Plan Review:
Purpose: To comprehensively review and update an entire plan
Scope: Covers all aspects of a plan
Process: Also follows the standard Schedule 1 process but involves a more extensive review and consultation
Timeframe: Typically longer due to the broader scope and need for thorough analysis and public input.
Examples: A complete overhaul of a plan under the RMA to address new development trends, environmental concerns, and community needs.

28. The key procedural steps and an indicative timeframe for Council to publicly notify a plan change are as follows:

[3] The purpose of the Sanctuary is to protect marine mammals, particularly the endangered Māui dolphin, through regulations on fishing, seabed mining, and seismic surveying. First established in 2008 the areal extent of the Sanctuary was substantially amended during the Plan review process (2020) to include the whole Taranaki CMA.

- Seek Council agreement to commence a plan change pursuant to section 79 of the RMA. This memorandum gives effect to that requirement.
- Undertake early consultation with Ngaruahine, Ngāti Mutunga, Te Atiawa, and other iwi authorities, which are also likely to be particularly interested in this issue. Officers note that some early conversations have already been had to socialise the issue. However, further engagement is proposed to occur in February and March 2025 to canvas the options and discuss potential drafting solutions.
- In March and April 2025, undertake additional targeted consultation with other key interested parties. This includes the Royal Forest and Bird Protection Society of New Zealand and Port Taranaki (that originally submitted on the Policy in the Proposed Coastal Plan), plus the Department of Conservation, the Minister for the Environment, Ministry for Primary Industries, the three local district councils, and any customary marine title group in the area (as per clauses 2 and 3 requirements of the First Schedule of the RMA).
- Throughout the consultation process, officers will work on drafting the plan change based on feedback received. Officers will also prepare a section 32 evaluation report.
- By June 2025, officers aim to have a plan change ready for public notification in accordance with Schedule 1 of the RMA. The Schedule 1 process involves:
    - public notification of the proposed plan change.
    - the release of the section 32 evaluation report.
    - call for submissions and further submissions from interested parties.
    - consideration of all submissions received.
    - pre-hearing meetings to discuss the issues and attempt to resolve any outstanding matters informally.
    - public hearing.
    - Council making a decision taking into account the hearing committee's recommendations and all submissions received.
    - public notification of Council decision; and,
    - right of appeals to the Environment Court if any party is dissatisfied with the Council's decision.

29. The indicative timeframe is based on the assumption that no significant concerns are raised through the initial engagement process.

Options

30. There are two options available. The Council can either approve the Agenda item to initiate a plan change to amend Policy 43, or not.
31. The benefit of undertaking a plan change would be to clarify the policy intent of Policy 43. Amendments would be limited to resolving the issue with Policy 43 and any consequential and administrative changes.
32. Option 2 is not to undertake a plan change and retain current wording in Policy 43. If the Council decides not to undertake a plan change, then the inclusive wording of Policy 43 will remain problematic in light of the range of legislation and protected areas that arguably capture most of the Taranaki CMA.
33. It is recommended that the Council agrees to initiate a plan change.

Significance

34. This decision is assessed as not significant with regards to the Significance and Engagement Policy. It will have no impact on levels of service, incur more than $10,000,000 budgeted or $5,000,000 of unbudgeted expenditure, or involve the transfer of ownership or control of a strategic asset. There will also be opportunities for broad public engagement throughout the plan change process.

Financial considerations—LTP/Annual Plan

35. This memorandum and the associated recommendations are not entirely consistent with the Council's adopted Long-Term Plan and estimates. Undertaking a plan change on the Coastal Plan is not foreshadowed in the LTP and estimates. However, due to the delay in the notification of the Land and Freshwater Plan (LFWP) as a result of central government direction, there is the opportunity to re-assign hearing costs for the LFWP to this plan change. Importantly this approach will still enable policy development to progress on the Land and Freshwater Plan. Any financial information included in this memorandum has been prepared in accordance with generally accepted accounting practice.

Policy considerations

36. This memorandum and the associated recommendations are consistent with the policy documents and positions adopted by this Council under various legislative frameworks including, but not restricted to, the *Local Government Act 2002*, the *Resource Management Act 1991* and the *Local Government Official Information and Meetings Act 1987*.

Climate change considerations

37. There are no climate change impacts to consider in relation to this item.

Iwi considerations

38. This memorandum and the associated recommendations are consistent with the Council's policy for the development of Māori capacity to contribute to decision-making processes (schedule 10 of the *Local Government Act 2002*) as outlined in the adopted Long-Term Plan and/or Annual Plan. Similarly, iwi involvement in adopted work programmes has been recognised in the preparation of this memorandum.
39. Officers have undertaken some initial outreach to Te Korowai o Ngāruahine Trust and select other iwi organisations. Substantive feedback has not yet been received. Ongoing consultation with iwi throughout the plan change process will be crucial.

Community considerations

40. This memorandum and the associated recommendations have considered the views of the community, interested and affected parties and those views have been recognised in the preparation of this memorandum.

Legal considerations

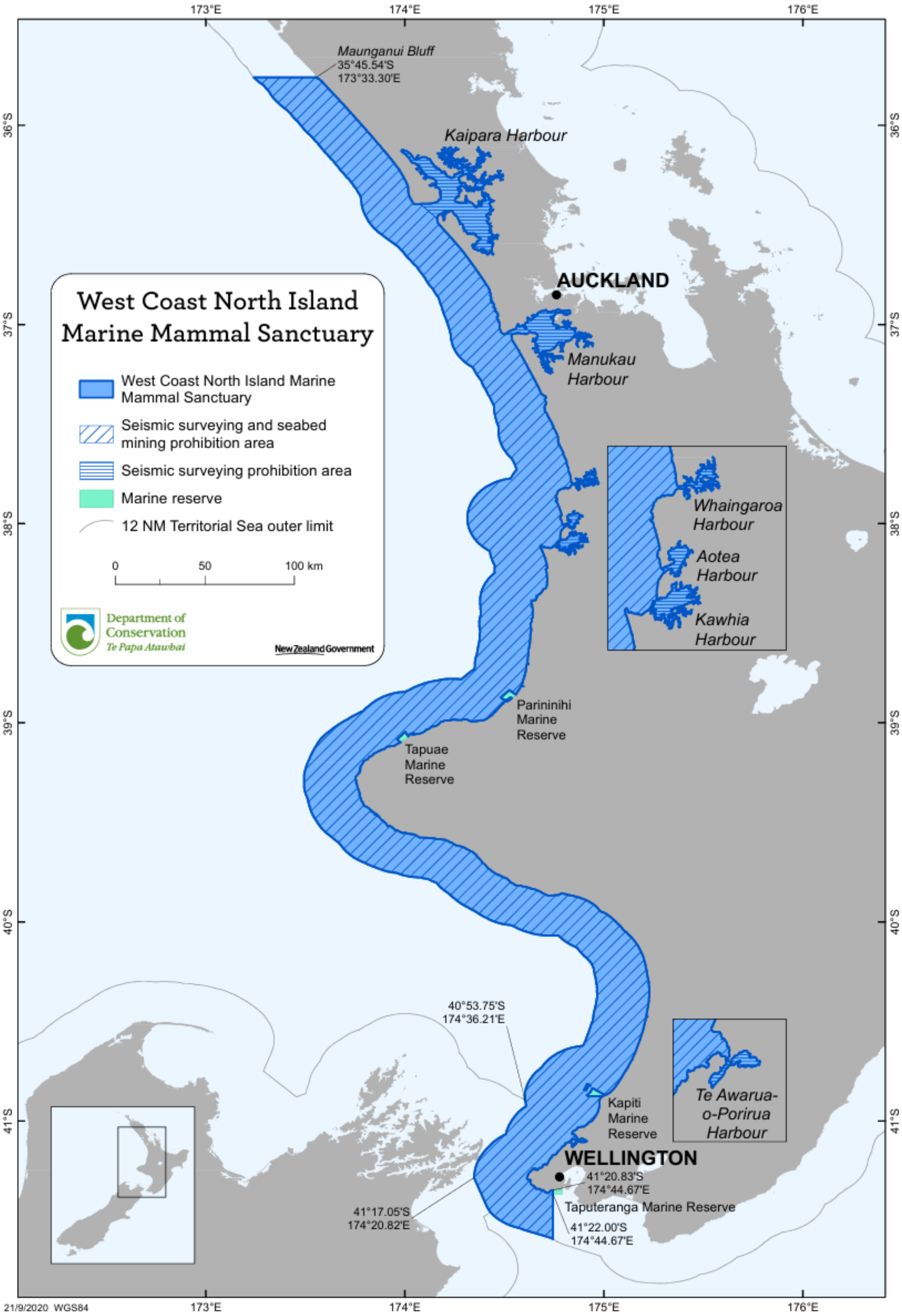
41. This memorandum and the associated recommendations comply with the appropriate statutory requirements imposed upon the Council.

Appendix I: Statutes managing marine areas

MANAGEMENT TOOL	LEGISLATION	RESTRICTIONS	AREA (KM²)	NZ WATERS WHERE TOOL APPLIES
Marine reserves	Marine Reserves Act 1971	Marine reserves prohibit fishing, removal of material, dredging, dumping, construction or any other direct human disturbance.	12,792	Territorial sea
Marine mammal sanctuaries	Marine Mammals Protection Act 1978	A range of restrictions depending on each marine mammal sanctuary. These vary from all commercial fishing being prohibited to special fisheries regulations.	6,180	Territorial sea
Marine parks	Hauraki Gulf Marine Park Act 2000 and amendment 2001 Fisheries Act 1996 Sugar Loaf Islands Marine Protected Area Act 1991	A range of restrictions depending on each marine park. These include a variety of fishing restrictions from all commercial fishing being prohibited to special fisheries regulations.	20,536	Territorial sea
Submarine cables and pipelines protection zones	Submarine Cables and Pipelines Protection Order 1992	No fishing or anchoring except for ships being used for research by or for the Ministry of Fisheries as long as research is done without directly or indirectly attaching any ship to the seabed.	1731.8	Territorial sea and Exclusive Economic Zone
Mātaitai – closed areas	Fisheries Act 1996 Fisheries (Declaration of Mātaitai Reserve and Appointment of Tangata Kaitiaki/Tiaki) Notice	In general, commercial fishing is prohibited, amateur regulations apply unless amended by appointed tangata tiaki/kaitiaki who can authorise customary food gathering.	204	Territorial sea
Taiapure – closed areas	Fisheries Act 1996 Fisheries Order	A spatial closure to set aside coastal fishing areas which customarily have been of special significance to an iwi or hapū as a source of food (kaimoana) or for spiritual or cultural reasons.	388	Territorial sea
Section 186 – temporary closures	Fisheries Act 1996 Fisheries (Temporary Closure) Notice	A range of restrictions applies dependent on the particular area. All restrictions prohibit the removal of at least one species. For example, a prohibition to take fish, aquatic life or seaweed from Pukerua Bay, except by the method of line fishing, applies during the period beginning 8 June 2007 and ending 7 June 2009.	769	Territorial sea
Benthic protected areas (BPAs)	Fisheries Act 1996 Fisheries (Benthic Protection Areas) Regulations 2007	Prohibition on use of dredge and restrictions on use of trawl net within 100 metres of the sea floor.	1,250,000	Territorial sea and Exclusive Economic Zone
Seamount closures	Fisheries Act 1996 Fisheries Regulations	Trawling prohibited.	100,997	Exclusive Economic Zone
		Total area	1,393,598	
Total area as a percentage of New Zealand's total waters (territorial sea and EEZ)[3]			34%[3]	

Source: Ministry of Fisheries (National Aquatic Biodiversity Information System: NABIS), 2008; Department of Conservation, Unpublished.

Appendix II: Map of the West Coast North Island Marine Mammal Sanctuary



Source: West Coast North Island Marine Mammal Sanctuary map

Appendix III: Section 79(4) of the RMA [Review of policy statements and plans]

(4) Without limiting subsection (1), a local authority may, at any time, commence a full review of any of the following documents it has:

(a) a regional policy statement:

(b) a regional plan:

(c) a district plan.

(5) In carrying out a review under subsection (4), the local authority must review all the sections of, and all the changes to, the policy statement or plan regardless of when the sections or changes became operative.

(6) If, after reviewing the statement or plan under subsection (4), the local authority considers that it requires alteration, the local authority must alter the statement or plan in the manner set out in Parts 1, 4, or 5 of Schedule 1 and this Part.

(7) If, after reviewing the statement or plan under subsection (4), the local authority considers that it does not require alteration, the local authority must still publicly notify the statement or plan—

(a) as if it were a proposed policy statement or plan; and

(b) in the manner set out in Parts 1, 4, or 5 of Schedule 1 and this Part.

(8) A provision of a policy statement or plan, or the policy statement or plan, as the case may be, does not cease to be operative because the provision, statement, or plan is due for review or is being reviewed under this section.

Taranaki Regional Council

MEMORANDUM
Policy & Planning

Date:	4 February 2025
Subject:	**Lake Rotorangi State of the Environment Monitoring Report 2021-2024**
Author:	T McElroy, Manager - Science and Technology
Approved by:	AJ Matthews, Director - Environment Quality
Document:	TRCID-1492626864-219

Purpose

1. The purpose of this memorandum is to provide the Committee with an overview of the Lake Rotorangi State of the Environment Monitoring Report 2021-2024.

Recommendations

That the Taranaki Regional Council:

a) receives the Lake Rotorangi State of the Environment Monitoring Report 2021-2024

b) notes the recommendations therein.

Background

2. Section 35 of the Resource Management Act (1991) requires local authorities to undertake monitoring of the region's environment, including land, air and water. To this effect, the Council has established a state of the environment (SoE) monitoring programme for the region.
3. The Council's SoE programme encompasses a number of individual monitoring activities, many of which are undertaken and managed on an annual basis (from 1 July to 30 June). The purpose of SoE reporting is to summarise and interpret regional environmental monitoring results and report on any changes (trends) in these data. One of these activities is a monitoring and reporting programme to assess the state and trends in water quality for ecosystem health and human contact freshwater values in Lake Rotorangi.
4. Lake Rotorangi was formed in May 1984 by the construction of an 82-metre-high earth fill dam on the Pātea River for the purpose of a hydro-electric power scheme. Lake Rotorangi is the longest artificial lake in New Zealand, being over 46 km long. It is fairly narrow and has a surface area of approximately 582 hectares (or 5.8 km^2).
5. By comparison, the next largest lake in Taranaki is Lake Moumahaki in the Waitotara catchment (30 hectares). A recent update to the Freshwater Environments of New Zealand geo-database recorded 94 lakes in Taranaki with a surface area of 1 hectare or greater (Schallenberg et al. 2024). Of these, 50 are artificial, while the dominant natural geomorphic classifications include wind-blown / dune lakes (19), lakes formed by landslides (16) and lakes formed by natural riverine processes (13).
6. To inform the development of Council's Proposed Regional Land and Freshwater Plan, a State of the Environment monitoring programme has been established to assess the state and trend of water

quality in six regionally representative, naturally formed lakes. However, with monitoring only commencing in May 2022, there has not yet been enough data collected to report on the findings.

7. In contrast, Lake Rotorangi has been monitored since the construction of the dam in 1984. The costs associated with this monitoring and reporting are shared between Council and Manawa Energy Ltd (the consent holder and operator of the Pātea Hydroelectric Powers Scheme).
8. The primary component of the Lake Rotorangi monitoring programme consists of four water quality surveys carried out each year, with samples collected from two locations at various depths and tested for a range of parameters. Measurements of thermal stratification (indicative of lake mixing patterns) are also recorded. A survey of macrophytes (aquatic plants) is carried out every three years. In the current reporting period, the macrophyte survey was completed in April 2024.
9. This report presents monitoring data collected during the three years from 1 July 2021 and 30 June 2024. Results from this reporting period are assessed in relation to previous data, and where applicable, relevant attribute states set out in the National Policy Statement for Freshwater Management 2020 (NPS-FM). Long-term trends (comprising the entire monitoring record) and short-term trends (ten years from 2014 to 2024) were also assessed.
10. A guide to the key water quality parameters assessed in this report is presented below, in Table 1.

Table 1 Key water quality parameters assessed in Lake Rotorangi SoE programme

Measure	Description	Associated attribute(s) in NPS-FM
Total nitrogen (TN)	Nitrogen is an essential nutrient for plant and algal growth. However elevated levels contribute to excessive growth and can result in negative ecological effects. Nitrogen can be present in water in several forms (nitrate, nitrite, ammoniacal nitrogen and organic nitrogen).	Yes
Total phosphorous (TP)	Total phosphorus is a measure of all forms of phosphorus in the water, including dissolved and particulate, organic and inorganic. Phosphorus is naturally present in water and essential for plant growth; however, like nitrogen, an excess of phosphorus can encourage the nuisance growth of algae and macrophytes and lead to the degradation of aquatic ecosystems.	Yes
Phytoplankton	Phytoplankton include algae and cyanobacteria that float in the water column and can produce oxygen through photosynthesis. All phytoplankton contain chlorophyll *a* (chl *a*) which can be used to assess the amount of algae in a lake, measured as phytoplankton biomass. The amount of phytoplankton in a lake is often closely linked with the amount of nutrient enrichment and biological productivity of a lake ecosystem (referred to as the trophic state).	Yes
Secchi depth	Secchi depth provides a measure of vertical water clarity. Elevated concentrations of suspended particulate, including sediment, phytoplankton and organic matter, result in reduced light penetration through the water column. As such, turbid water will generate a shallow secchi depth result which is often indicative of elevated nutrients and or sediment concentrations can be detrimental in lake ecosystems.	No
Trophic Level Index (TLI)	The TLI integrates the four water quality indicators listed above such to provide a comprehensive assessment of lake health and its potential for supporting aquatic life.	No

Dissolved oxygen	Dissolved oxygen is critical to all aquatic life within a lake ecosystem. Oxygen can enter water by diffusion from the atmosphere, aeration of the water through surface turbulence, and as a product of photosynthesis. Excessive plant and algae growth and decomposition in response to increasing nutrients in waterbodies can adversely affect dissolved oxygen concentrations.	Yes

Discussion

11. Lake water quality across the monitoring period was generally comparable to the long-term record, though there was notable inter-annual variability in the concentrations of some parameters over the three years and annual median concentrations of total nitrogen, nitrate/nitrite and chlorophyll *a* in 2021/22 were elevated compared to previous results. The annual median concentrations for total nitrogen and chlorophyll *a* were the highest on record (for at least one site and sampling depth). However, concentrations of these parameters were similar to previous results in 2022/23, and generally much lower in 2023/24 (reduced concentrations of total phosphorous and dissolved reactive phosphorous were also observed). In 2023/24, the annual median concentrations for a range of parameters were the lowest on record for at least one site and sampling depth.
12. These water quality results are summarised below, in Table 2. Coloured cells denote annual median results in the current monitoring period that were outside of the range of annual medians previously recorded (red cells exceeded the highest annual median previously recorded, and blue cells were lower than the lowest annual median previously recorded.

Table 2 Summary of key water quality monitoring results and historical statistics

Parameter	Site	Sampling depth	Previous annual median minima	Previous annual median maxima	Long-term annual median	2021/22 annual median	2022/23 annual median	2023/24 annual median
Total nitrogen (g/m^3)	LRT000300	Epilimnion	0.30	0.99	0.61	0.93	0.66	0.48
		Hypolimnion	0.65	0.97	0.77	**0.98**	0.77	**0.65**
	LRT000450	Epilimnion	0.45	0.84	0.56	**0.88**	0.63	**0.41**
		Hypolimnion	0.40	0.88	0.73	0.84	0.81	0.64
Total phosphorous (g/m^3)	LRT000300	Epilimnion	0.012	0.068	0.022	0.028	0.027	0.019
		Hypolimnion	0.014	0.11	0.022	0.023	0.031	**0.011**
	LRT000450	Epilimnion	0.010	0.050	0.018	0.025	0.020	**0.010**
		Hypolimnion	0.010	0.076	0.017	0.017	0.019	**0.008**
Secchi depth (m)	LRT000300	Surface	0.72	3.9	2.54	1.46	1.15	2.48
	LRT000450	Surface	0.43	4.42	3.2	1.40	1.73	3.35
Chlorophyll a (mg/m^3)	LRT000300	Photic zone	1.25	5.05	2.48	**5.57**	3.60	**1.05**
	LRT000450	Photic zone	1.25	8.70	2.23	2.09	2.40	1.35
TLI score	LRT000300	n/a	3.98	4.93	4.17	**4.94**	4.48	**3.80**
	LRT000450	n/a	3.73	4.97	3.98	4.62	4.20	**3.40**

13. Inter-annual variability was also reflected in the Trophic Level Index (TLI) scores (as shown in Table 2, above). Historically, the TLI for Lake Rotorangi has remained very close to the mesotrophic-eutrophic threshold. A mesotrophic lake status is indicative of moderate levels of nutrients and algal growth and some reduction in water clarity. A eutrophic lake status is indicative of high concentrations of nutrients, algae and murky water.

14. The Land Air Water Aotearoa (LAWA) website[1] offers a simple interpretation of these TLI categories, with the mesotrophic status corresponding to fair water quality, and the eutrophic status corresponding to poor water quality, as shown below in Table 3.

Table 3 TLI scores, descriptions and LAWA Icons

LAWA Icon	TLI Score	Description
VERY GOOD	0 - 2	**Microtrophic:** The lake is very clean with very low levels of nutrients and algae. The lake can have snow or glacial sources.
GOOD	>2 - 3	**Oligotrophic:** The lake is clear and blue, with low levels of nutrients and algae.
FAIR	>3 - 4	**Mesotrophic:** The lake has moderate levels of nutrients and algae.
POOR	>4 - 5	**Eutrophic:** The lake is murky, with high amounts of nutrients and algae.
VERY POOR	>5	**Supertrophic:** The lake has very high amounts of phosphorus and nitrogen, can be overly fertile and often associated with poor water clarity. Excessive algae growth can occur. Suitability for recreational purposes is often poor.

15. In 2021/22, overall TLI scores reached, or were close to, the highest previously recorded at both sites. Whereas in 2023/24, overall TLI scores were the lowest ever recorded at either site. These scores corresponded to the upper end of the eutrophic range in 2021/2022, and near the middle of the mesotrophic range in 2023/24.

16. With regard to water quality attributes set out within the NPS-FM, concentrations of water quality parameters recorded during the monitoring period were indicative of varying levels of degradation or disturbance. It should be noted that these assessments do not strictly adhere to the data requirements set out in the NPS-FM (due to sampling frequency), and as such they should be interpreted as indicative gradings. These grades are summarised in Table 4 and discussed below:
    - Ammoniacal nitrogen concentrations fell within band A, corresponding to minimal toxicity impacts on aquatic life.
    - Total nitrogen concentrations achieved band C, corresponding to moderate trophic impacts on aquatic life.
    - Total phosphorous concentrations fell within band C at the upper lake site, and band B at the lower lake site. These grades correspond to moderate and low trophic impacts on aquatic life, respectively.
    - Median chlorophyll-a concentrations achieved band A at both sites, however, maximum concentrations fell within bands C and B at the upper and lower lake sites, respectively.

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[1] https://www.lawa.org.nz/learn/factsheets/lake-trophic-level-index

- Lake-bottom and mid-hypolimnetic dissolved oxygen concentrations at both sites fell within band D which is below the national bottom line, indicative of significant stress on fish species and the potential for nutrient release from lakebed sediments.
- *E. coli* concentrations achieved band A category, corresponding to a low risk of infection arising from swimming and other water sports.

Table 4 Summary of the current state of lake water quality attributes under the NPS-FM

Attribute	Site	Overall band
Ammoniacal nitrogen	LRT00E300	A
	LRT00E450	A
Total Nitrogen	LRT00E300	C
	LRT00E450	C
Total Phosphorus	LRT000300	C
	LRT000450	B
Chlorophyll-*a*	LRT00P300	C
	LRT00P450	B
E. coli	LRT00S300	A
	LRT00S450	A
Dissolved oxygen (mid-hypolimnion)	LRT000300	D
	LRT000450	D
Dissolved oxygen (lake-bottom)	LRT000300	D
	LRT000450	D

Note: Where an attribute has more than one statistical criteria, the lowest overall grade is presented

17. The results from the current macrophyte survey were comparable to the previous survey carried out in 2020/21 and show a continued trend of range expansion of the highly invasive *Ceratophyllum demersum* (also known as hornwort). First detected in 2012, hornwort has since spread throughout the lake and is now the dominant species across the entire surveyed area.
18. Even at the time it was first detected, the distribution of hornwort in Lake Rotorangi was such that containment and eradication was not possible. The highly invasive nature of hornwort highlights the need for education and awareness amongst lake users. This is the purpose of the Ministry for Primary Industries' 'Check, Clean, Dry' programme, which is promoted by Council.
19. Long-term water quality trend analyses (including the entire monitoring record) found evidence of improving trends for total nitrogen concentrations and even stronger evidence of improving trends for ammoniacal nitrogen and dissolved reactive phosphorous concentrations. Strong evidence of degrading trends in total phosphorous concentrations was noted at the upper lake monitoring site, but not the lower lake monitoring site. Evidence of degrading trends in both chlorophyll *a* and water clarity was identified at both sites, as well as *E. coli* at the lower lake site.
20. As observed in the previous monitoring report (TRC, 2021), long-term trend analyses found strong evidence of degrading trends in TLI scores at both lake monitoring sites. However, the rate of degradation is considered very low (0.20 – 0.24% annual change).
21. Short-term water quality trend analyses (2014-2024) found evidence of improving trends in 16 out of the 24 site and parameter combinations that were assessed. The remaining eight combinations lacked sufficient evidence to establish a trend direction. No degrading trends were identified. Short-term trend analyses were not possible for TLI due to the limited data record.

22. The parameters with evidence of contrasting long-term and short-term trend directions include chlorophyll *a* (degrading long-term trend and an improving short-term trend at all sites) and total phosphorous (degrading long-term trend and an improving short-term trend at one site).
23. While the drivers behind these trends are not fully understood, recent modelling carried out to support the Council's freshwater policy programme highlights the importance of good farm management practices in the Pātea catchment upstream of Lake Rotorangi.
24. Cox et al. (2022, 2024) estimates that approximately 90% of the total nitrogen load and 70% of the total phosphorus load entering the lake comes from diffuses sources associated with pastoral farming.
25. Cox et al. (2024b) tested a range of hypothetical management scenarios that related to current and emerging practices in order to quantify potential impacts on lake water quality. The key results are summarised below:
    - Completion of planned riparian fencing and planting, and redirecting all remaining dairy effluent discharges to land resulted in estimated reductions in concentrations of total nitrogen (-4%), total phosphorous (-5%) and chlorophyll *a* (-5%) in Lake Rotorangi.
    - By comparison, full implementation of 'established' and 'developing' mitigations (including recently developed novel practices and technologies) resulted in estimated reductions in concentrations of total nitrogen (-32%), total phosphorous (-21%) and chlorophyll-a (-25%).
26. These assessments highlight the importance of continuing to promote riparian management, soil conservation and best practice dairy effluent management throughout the region. However, it is also clear based on the data that additional tools and strategies will be required to help achieve improved long-term water quality outcomes.

Financial considerations—LTP/Annual Plan

27. This memorandum and the associated recommendations are consistent with the Council's adopted Long-Term Plan and estimates. Any financial information included in this memorandum has been prepared in accordance with generally accepted accounting practice.

Policy considerations

28. This memorandum and the associated recommendations are consistent with the policy documents and positions adopted by this Council under various legislative frameworks including, but not restricted to, the *Local Government Act 2002*, the *Resource Management Act 1991* and the *Local Government Official Information and Meetings Act 1987*.

Climate change considerations

29. Lake water quality and overall ecosystem health will likely be impacted by climate change. We are considering these potential impacts as part of our State of the Environment monitoring and reporting, and policy development programmes.

Iwi considerations

30. This memorandum and the associated recommendations are consistent with the Council's policy for the development of Māori capacity to contribute to decision-making processes (schedule 10 of the *Local Government Act 2002*) as outlined in the adopted Long-Term Plan and/or Annual Plan.
31. Through recent engagement with iwi/hapū via freshwater consultation hui, we identified a number of opportunities for collaboration in respect to freshwater monitoring. Further kōrero around these opportunities will be pursued with iwi/hapū in coming months.

Community considerations

32. This memorandum and the associated recommendations have considered the views of the community, interested and affected parties and those views have been recognised in the preparation of this memorandum.

Legal considerations

33. This memorandum and the associated recommendations comply with the appropriate statutory requirements imposed upon the Council.

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Appendices/Attachments

Document TRCID-1672683750-36: Lake Rotorangi State of the Environment Monitoring Report 2021-2024, Technical Report 2024-98

Lake Rotorangi

State of the Environment Monitoring
Annual Report
2021-2024
Technical Report 2024-98

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Taranaki Regional Council

Lake Rotorangi

State of the Environment Monitoring
Annual Report
2021-2024

Technical Report 2024-98

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Executive summary

Lake Rotorangi was formed in May 1984 by the construction of an earth fill dam on the Pātea River for hydroelectric power generation. In recognition of both the regionally significant recreational resource created, and the considerable environmental impacts which might occur, a comprehensive monitoring programme was developed and implemented for the lake. This report presents the most recent monitoring results, covering the period from 1 July 2021 to 30 June 2024.

Each year, four water quality surveys are undertaken at two sites. One site is located in the mid reaches of the lake (site LRT000300), while the second site is located closer to the dam (site LRT000450).

Thermal stratification patterns observed in 2021-2024 were comparable to previous monitoring periods. Oxygen depletion was frequently observed in the lower water column.

Water quality results were variable across the monitoring period. In 2021/22, annual median concentrations were elevated for a range of parameters, including total nitrogen, nitrite/nitrate and chlorophyll *a*. These results produced an elevated trophic level index (TLI) score corresponding to the upper eutrophic range (indicative of degraded lake water quality). Concentrations of key water quality parameters were more typical of previous results in 2022/23 and were much lower than typical results in 2023/24. In 2023/24, these results produced a lower TLI score corresponding to the middle of the mesotrophic range (indicative of fair water quality). Historically, the TLI for Lake Rotorangi has tended to sit very close to the mesotrophic-eutrophic threshold.

Based on the attributes set out in the National Policy Statement for Freshwater Management (2020), ammonia and *E. coli* concentrations classify the lake in the 'A' band, or minimally impacted compared to reference conditions. Total nitrogen concentrations classify the lake as being in the 'C' band, or moderately impacted compared to reference conditions. Total phosphorus classifies the upper lake as moderately impacted and the lower lake as mildly impacted. Typical (median) chlorophyll *a* concentrations correspond to the 'A' band, whereas maximum concentrations correspond to the C and B bands in the upper and lower monitoring sites, respectively. Lake bottom and mid-hypolimnetic dissolved oxygen concentrations at both sites were in the D band category which is below the national bottom line, indicative of significant stress on fish species and the potential for nutrient release from lakebed sediments.

Long-term trend analyses (comprising the entire monitoring record) found evidence of improving trends for nine out of 26 site-parameter combinations that were assessed. Evidence of long-term degrading trends was discovered for 12 site-parameter combinations, and the remaining five combinations lacked sufficient evidence to establish a trend direction. The trends with the highest certainty were the improving trends for dissolved reactive phosphorous and ammoniacal nitrogen, the degrading trends for total phosphorous and chlorophyll *a*, and degrading trends in TLI. The rate of annual change varied by parameter. TLI was found to be increasing relatively slowly, corresponding to an average increase in TLI of 0.2% per year.

Short-term trend analysis (from 2014 to 2024) found evidence of improving trends for 16 out of 24 site-parameter combinations. For the remaining eight site-parameter combinations, there was insufficient evidence to establish trend direction. No degrading trends were observed. The trends with the highest certainty were the improving trends for total phosphorous, dissolved reactive phosphorous, ammoniacal nitrogen and chlorophyll *a*, The rate of annual change in these trends varied by parameter, but were generally much higher than those seen with the long-term trends.

The results from the macrophyte survey carried out in April 2024 were comparable to the previous survey carried out in 2020/21 and show a continued trend of range expansion of the highly invasive *Ceratophyllum demersum* (also known as hornwort). First detected in 2012, hornwart has since spread throughout the lake and is now the dominant species across the entire surveyed area.

The results from a spatial water quality modelling investigation recently carried out to support the development of the proposed Regional Land and Freshwater Plan are also presented here. The key sources of total nitrogen and phosphorous loads delivered to Lake Rotorangi were estimated, and a range of hypothetical management scenarios and lake water quality responses were also simulated. These assessments highlight the importance of continuing to promote riparian management, soil conservation and best practice dairy effluent management throughout the region. However, it is also clear based on the data that additional tools and strategies will be required to help achieve improved long-term water quality outcomes.

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1. Introduction

1.1 General

The *Resource Management Act 1991* (RMA) established requirements for local authorities to undertake environmental monitoring. Section 35 of the RMA requires local authorities to monitor the state of the environment of their region or district, to the extent that is appropriate to enable them to effectively carry out their functions under the Act.

To this effect, Taranaki Regional Council (the Council) has established a state of the environment monitoring (SoE) programme for the region. This programme is outlined in the Council's 'State of the Environment Monitoring Procedures Document', which was prepared in 1997. The monitoring programme is based on the significant resource management issues that were identified in the Council's *Regional Policy Statement for Taranaki 1994*. The overall aim being to report on the state and trends of freshwater health to enhance the effectiveness of RMA policies and to support the region's freshwater ecosystems.

The SoE programme is made up of several individual monitoring activities, many of which are undertaken and managed on an annual basis (from 1 July to 30 June). For these monitoring activities, summary reports are produced to summarise regional environmental monitoring in relation to state and trends. SoE reports act as 'building blocks' towards the preparation of the regional state of the environment report every five years.

This report summarises the results of the Lake Rotorangi SoE programme over the 2021-2024 monitoring period.

1.2 Lake Rotorangi

Lake Rotorangi was formed in May 1984 by the construction of an earthfill dam on the Pātea River for a hydro-electric power scheme. An initial sampling programme was designed to assess the state and environmental consequences of the new lake. The results of this intensive monitoring programme were published in the 'Lake Rotorangi - Monitoring a New Hydro Lake' (Taranaki Catchment Board 1988) report. Results of monitoring since this time are published in annual reports listed in the references of this report.

This initial monitoring determined that the lake was mildly eutrophic or mesotrophic. Further, the annual thermal stratification cycle which the lake undergoes was identified as the single most important factor influencing water quality within the lake.

Since monitoring began, the trophic state of Lake Rotorangi has been increasing (degrading) at a very slow rate, in the order of 0.02±0.01 units per year. Initial monitoring showed the lake was in a mesotrophic state, and has over time moved to a mildly eutrophic state. Previous analysis has determined that the trophic level is heavily influenced by high turbidity values and therefore not a true indication of actual trophic status (as determined by primary production) of the lake (Burns 2006).

The Pātea catchment upstream of the dam covers an area of 86,944ha. This includes both the Pātea River sub-catchment and the Mangaehu River sub-catchment. Approximately 841ha (1%) of this area is urban, while another 6,589ha (8%) is conservation land. The remainder of the catchment (71,514ha, 91%) is in pastoral land, with a mixture of dry stock and dairy farming in the catchment. Identifying and implementing actions to address hill country erosion is a significant focus for this catchment. Farm plans addressing land management and sediment issues cover around 43,055ha (50%) of the catchment, primarily in the area where dry stock faming is the dominant land use.

1.2.1 Lake stratification processes

Stratification is a seasonal process, which occurs when the upper water column near the surface warms much faster than the lower water column. Changes in the density of water at differing temperatures creates a physical barrier separating the upper water column (epilimnion) and lower water column (hypolimnion). Biological and chemical processes differ between the epilimnion and hypolimnion, which can cause differences in water quality between the layers.

Substantial differences in water quality can occur between the epilimnion and hypolimnion as a result of stratification. Typically, the epilimnion has the majority of primary production because light levels are highest in the upper water column. Organic detritus sinks from the epilimnion though the water column, resulting in the transfer of nutrients to the hypolimnion. Therefore over time, the concentrations of bioavailable nutrients decrease in the epilimnion compared to the hypolimnion.

Oxygen depletion may occur in the hypolimnion, because oxygen consumed by biological and chemical processes cannot be replaced due to the physical separation from the more oxygenated surface waters. Replacement of oxygen in the hypolimnion results from mixing caused by either the natural overturn processes or as a results of flood events in the river inflow. Oxygen depletion in the hypolimnion can in turn alter the pH of the hypolimnion. The increased pH in anoxic waters creates a risk of nutrient release from the lakebed sediment into the water column.

2. Monitoring methodology

2.1 Program design

The current Lake Rotorangi Monitoring programme consists of two primary components; physicochemical and biological monitoring. Sampling is undertaken at two sites along the lake, on four occasions each year. The sampling occasions are timed to target particular stratification conditions of the lake. Details of the sites are provided in Table 1 and Figure 1.

Table 1 Monitoring site locations in Lake Rotorangi

Site code	Site	Location
LRT000300	L2 (near Tāngāhoe Valley Road)	E1729856 N5626435
LRT000450	L3 (near Pātea Dam)	E1734948 N5621974

The targeted conditions are described in Table 2. Sampling in the specified months is aimed to be undertaken within seven days of the 20th of the month. The dates sampled in the 2021-2024 monitoring period are also provided in Table 2.

Table 2 Seasonal sampling dates

Season	Month	Target conditions	Sampling date (2021/22)	Sampling date (2022/23)	Sampling date (2023/24)
Spring	October	Pre-stratification	21 Oct 2021	19 Oct 2022	25 Oct 2023
Late Summer	February	Stable stratification	21 Feb 2022	20 Feb 2023	21 Feb 2024
Early Autumn	March	Pre-overturn	21 Mar 2022	22 Mar 2023	27 Mar 2024
Winter	June	Post-overturn	29 Jun 2022	22 Jun 2023	19 Jun 2024

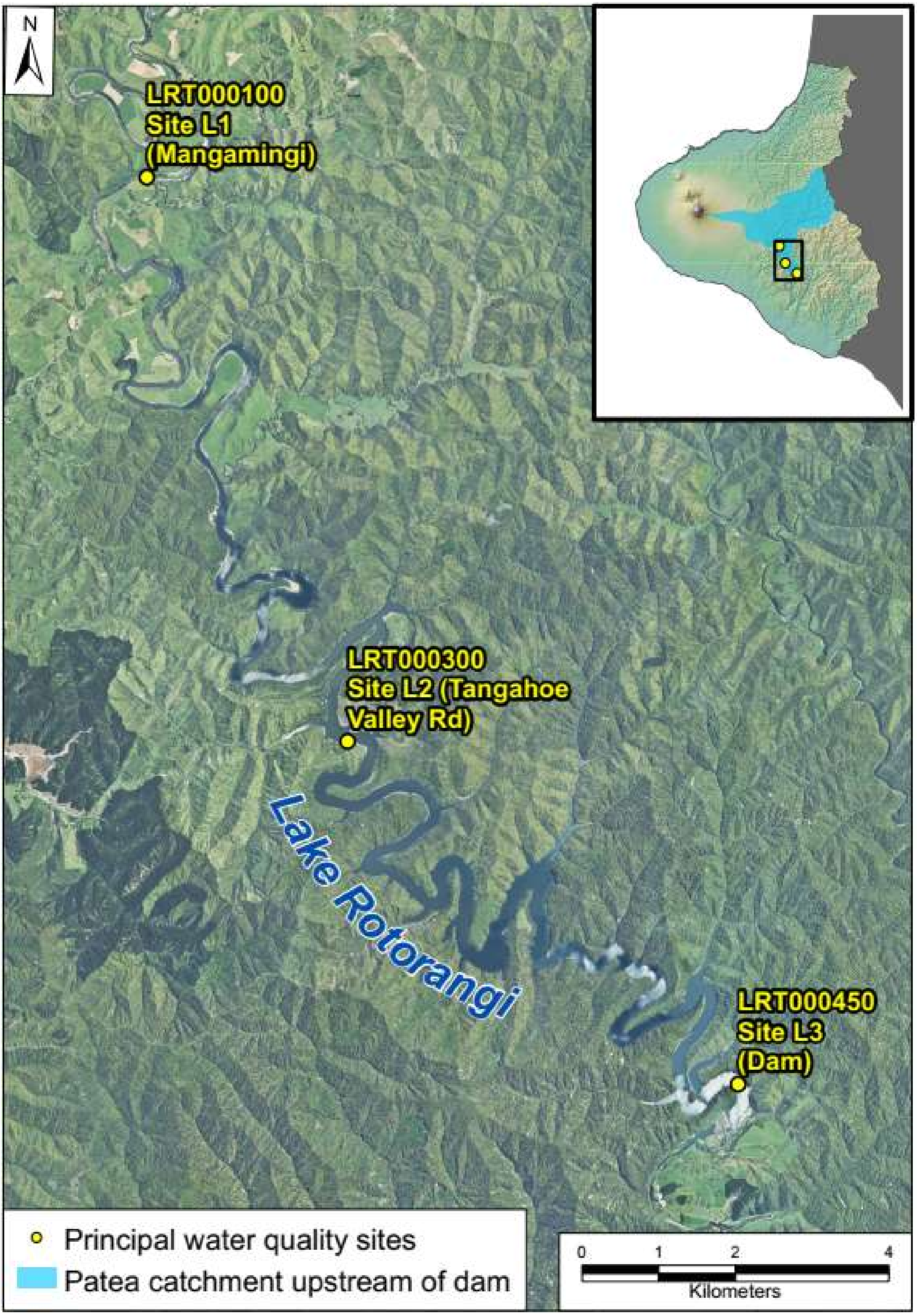

Figure 1 Location of monitoring sites in Lake Rotorangi with inset showing the location and catchment of the lake. Note: Monitoring at Site L1 was discontinued in 2010 due to the riverine nature of the lake at this northern location.

2.2 Physicochemical monitoring

At each site, a depth profile is collected measuring temperature and dissolved oxygen. On all sampling occasions, water samples are collected using a grab sample to reflect conditions at the surface and using a Van Dorn sampler at points in the water column to understand conditions in the epilimnion and hypolimnion. In February and March (under targeted stratified conditions), additional water samples are collected near the base of the water column to assess the impact of anoxia at the sediment-water interface.

Table 3 Physicochemical parameters monitored at each sampling depth in Lake Rotorangi

Parameter	Units	Surface	Epilimnion	Hypolimnion	Lower hypolimnion (Lake benthos)[1]
Black disc transparency	m	x			
Secchi disc transparency	m	x			
pH	pH units	x	x	x	x
Conductivity	µS/cm	x	x	x	
Turbidity	FNU	x	x	x	x
Suspended solids	g m^{-3}	x	x	x	
E. coli	MPN/100mL	x			
Dissolved reactive phosphorus (DRP)	g m^{-3} P		x	x	x
Total phosphorus (TP)	g m^{-3} P		x	x	x
Ammoniacal nitrogen	g m^{-3} N		x	x	x
Nitrite nitrogen	g m^{-3} N		x	x	
Nitrate nitrogen	g m^{-3} N		x	x	
Nitrate and nitrite nitrogen	g m^{-3} N		x	x	x
Total Kjeldahl nitrogen	g m^{-3} N		x	x	
Total nitrogen (TN)	g m^{-3} N		x	x	

[1] Sampled in late summer and early autumn only

Sampling of the photic zone is undertaken in conjunction with physicochemical monitoring. A depth-integrated sample is collected and analysed for chlorophyll *a* (chl *a)*, and a sub-sample is used to identify the phytoplankton species present.

Samples are collected in accordance with the National Environmental Monitoring Standard (NEMS) for discrete lake water quality data (NEMS 2019).

2.3 Biological monitoring

A macrophyte survey is also undertaken triennially in autumn and was completed in the 2023/24 monitoring year.

2.4 Statistical analyses

This report provides a summary of the key results and analyses described below. A full copy of monitoring results can be provided by Council upon request.

2.4.1 Trophic level index (TLI)

The trophic level index (TLI) is calculated for the lake as well as for individual sites. The equations used are consistent with Burns et al. (2000). For this equation, four parameters are used (chlorophyll *a*, Secchi disk depth, total phosphorus and total nitrogen). Although total phosphorus and total nitrogen were measured throughout the water column, only the epilimnion was used for all TLI calculations in this report. This differed from past reports which used both the epilimnion and hypolimnion during unstratified periods.

This deviation from past methods was in part due to missing depth profiles being unable to determine if a lake was stratified or not during some sampling occasions. Concentrations of total phosphorus and total nitrogen in the epilimnion were comparable to those in the hypolimnion while the lake was observed as being unstratified during the monitoring period. Therefore, this difference in method should not result in any significant changes to the calculated TLI. Annual average values of the four parameters used are calculated, and are then input into these equations to calculate the four components of the TLI as follows:

TLc = 2.22 +2.54 log (Chl *a*)
TLs = 5.10 + 2.27 log ((1/Secchi) – (1/40))
TLp = 0.218 + 2.92 log (TP)
TLn = -3.61 + 3.01 log (TN)

These four component values are then averaged to obtain the overall TLI. The results of the trophic index will determine the lake trophic status (Table 4). Table 4 also shows how different values of the trophic level components (chlorophyll *a*, Secchi depth, total phosphorus, and total nitrogen) would be classified.

Table 4 Lake status, trophic level and the different contributing parameters (adapted from Burns et al. (2000))

Lake status	Trophic level	Chl *a* (mg/m^3)	Secchi depth (m)	Total phosphorus (mg/m^3)	Total nitrogen (mg/m^3)
Ultra microtrophic	0 – 1	0.13 – 0.33	25 – 33	0.84 – 1.8	16 – 34
Microtrophic	1 – 2	0.33 – 0.82	15 – 25	1.8 – 4.1	34 – 73
Oligotrophic	2 – 3	0.82 – 2	7 – 15	4.1 – 9	73 – 157
Mesotrophic	3 – 4	2 – 5	2.8 – 7	9 – 20	157 – 337
Eutrophic	4 – 5	5 – 12	1.1 – 2.8	20 – 43	337 – 725
Supertrophic	5 – 6	12 – 31	0.4 – 1.1	43 – 96	725 – 1558
Hypertrophic	6 – 7	>31	<0.4	>96	>1558

2.4.2 Trend analyses

In this report, left censored data has been replaced with imputed values using regression on order statistics (ROS). This method fits a distribution to the non-censored values in the data record and uses the resulting model to impute replacement values for the censored data. The resulting calculated summary statistics and graphs are more robust than those used in reports prior to the 2021 report (Taranaki Regional Council 2021a), where summary statistics were biased by censored data being replaced with a value equal to half the censor limit.

Trend analyses were carried out using the LWP-Trends library R package (version 1901), developed by Land Water People Ltd. (Snelder & Fraser 2019). The methods employed have the primary purpose of establishing the direction and rate of any trend, along with a measure of the uncertainty in the result. The use of the LWP-Trends package represents a major change in trend analysis methodology compared to the Council's SoE reports prior to 2021, in part due to different methods used in the past, but also due to a recent conceptual shift in how to assess confidence in trend analysis results (Greenland et al. 2016, McBride 2019, Helsel et al. 2020).

As a first step in the trend analysis, a visual inspection of the raw time-series data is undertaken, giving a view of the proportion and temporal distribution of censored data. A Kruskal-Wallis test, using a threshold of $\alpha=0.05$, is employed to determine whether data is seasonal or not over the four separate annual samplings.

Depending on the result of the seasonality test, a non-parametric Mann-Kendall or seasonal Kendall test is used to determine the direction of a monotonic trend through the time-series data. Trend rate and the confidence in trend rate are evaluated using Sen-slope regression of observations against time. This is a non-parametric regression procedure, where the Sen-slope estimate (SSE) is taken as the median of all possible inter-observation slopes (Hirsch et al. 1982). In calculating the Kendall S statistic, censored data are dealt with as robustly as possible, following the methods of Helsel (2011), this allows inter-observation increases and decreases to be identified whenever possible (Snelder and Fraser 2019). In calculating the SSE, censored data are replaced by a value 0.5 times the highest common censor limit. While this biases inter-observation slopes associated with censored data, in most cases with a small proportion of censored data, the median slope will be unaffected. In general, when the SSE is affected by censored data, this usually indicates that the trend rate is smaller than can be detected. Trends noted as being affected by censored data are critically analysed to assess if the resulting statistics are meaningful or not.

While past trend analysis has reported on the 'significance' of any reported trend, in this report the assessment of confidence in a trend direction moves away from the traditional null hypothesis significance testing (NHST) approach and instead follows the recommended credible interval assessment method of McBride (2019). As a result of this change, the confidence in the reported trend direction (ranging from 50 to 100%) is now categorised as in Table 5.

Table 5 Confidence categorisation for trend direction results

Confidence Category	Confidence in reported trend direction
Very Likely Improving	90 – 100%
Likely Improving	67 – 90%
Indeterminate	50 – 67%
Likely Degrading	67 – 90%
Very Likely Degrading	90 – 100%

In the case of parameters that are sampled at multiple depths within the lake, trend analysis has been carried out on the data from the epilimnion. Differences in the water chemistry between the epilimnion and hypolimnion may mask any trends present in either layer. Furthermore, the magnitude of the seasonal change in the hypolimnion is greater for many parameters, and the magnitude of seasonal variation may hinder the ability to detect the trend over time. The use of epilimnion data in trend analysis is consistent with national reporting (Larned et al. 2015).

Trend analyses were performed on both sites, as well for the lake overall. Although it is typical to report statistical analyses for a lake holistically, the riverine nature of Lake Rotorangi means that there are differences in water chemistry between the mid and lower lake sites. Therefore, the trend analysis for the whole lake should be interpreted with caution. Additionally, trends were determined using the raw data, from the respective site, or in the case of the whole lake, the raw data from both sites. Although samples began in 1990 for most parameters, these were often missing certain seasons and therefore these years were omitted for trend analyses.

2.4.3 Attribute state and the National Objectives Framework

With some of the parameters, including ammoniacal nitrogen (epilimnion), total nitrogen (epilimnion), chlorophyll *a* (photic zone) and total phosphorus (epilimnion), we can assess the results against the numeric attribute state included in the National Objectives Framework (NOF), as part of the National Policy Statement for Freshwater Management 2020 (NPS-FM). Generally, this uses annual medians, however, due to this programme's quarterly sampling design, this data is limited and instead measurements over three years have been used. In this report we also assess numeric attribute states for five years of *E. coli* data and dissolved oxygen annual minima. It is important to note that *E. coli* measurements should be taken once a month as per the NPS-FM, however, the Council takes four samples a year, therefore analyses are completed with a limited sample size.

3. Results

3.1 General observations

General observations made on each sampling occasion during the period under review are presented in Table 6.

Table 6 Observations at Lake Rotorangi monitoring sites during sampling in 2021-2024

Date	Lake level (m asl)	Weather	Wind		Lake appearance	
			LRT000300	LRT000450	LRT000300	LRT000450
21 Oct 2021	76.95	Overcast; rain in last week	No wind	No wind	Slightly turbid, green-brown; flat	Slightly turbid, green-brown; flat
21 Feb 2022	77.35	Heavy rain week prior, warm, calm, dry	No wind	Light breeze	Turbid, brown, flat	Turbid, brown; flat
21 Mar 2022	76.47	Moderate rain, heavy rain overnight, overcast	Light breeze	Light breeze	Clear, dark green; rippled	Slightly turbid, brown; rippled
29 Jun 2022	76.95	Overcast, drizzle	No wind	No wind	Slightly turbid, brown-green; surface flat	turbid, brown; flat
19 Oct 2022	75.57	Light showers and light wind	No wind	Light breeze	Turbid, brown, flat	Slightly turbid, brown-green, rippled
20 Feb 2023	-	Fine	No wind	No wind	Turbid, brown, flat	Turbid, brown, rippled
22 March 2023	-	Drizzle, overcast	No wind	No wind	Slightly turbid, green, flat	Turbid, Green, flat
22 June 2023	76.23	Overcast	Light breeze	No wind	Slightly turbid, brown, rippled	Slightly turbid, brown, flat
25 October 2023	76.53	Overcast, sun showers,	Moderate wind	mixture of wind then no wind	Slightly turbid, green brown, choppy	Clear, brown, rippled
21 February 2024	76.50	Fine, overcast	No wind	No wind	Clear, green, flat	Clear, green, flat
27 March 2024	-	Fine	Light breeze	Light Breeze	Clear, green, rippled	Clear, green, rippled,
19 June 2024	-	Fine, heavy rain two days prior	Light to moderate breeze	Light to moderate breeze	Turbid, rippled	Clear, brown/green, rippled

3.2 Lake stratification

In this monitoring programme, thermal stratification events have previously been defined by a difference in lake water temperature of 3°C or greater with depth through the water column. Here, this 3°C criteria is use as a guideline, rather than a strict limit, given the variability in stratification patterns that can occur. This is consistent with the protocol included in Burns et al (1999). Complete depth profile charts, including temperature and dissolved oxygen measurements, are included in Appendix II.

Throughout the reporting period, there was a range of different stratification profiles seen (Appendix II). There was weak stratification at both sites during all three October surveys. Lake bottom waters were deoxygenated but not anoxic (defined as dissolved oxygen (DO) concentrations less than 0.5g/m^3) at both sites in 2021 (0.65g/m^3 and 1.04g/m^3, respectively). In 2022, anoxic conditions were observed at the lake-bottom at both monitoring sites. In 2023, lake-bottom waters were more oxygenated, with a 5.76g/m^3 DO concentration recorded at LRT000300 and 4.28g/m^3 recorded at LRT000450.

Stratification was observed during all three February sampling surveys at both sites. Anoxia at the lake bottom was observed on every occasion that the measurements were taken.

In March 2023, both sites were stratified with anoxic lake-bottom waters. There was no depth profile taken in 2022 or 2024 due to equipment issues.

In June 2022, both sites were stratified, with anoxia observed at the lake bottom at site LRT000450 but not LRT000300. In June 2024, both sites were stratified, though the differences in water temperatures between layers were relatively small. Both sites were anoxic at the lake bottom during this survey.

For both sites, over the past three monitoring years, the annual minima mid-hypolimnion and lake-bottom dissolved oxygen concentrations were below the national bottom line (band D) that is prescribed in NOF (Table 7).

Table 7 Minimum dissolved oxygen concentrations (g/m^3) in Lake Rotorangi assessed against National Objective Framework attribute bands (NPS-FM, 2020)

Year	Site	Minimum	Layer
2021/22	LRT000300	0.38	Lake-bottom
	LRT000450	0.00	
	LRT000300	0.00	Mid-hypolimnion
	LRT000450	0.00	
2022/23	LRT000300	0.02	Lake-bottom
	LRT000450	0.00	
	LRT000300	0.00	Mid-hypolimnion
	LRT000450	0.00	
2023/24	LRT000300	0.00	Lake-bottom
	LRT000450	0.00	
	LRT000300	0.00	Mid-hypolimnion
	LRT000450	0.00	

Note: (A = blue, B = green, C = yellow, D = red)

Anoxia in the lower hypolimnion means the biogeochemical conditions are likely to cause release of nutrients from lakebed sediment into water column during periods of stratification. In recognition of this, water samples have been collected from the bottom of the water column and analysed for nutrient concentrations during stratified periods since 1996. Over this time period, the data have shown a small increase in ammoniacal nitrogen and a very small decrease in nitrate nitrogen near the lakebed compared to in the hypolimnetic water column. This change may result from the reduction of nitrate to ammonia in the water column or the release of ammonia from anoxic sediments.

Concentrations of ammoniacal nitrogen in the water column near the lakebed were elevated on several occasions (Figure 2). At LRT000300, there were three sampling occasions where ammoniacal nitrogen concentrations were more than double those observed in the hypolimnion. However, whilst these concentrations were elevated in relation to those in the hypolimnion, they remained lower than the long-term median concentration. At LRT000450, ammoniacal nitrogen concentrations were markedly elevated compared to the hypolimnion in February and March 2022. In March 2022, this result was also elevated compared to the long-term median.

The differences in concentrations of nitrate/nitrite and DRP between the two levels in the lake water column were much less pronounced. At LRT000300, concentrations of DRP in the hypolimnion were approximately double those observed in the water column near the lakebed.

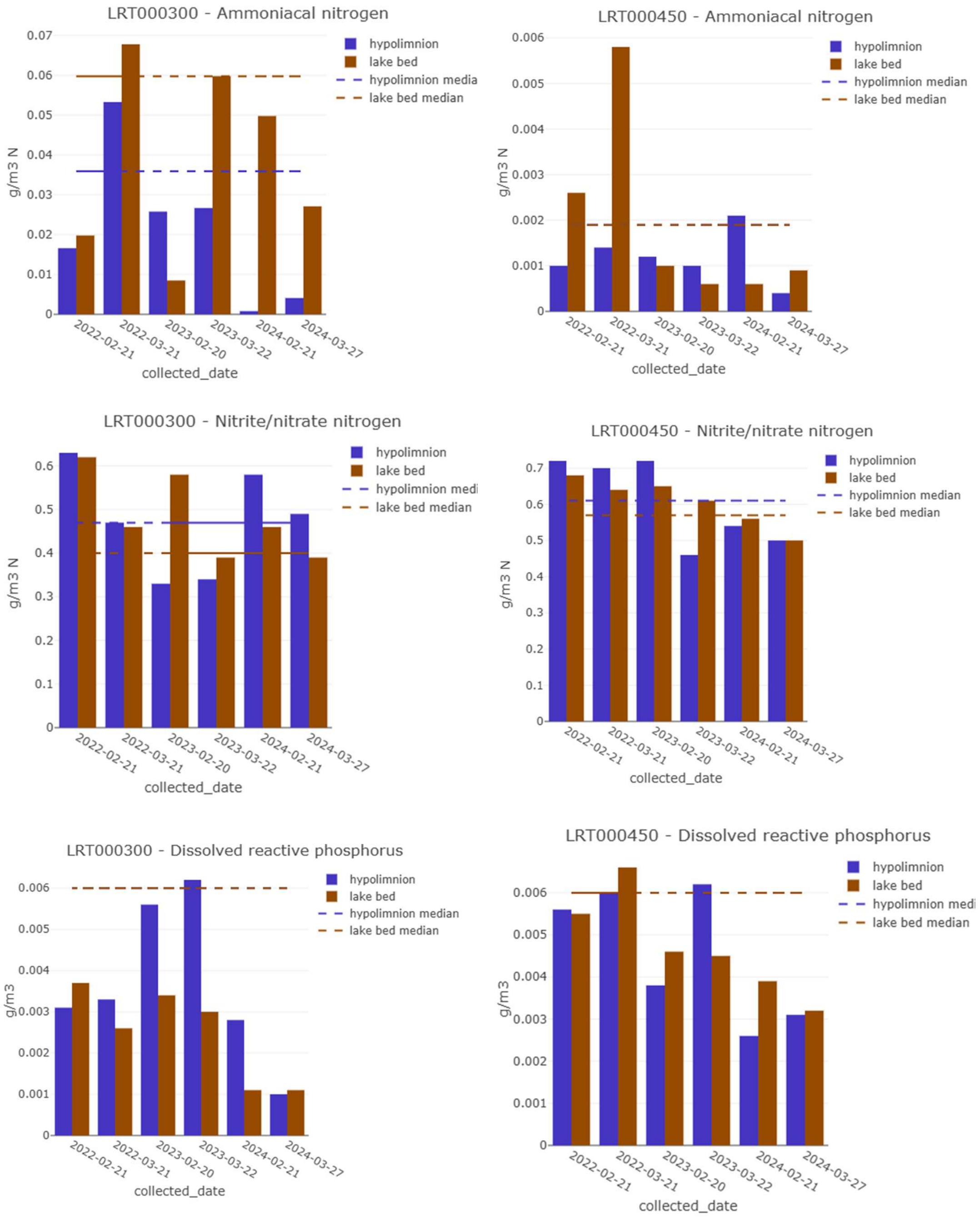

Figure 2 Concentrations of selected nutrients in the water column near the lakebed and in the hypolimnion in February and March (2021-2024)

3.3 Lake water quality

3.3.1 Nitrogen

Annual median concentrations of total nitrogen were variable over the three years from 2021 to 2024 (Figure 3, Figure 4 and Appendix III).

In 2021/22, annual median concentrations in both the epilimnion and hypolimnion were particularly high compared to the respective historical medians at both sites. At site LRT000300, the annual median concentration in the hypolimnion was 0.98g/m^3, which is the highest ever recorded (slightly greater than the highest annual median which was recorded in 2003/04). The annual median concentration in the epilimnion was 0.93g/m^3, which is comparable, but slightly lower than the highest annual median recorded in 2003/04. At site LRT000450, the annual median concentration in the epilimnion was also the highest recorded (0.88g/m^3). In 2022/23, annual median concentrations in both the epilimnion and hypolimnion were generally comparable to the historic medians at both sites. In 2023/24, the annual medians at both sites for both the epilimnion and hypolimnion were lower than their respective historical medians. For the hypolimnion, this annual median concentration was the lowest ever recorded for that site and sampling depth (0.65g/m^3). At site LRT000450, the annual median concentration in the epilimnion was also the lowest recorded (0.41g/m^3).

The median total nitrogen concentrations at sites LRT00300 and LRT00450 over the past three years of monitoring were 665 and 655mg/m^3 respectively, both of which fall into band C under the NOF framework (Table 8).

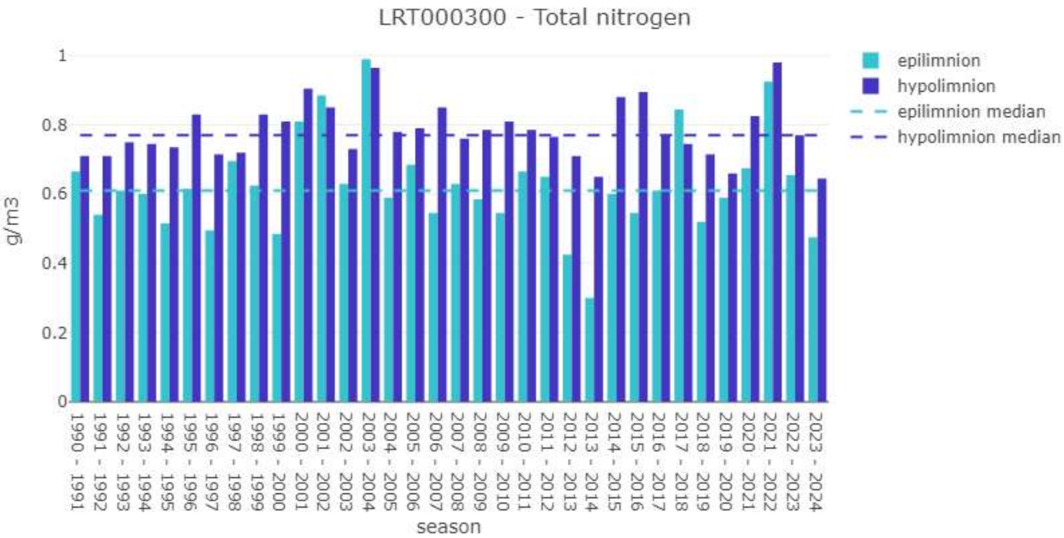

Figure 3 Annual median total nitrogen concentrations at LRT00300 since 1990

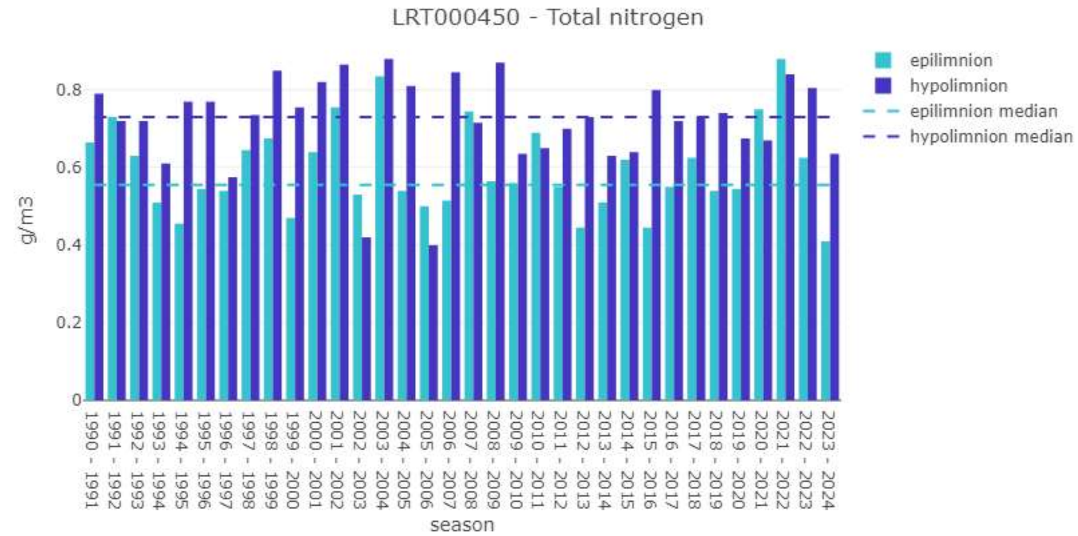

Figure 4 Annual median total nitrogen concentrations at LRT00450 since 1990

Annual median concentrations of nitrite/nitrate in the epilimnion and hypolimnion were above their respective historic medians at both sites in the 2021/22 monitoring year, equalling the highest previously recorded in the epilimnion (Figure 5, Figure 6 and Appendix III). In 2022/23, annual medians were comparable to historic medians. In 2023/24 annual medians were comparable to, or below, historic medians.

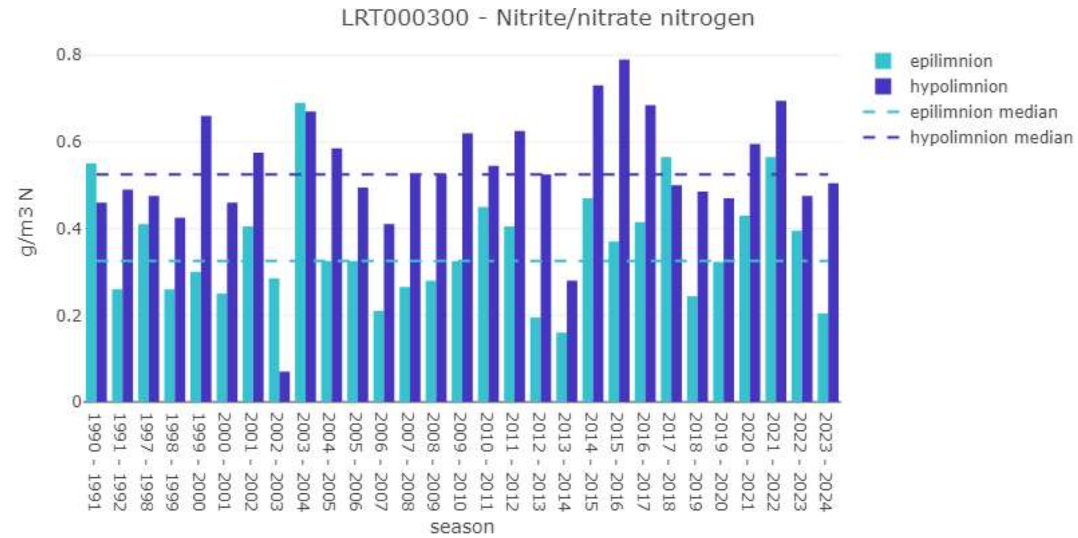

Figure 5 Annual median nitrite/nitrate concentrations at LRT00300 since 1990

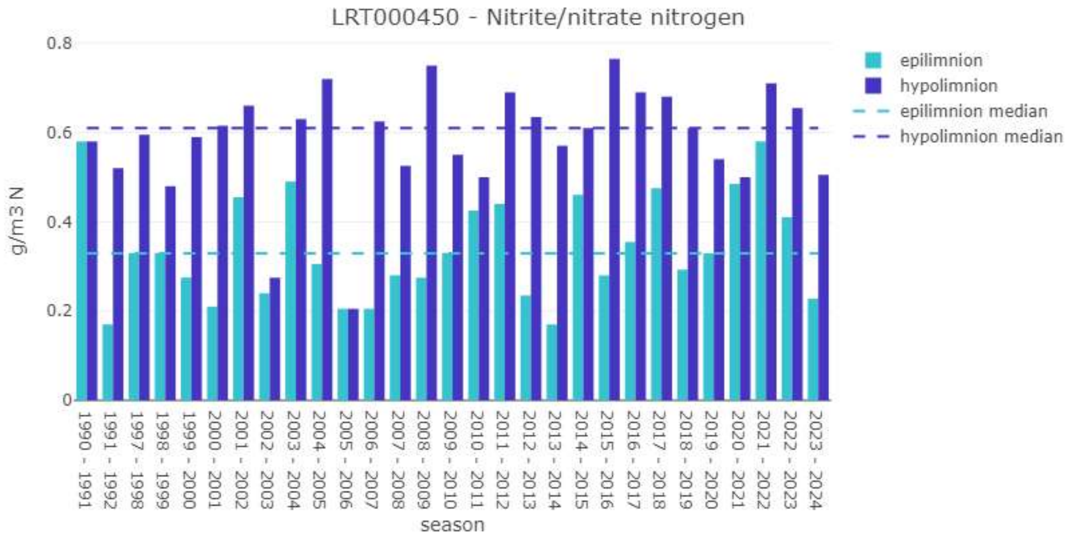

Figure 6 Annual median nitrite/nitrate concentrations at LRT00450 since 1990

Annual median concentrations for ammoniacal nitrogen were comparable to, or below, the respective historic medians for both sites and sampling depths (Figure 7, Figure 8 and Appendix III).

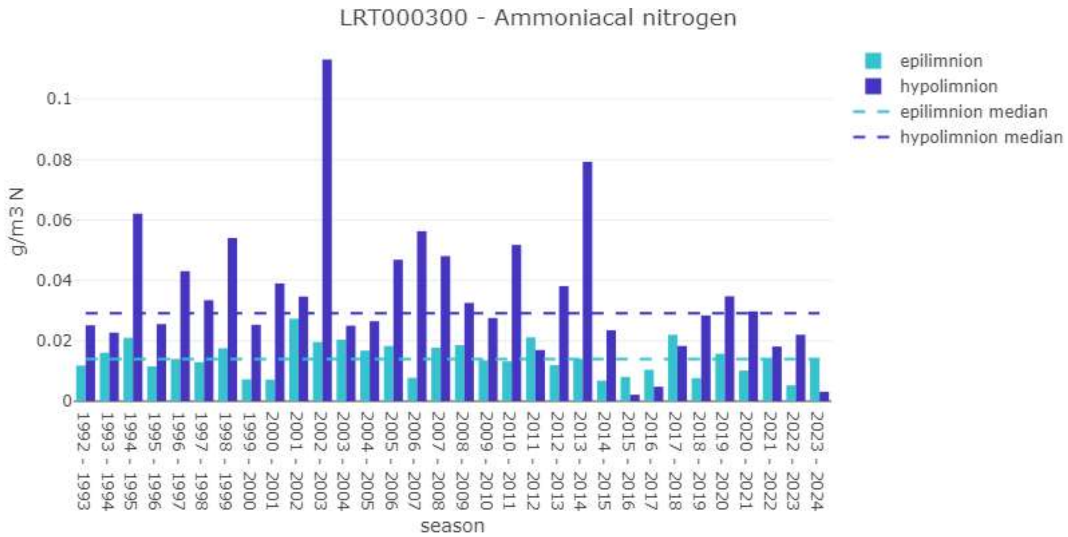

Figure 7 Annual median ammoniacal nitrogen concentrations at LRT00300 since 1992

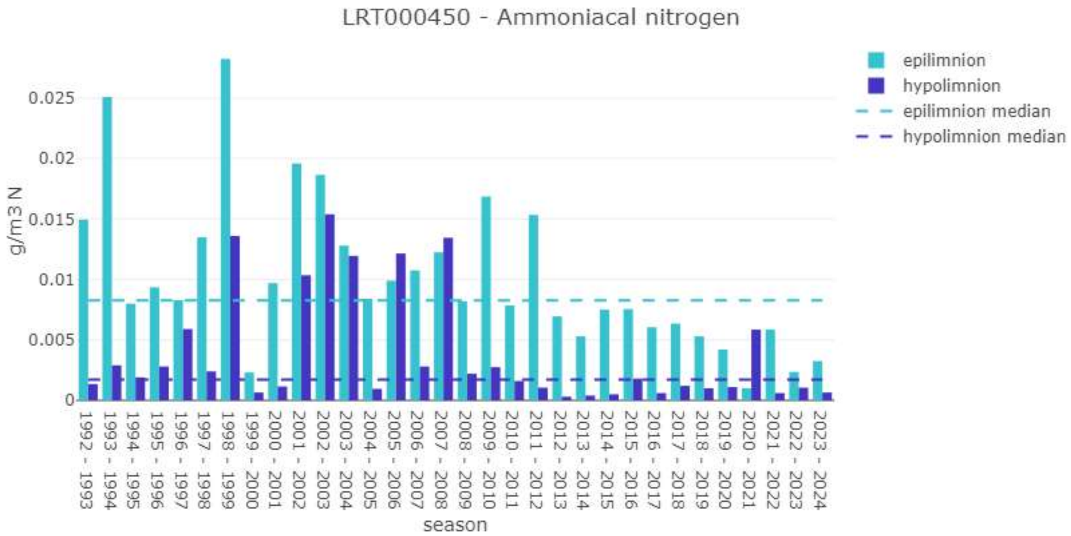

Figure 8 Annual median ammoniacal nitrogen concentrations at LRT00450 since 1992

The three-year ammoniacal nitrogen median and 95th percentile concentrations were in the NOF band A for both sites (Table 8).

Table 8 Median ammoniacal nitrogen and total nitrogen concentrations assessed against the National Objective Framework attribute bands (NPS-FM, 2020)

Parameter (unit)	Site	Median	95th percentile
Ammoniacal nitrogen (mg/L)	LRT00E300	0.022	0.04
	LRT00E450	0.007	0.02
Total Nitrogen (mg/m^3)	LRT00E300	665	
	LRT00E450	655	

Note: (A = blue, B = green, C = yellow, D = red)

3.3.2 Phosphorous

The annual median concentrations for total phosphorous in 2021/22 and 2022/23 were generally comparable to, or slightly higher than the historic medians at both monitoring sites and sampling depths (Figure 9, Figure 10 and Appendix III). In 2023/24, the annual median concentration from epilimnion samples at site LRT000300 was comparable to the historic median, whereas the annual median concentrations in the hypolimnion at LRT000300 and both the epilimnion and hypolimnion at LRT000450 were all equal to, or lower than, the lowest annual medians on record previously (0.011, 0.010, and 0.008g/m^3, respectively).

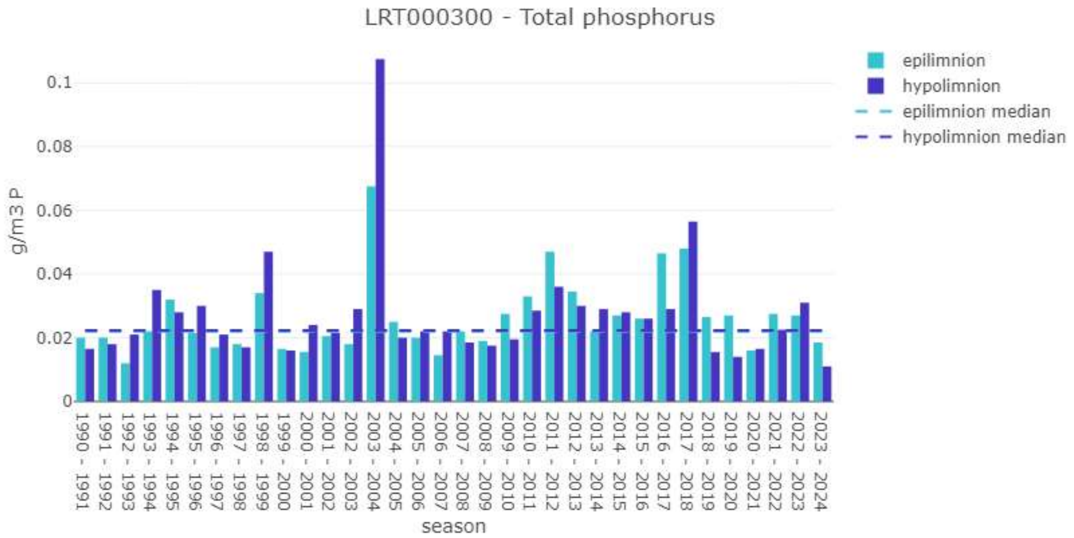

Figure 9 Annual median total phosphorus concentrations LRT00300 since 1990

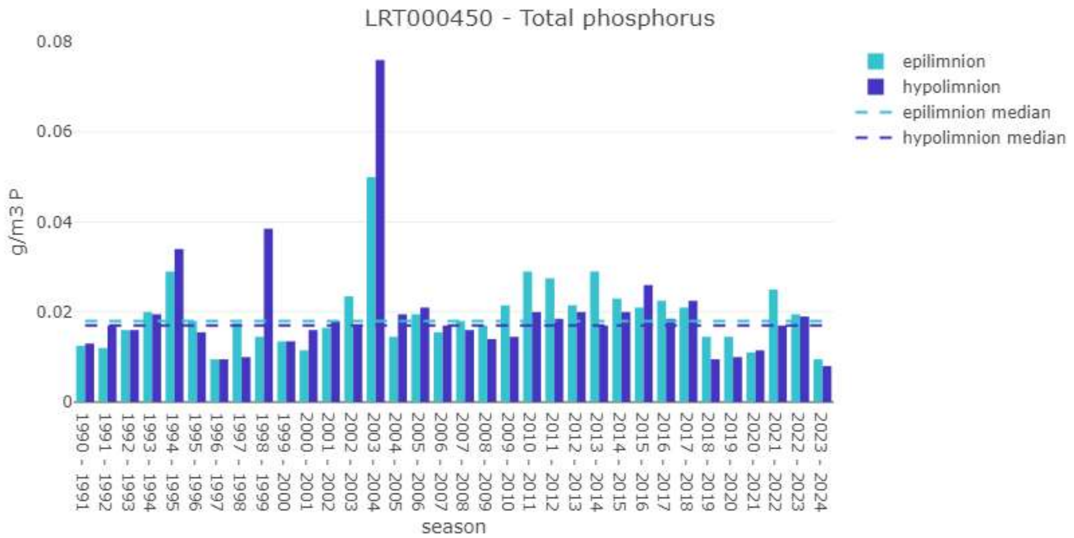

Figure 10 Annual median total phosphorus concentrations LRT00450 since 1990

During the period under review, total phosphorous concentrations were in NOF band C for LRT000300 and band B for LRT000450 (Table 9).

Table 9 Median total phosphorus concentrations assessed against the National Objective Framework attribute bands (NPS-FM, 2020)

Parameter (unit)	Site	Median
Total Phosphorus (mg/m3)	LRT000300	25
	LRT000450	18

Note: (A = blue, B = green, C = yellow, D = red)

At LRT000300, annual median concentrations of dissolved reactive phosphorous were lower than the historic median concentrations for their respective sampling depths on all three years of this reporting period (Figure 11 and Appendix III). These differences were most pronounced in the hypolimnion in 2021/22 and 2023/24, and in the epilimnion in 2022/23 and 2023/24. The 2023/24 annual median concentration in the hypolimnion was the lowest recorded for that site and sampling depth (0.0026g/m^3).

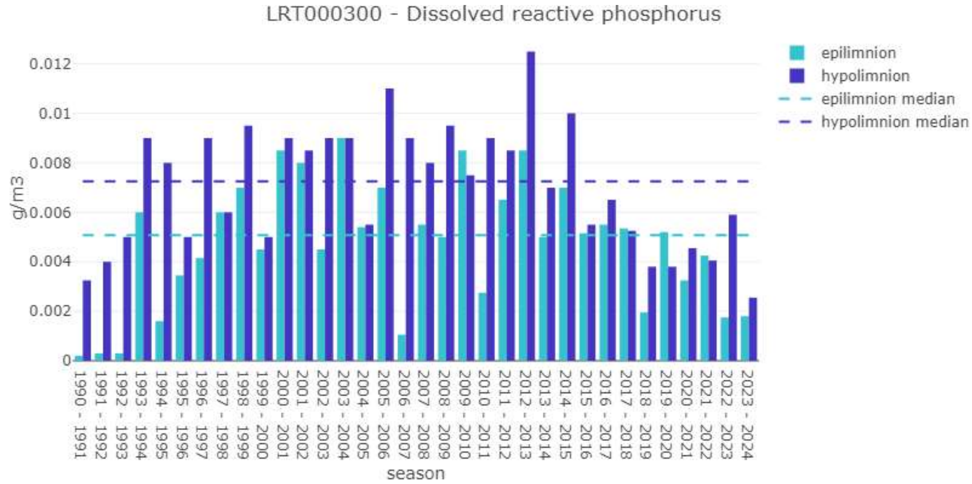

Figure 11 Annual median dissolved reactive phosphorus concentrations at LRT00300 since 1990

At LRT000450, the 2021/22 annual median concentrations for DRP were comparable to historic medians at both sampling depths (Figure 12 and Appendix III). Annual medians in the epilimnion were lower than the historic median in 2022/23 and equalled the lowest annual median on record in 2023/24 (0.0002g/m^3, also recorded in 1991/92). In the hypolimnion, annual median concentrations were comparable to, but below the historic median in 2022/23, and approximately half the historic median concentration in 2023/24.

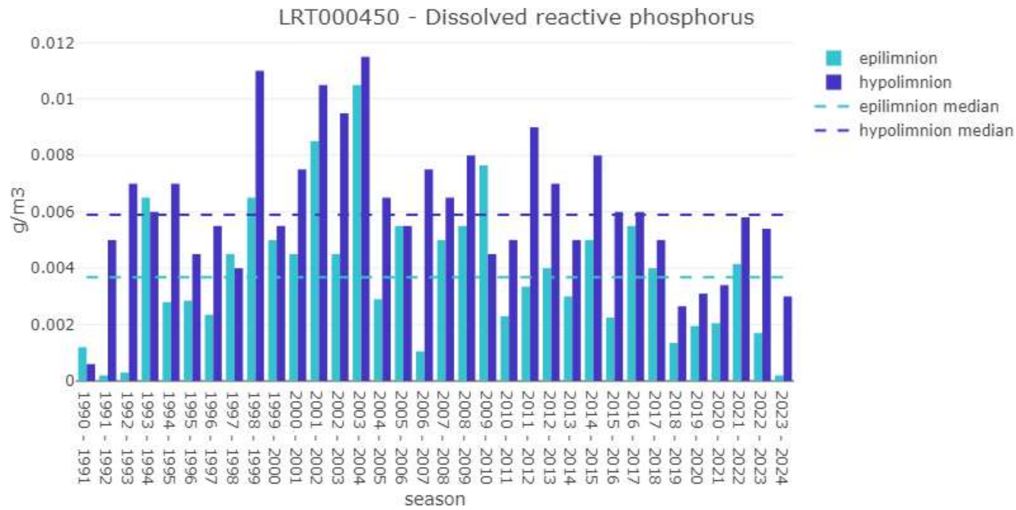

Figure 12 Annual median dissolved reactive phosphorus concentrations at LRT00450 since 1990

3.3.3 Secchi disc depth

At LRT000300, the annual median Secchi disc depth was 1.46m, 1.15m, and 2.48m in 2021/22, 2022/23 and 2023/24, respectively (Figure 13 and Appendix III). Compared to the historic median depth of 2.54m, these measurements were much lower in 2021/22 and 2022/23, and very similar in 2023/24.

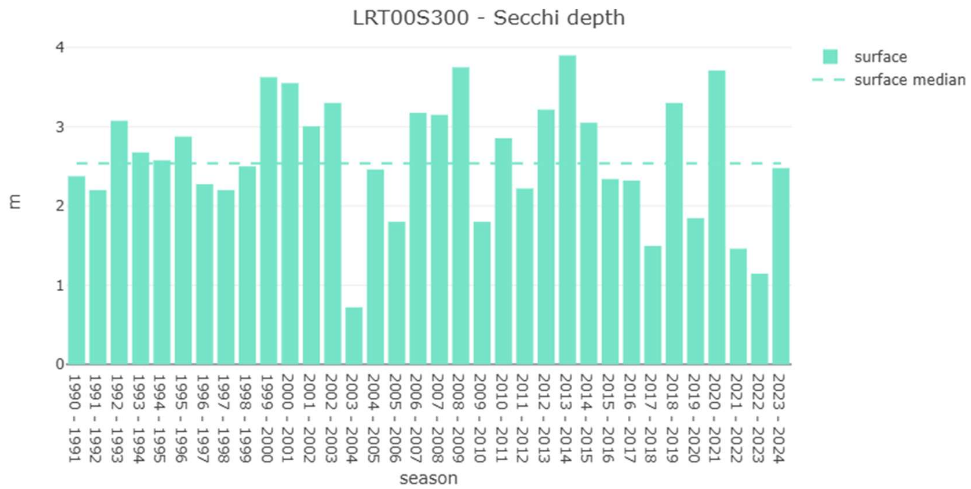

Figure 13 Annual median Secchi disc depth at site LRT00300 since 1990

At LRT000450, the annual median Secchi disc depth was 1.40m, 1.73m, and 3.35m in 2021/22, 2022/23 and 2023/24, respectively (Figure 14 and Appendix III). Compared to the historic median depth of 3.20m, these measurements were much lower in 2021/22 and 2022/23, and very similar in 2023/24.

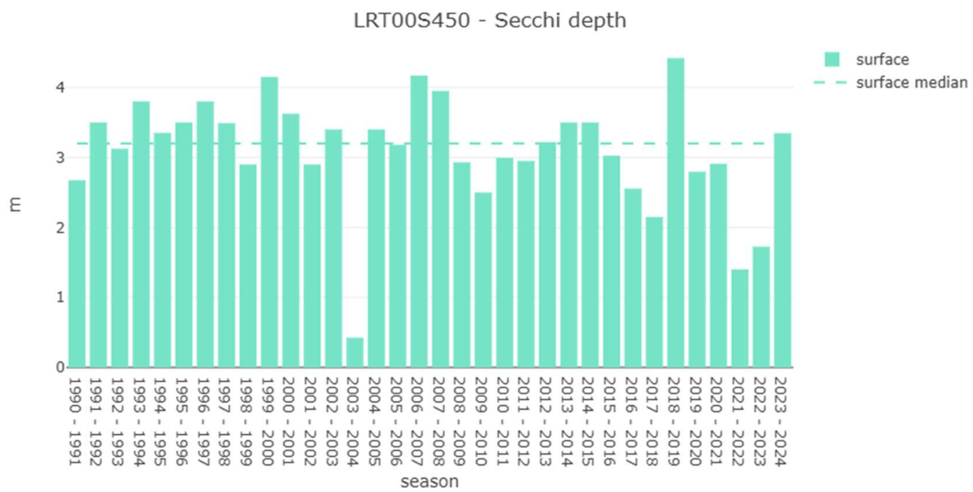

Figure 14 Annual median Secchi disc depth at site LRT00450 since 1990

3.3.4 Chlorophyll *a* (phytoplankton)

At site LRT00P300, in 2021/22 and 2022/23, annual median chlorophyll *a* concentrations were above the historic median of 2.48mg/m^3 (Figure 15 and Appendix III). The annual median in 2021/22 was the highest ever recorded at this site (5.57mg/m^3). In contrast, the 2023/24 annual median at site LRT00P300 was the lowest annual median recorded at this site (1.05mg/m^3).

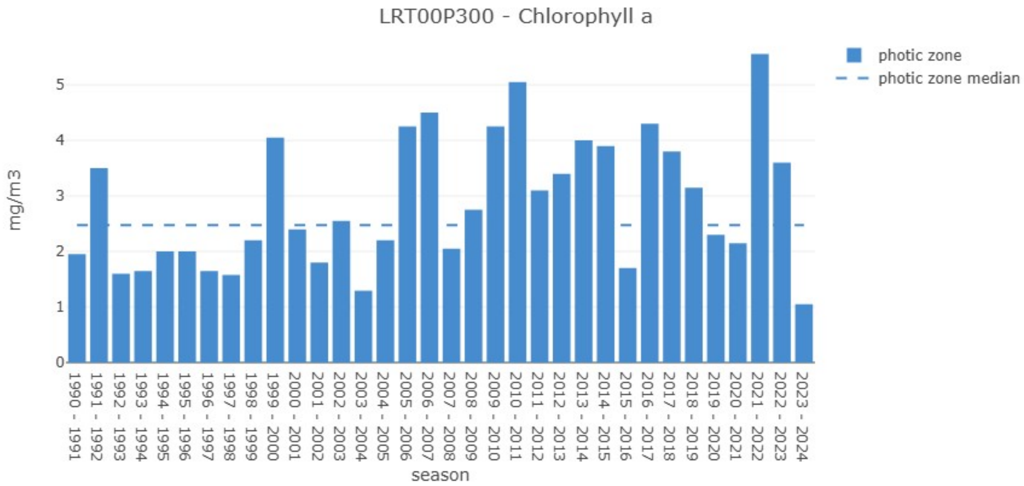

Figure 15 Annual median chlorophyll *a* concentrations at site LRT00P300 since 1990

At site LRT00P450 in 2021/22 and 2022/23, the annual median concentrations were comparable to the historic median (2.23mg/m^3, Figure 16 and Appendix III). In contrast, the annual median concentration in 2023/24 was the second lowest on record (1.35mg/m^3).

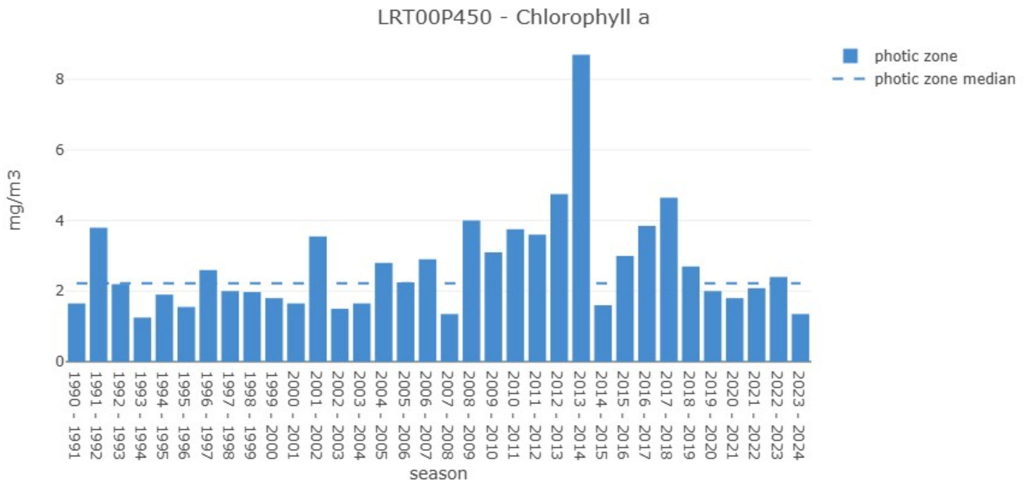

Figure 16 Annual median chlorophyll *a* concentrations at site LRT00P450 since 1990

Assessment of chlorophyll *a* concentrations in Lake Rotorangi against the NOF phytoplankton attribute based on the three years of data from 2021 to 2024 places both sites in band A for median concentrations. For maximum chlorophyll *a* concentrations, site LRT00P300 is in band C and site LRT00P450 is in band B (Table 10).

Table 10 Chlorophyll *a* concentrations assessed against the National Objectives Framework attribute bands (NPS-FM, 2020)

Site	Median (mg/m³)	Maximum (mg/m³)
LRT00P300	1.3	38
LRT00P450	1.55	16.9

Note: (A = blue, B = green, C = yellow, D = red)

At site LRT00P300, the median phytoplankton taxonomic richness (number of species) was 9.5, 12, and 11.5 in the years 2021/22, 2022/23, and 2023/24, respectively (Figure 17). At site LRT00P450, the annual median taxonomic richness was 8.0, 5.5, and 10.5 in the years 2021/22, 2022/23, and 2023/24, respectively (Figure 18).

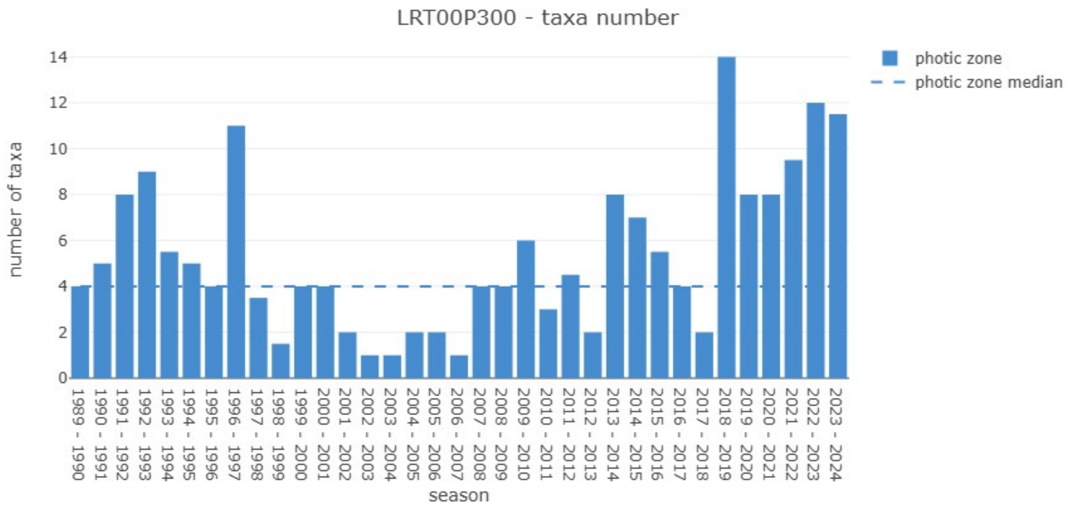

Figure 17 Annual median phytoplankton taxa richness at site LRT00P300 since 1989

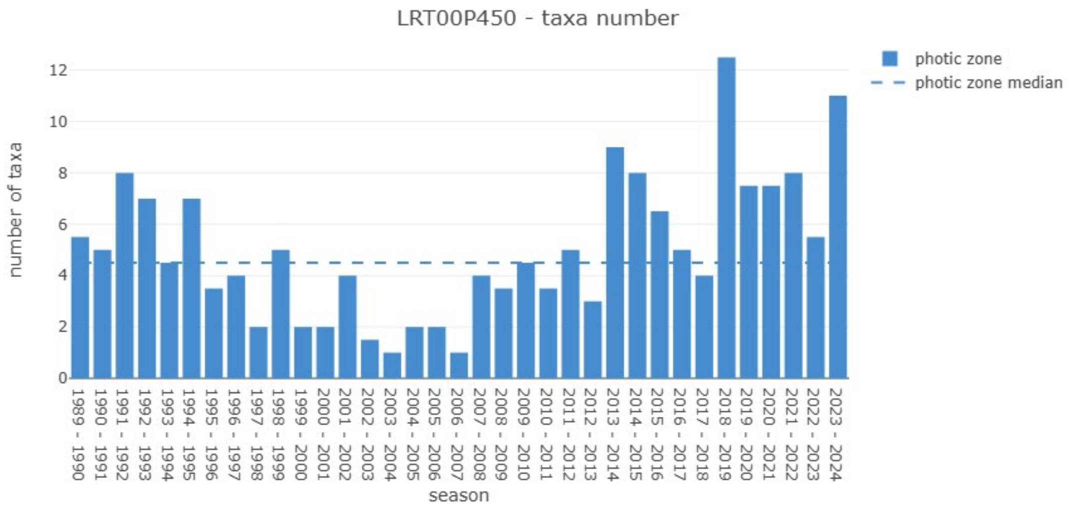

Figure 18 Annual median phytoplankton taxa richness at site LRT00P450 since 1989

3.3.5 Escherichia coli *(E. coli)*

At LRT000300, the annual median *E. coli* concentration was 26, 13 and 18 MPN/100 ml in 2021/22, 2022/23 and 2023/24, respectively (Figure 19 and Appendix III). These results were all similar to the historic median concentration for this site (21 MPN/100ml).

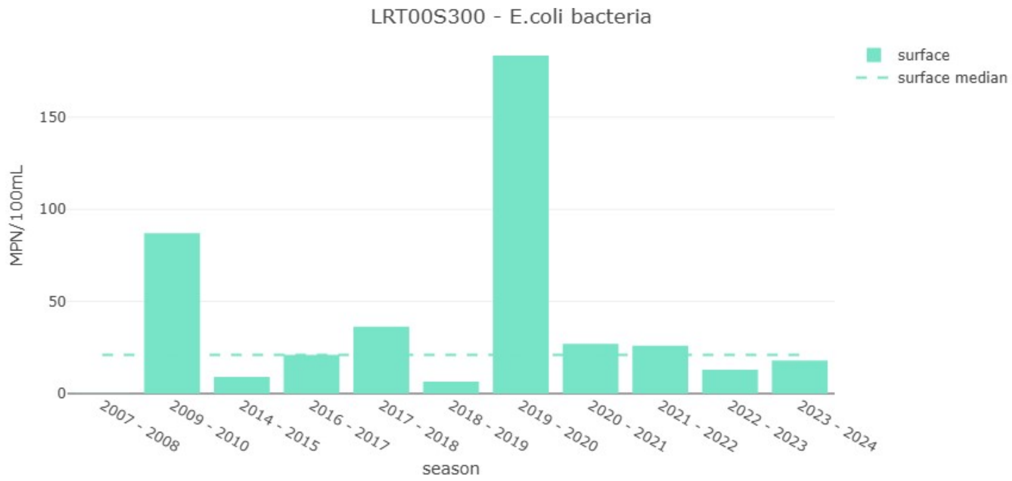

Figure 19 Annual median *E. coli* concentrations at site LRT00S300 since 2009

At LRT000450, the annual median *E. coli* concentration was 5, 9 and 2 MPN/100 ml in 2021/22, 2022/23 and 2023/24, respectively (Figure 20 and Appendix III). These results were all similar to the historic median concentration for this site (4 MPN/100ml). Overall, *E. coli* concentrations remained low at both sites during the monitoring period. The results reflected the long-term differences observed between sites, with concentration at LRT000450 lower than those at LRT000300.

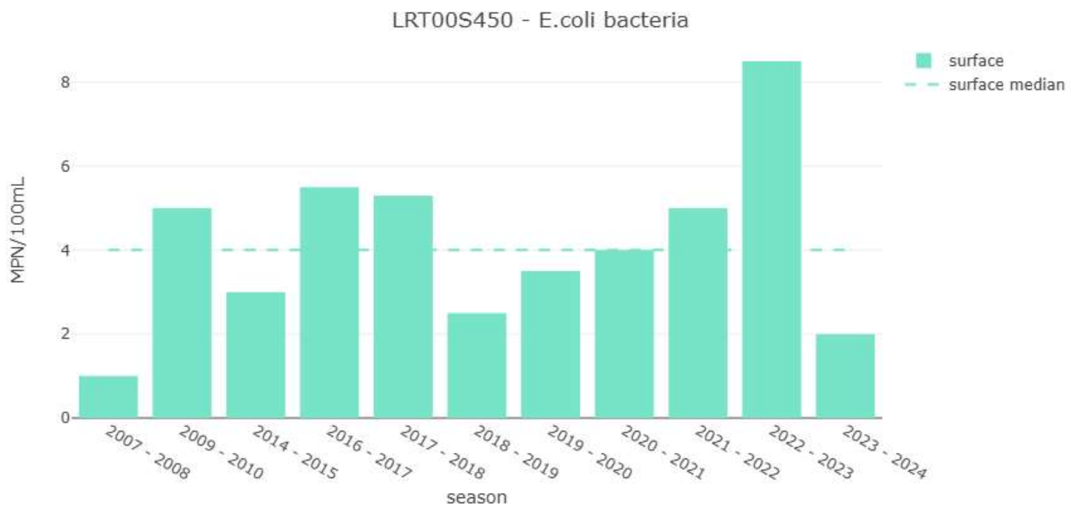

Figure 20 Annual median *E. coli* concentrations at site LRT00S450 since 2009

Assessment of *E. coli* concentrations in Lake Rotorangi against the NOF phytoplankton attribute based on the five years of data from 2019 to 2024 places both sites in band A for all four statistical criteria (Table 11)

Table 11 *E. coli* concentrations assessed against the National Objectives Framework attribute bands (NPS-FM, 2020)

Site	% exceedances over 540/100mL	% exceedances over 260/100mL	Median	95th percentile
LRT00S300	0	10.5	24	366.9
LRT00S450	0	0	3	23.1

Note: Colours indicate which band the numeric attributes fall within (A = blue, B = green, C = yellow, D = red).

3.4 Overall trophic state

The overall lake trophic level indices were 4.78, 4.34, and 3.60 for the monitoring years 2021/22, 2022/23 and 2023/24, respectively (Table 12). As such, the lake was classified as eutrophic in 2021/22 and 2022/23, but mesotrophic in 2023/24. These overall lake classifications were consistent for both monitoring sites.

When the individual components of trophic level are considered, in 2021/22, chlorophyll *a*, Secchi depth and total phosphorus concentrations were indicative of a eutrophic lake status, while total nitrogen concentrations were indicative of a supertrophic lake status. In 2022/23, Secchi depth, total nitrogen and total phosphorus concentrations were indicative of a eutrophic lake status, while chlorophyll *a* concentrations were indicative of a mesotrophic lake status. The individual components in 2023/24 varied. Chlorophyll *a* concentrations were indicative of an oligotrophic lake status, total nitrogen concentrations were indicative of a eutrophic lake status, while Secchi depth and total phosphorus concentrations were indicative of a mesotrophic lake status.

Table 12 Trophic level and values of key variables defining the trophic status of Lake Rotorangi from the previous three monitoring seasons, numbers based on Burns (1999)

Monitoring year	Trophic Level Components	LRT000300	LRT000450	Combined sites
2021/22	Overall trophic status	Eutrophic	Eutrophic	Eutrophic
	Trophic level	4.94 (E)	4.62 (E)	4.78 (E)
	Chlorophyll *a* (mg/m^3)	12.23 (S)	5.175 (E)	8.7 (E)
	Secchi depth (m)	1.49 (E)	1.56 (E)	1.53 (E)
	Total nitrogen (mg/m^3)	875 (S)	865 (S)	870 (S)
	Total phosphorus (mg/m^3)	38.75 (E)	30.75 (E)	34.75 (E)
2022/23	Overall trophic status	Eutrophic	Eutrophic	Eutrophic
	Trophic level	4.48 (E)	4.20 (E)	4.34 (E)
	Chlorophyll *a* (mg/m^3)	3.8 (M)	3.03 (M)	3.41 (M)
	Secchi depth (m)	1.11 (E)	1.84 (E)	1.47 (E)
	Total nitrogen (mg/m^3)	626.5 (E)	642.5 (E)	652.5 (E)
	Total phosphorus (mg/m^3)	26.5 (E)	21 (E)	23.75 (E)
2023/24	Overall trophic status	Mesotrophic	Mesotrophic	Mesotrophic
	Trophic level	3.80 (M)	3.40 (M)	3.60 (M)
	Chlorophyll *a* (mg/m^3)	1.58 (O)	1.33 (O)	1.45 (O)
	Secchi depth (m)	2.51 (E)	3.52 (M)	3.01 (M)
	Total nitrogen (mg/m^3)	467.5 (E)	425 (E)	446.25 (E)
	Total phosphorus (mg/m^3)	18.75 (M)	9 (M)	13.88 (M)

Note: Letters in brackets relate to the trophic status of each component; M=Mesotrophic, E=Eutrophic, S=Supertrophic

Over the entire monitoring record, the trophic level index at LRT000300 has ranged from 3.80 to 4.94, with an historic median of 4.17 (Figure 21 and Appendix III). The maximum and minimum results were both recorded during the monitoring period under review. In 2021/22, the trophic level index at this site was the highest ever recorded (4.94 TLI units). Conversely, in 2023/24, the trophic level index was the lowest ever recorded (3.80 TLI units.)

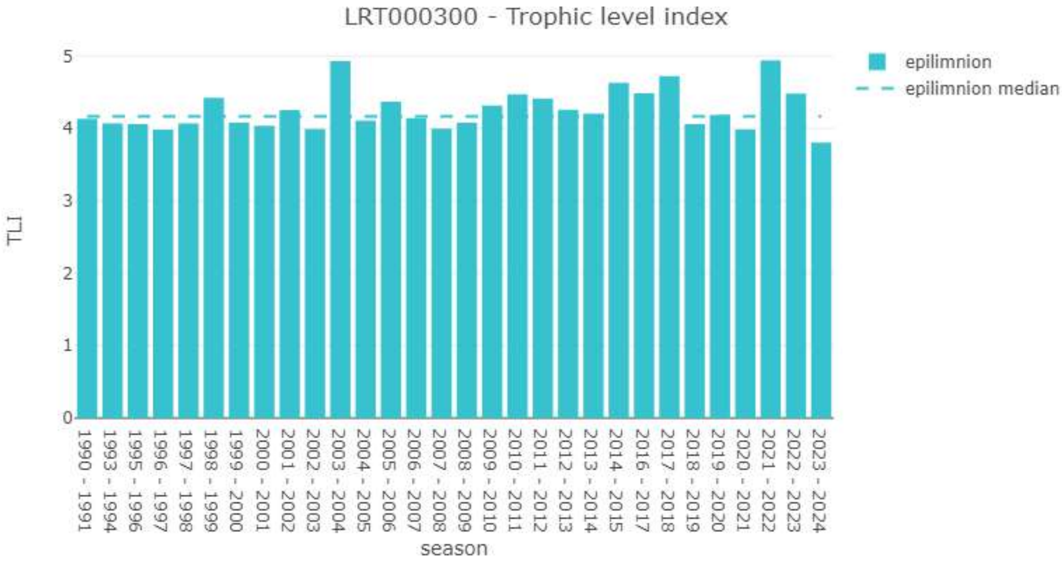

Figure 21 Annual trophic level index at site LRT000300 over the monitoring years since 1990

At LRT000450, the trophic level index over the entire monitoring record has ranged from 3.40 to 4.97, with an historic median of 3.98 (Figure 22 and Appendix III). While the two results from 2021/22 and 2022/23 were both above the historic median, the lowest ever result was recorded in 2023/24 (3.40).

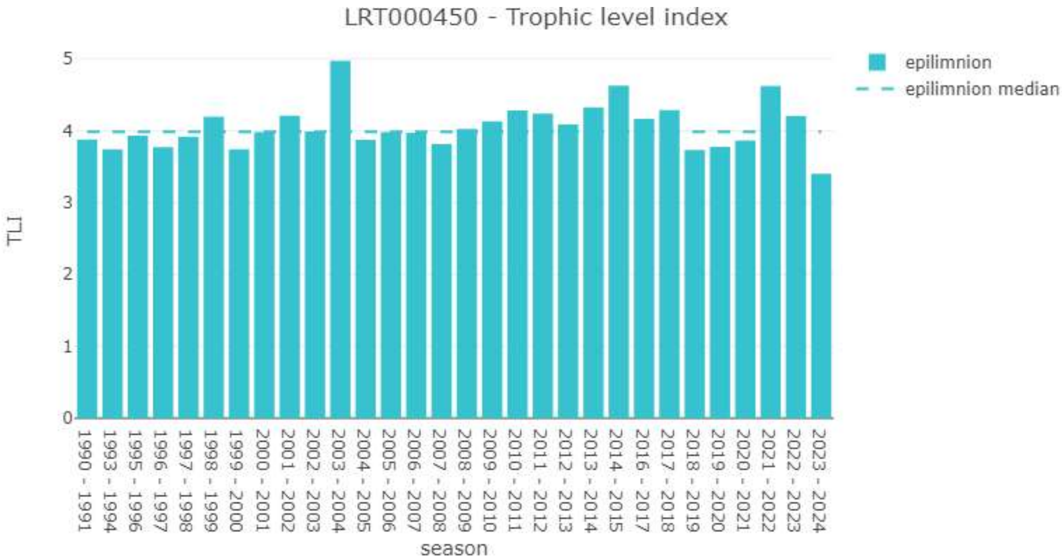

Figure 22 Annual trophic level index at site LRT000450 over the monitoring years since 1990

3.5 Autumn macrophyte survey

An autumn macrophyte survey in Lake Rotorangi is undertaken on a triennial basis. This was completed in the 2023/24 monitoring year. For this survey, a boat travels along the lake edge at consistent speed while staff watch and identify macrophyte species. There have been large changes in the macrophyte community since the surveys began in 1987, where *Lagarosiphon major* was the dominant species, and *Egeria densa* being the next most common. Following on from that, up until 2005, *E. densa* was noted as the most dominant species. In 2005 and 2008, *L. major* was the most dominant species, however, in 2012 it switched back to *E. densa*. Also in 2012, the macrophyte survey first picked up the highly invasive *Ceratophyllum demersum*, also known as hornwort. As predicted in a report prepared by NIWA (Wells 2012), the distribution of hornwort has increased markedly. In 2015, hornwort became more prolific and dominated the middle reaches of Lake Rotorangi, as well as being the only dominant species on the true left bank downstream of the Hāwera water ski club rooms. In 2018, hornwort was the dominant macrophyte in the upper reaches of the lake, however, it should be noted that although the 2018 survey recorded no macrophytes through the mid-section of the lake, it may have been present but obscured by high turbidity. In the previous survey (2021) hornwort was the dominant macrophyte throughout the entirety of the lake, with the exception of a small section at the northern end of the lake that was <2km in length, and in small sections down one arm on the eastern side of the lake, which were instead dominated by *E. densa*.

The current survey results suggest that hornwort has become the dominant species throughout the whole lake. Apart from hornwort, there was only one other macrophyte recorded in this year's survey, *Potamogeton cheesmanii*, a native pondweed. However, *P. cheesmanii* was only found in a small density, approximately $1m^2$.

The full survey report is provided in Appendix I.

3.6 Temporal trends

Long-term trend analyses were carried out on eight water quality measures for each monitoring site, as well as the whole lake by combining the two datasets. Long-term trends in trophic level index were also assessed for each monitoring site. Short-term trends were carried out for the same water quality measures, but there were insufficient data to assess trophic level index. These results are summarised by trend direction in Table 13, with the complete results presented in Table 14 and Table 15. An increasing trend direction corresponds to degrading water quality for all of the parameters assessed except Secchi depth. For Secchi depth, an increasing trend corresponds to improving water quality. Further explanation of the trend analysis methodology and interpretation of results is provided in Section 2.4.2.

Table 13 Number of long-term and short-term trends in each trend direction category

	Site	Improving	Degrading	Indeterminate
Long-term (n=26)	LRT000300	3	4	2
	LRT000450	3	4	2
	Whole lake	3	4	1
Short-term (n=24)	LRT000300	4	0	4
	LRT000450	6	0	2
	Whole lake	6	0	2

Long-term trend results were fairly evenly distributed between categories, with three improving trends, four degrading trends and two indeterminate trends observed at each monitoring site (Table 13). Trend directions were consistent between sites for every parameter (Table 14). Improving trends were recorded for DRP, ammoniacal nitrogen, and TN. Degrading trends were observed for TP, chlorophyll *a*, Secchi depth and *E. coli*. There was no clear trend direction observed for nitrite/nitrate at either monitoring site or the combined dataset. The trends with the highest level of confidence were those for chlorophyll *a* (whole lake), TP (LRT000300), DRP (all sites), ammoniacal nitrogen (all sites) and trophic level index (LRT000300 and LRT000450). Except for trophic level index, the rates of annual change associated with this sub-set of trends were all greater than 1%, with the highest rates observed for DRP (improving by 3.05% per year at LRT000450) and ammoniacal nitrogen (improving by 3.54% per year at LRT000450). A lower rate of annual change was observed for trophic level index (0.20% at LRT000300 and 0.24% at LRT000450).

By comparison, the majority of short-term trend results were found to be improving (16 out of 24), with the remainder indeterminate (Table 13). No degrading trends were observed. Improving trends were observed for at least one site for every parameter, except for *E. coli*, for which the trends at both sites and the combined dataset were all indeterminate (Table 15). The trends with the highest level of confidence were those for chlorophyll *a* (LRT000450), TP and DRP (all sites), and ammoniacal nitrogen (LRT000450). For seven out of eight of those trends, the rate of annual change was greater than 5%. The highest rate of annual change was observed for DRP (improving by 10.58%, 8.80% and 13.10% per year at LRT000300, LRT000450 and the combined lake dataset, respectively).

The parameters with evidence of consistent long-term and short-term trend directions include DRP (improving across time periods at all sites), ammonia (improving across time periods at one site), total nitrogen (improving across time periods at one site), and Secchi depth (degrading across time periods at one site). The parameters with evidence of contrasting long-term and short-term trend directions include chlorophyll *a* (degrading to improving at all sites) and TP (degrading to improving at one site). The remaining combinations of sites and parameters showed evidence of a trend over one time period but were indeterminate over the other time period.

Table 14 Long-term trend analysis of selected variables in Lake Rotorangi from the beginning of the monitoring record to 2024

Measure	Site	Seasonal (Yes / No)	No. of data points	Proportion censored	Median Slope	Percent Annual Change	Trend	Confidence (%)
Chlorophyll *a* (photic zone)	LRT00P300	No	111	0.14	0.025	0.89	Likely Increasing	86.49
	LRT00P450	No	111	0.13	0.023	0.95	Likely Increasing	81.43
	Whole Lake	No	222	0.13	0.32	1.23	Very Likely Increasing	92.29
E. coli (surface)	LRT00S300	No	37	0.054	0.18	0.92	Indeterminate	58.18
	LRT00S450	No	38	0.11	0.10	3.40	Likely Increasing	77.99
	Whole Lake	No	75	0.08	0.24	4.89	Likely Increasing	75.06
Total phosphorus (epilimnion)	LRT00E300	No	112	0	0.00030	1.24	Very Likely Increasing	93.36
	LRT00E450	No	112	0	0.000025	0.13	Indeterminate	59.92
	Whole Lake	No	224	0	0.00016	0.77	Likely Increasing	84.15
DRP (epilimnion)	LRT00E300	No	112	0.24	-0.000010	-2.00	Very Likely Decreasing	96.55
	LRT00E450	No	112	0.28	-0.00012	-3.05	Very Likely Decreasing	99.71
	Whole Lake	No	224	0.26	-0.00011	-2.66	Very Likely Decreasing	98.93
Ammonia (epilimnion)	LRT00E300	No	112	0.04	-0.00016	-0.78	Very Likely Decreasing	91.66
	LRT00E450	No	112	0.15	-0.00035	-3.54	Very Likely Decreasing	100
	Whole Lake	No	224	0.098	-0.00029	-1.98	Very Likely Decreasing	99.92
Total nitrogen (epilimnion)	LRT00E300	No	112	0	-0.0045	-0.72	Likely Decreasing	85.69
	LRT00E450	No	112	0	-0.0031	-0.51	Likely Decreasing	82.81
	Whole Lake	No	224	0	-0.0039	-0.63	Likely Decreasing	88.37
Nitrite/nitrate (epilimnion)	LRT00E300	No	108	0.00	0	0	Indeterminate	55.03
	LRT00E450	No	108	0.019	0.0012	0.32	Indeterminate	67.32
	Whole Lake	No	216	0.0093	0.001	0.27	Indeterminate	61.86

Measure	Site	Seasonal (Yes / No)	No. of data points	Proportion censored	Median Slope	Percent Annual Change	Trend	Confidence (%)
Secchi depth	LRT00E300	No	112	0	-0.014	-0.56	Likely Decreasing	77.90
	LRT00E450	No	112	0	-0.014	-0.45	Likely Decreasing	77.09
	Whole Lake	No	224	0	-0.015	-0.52	Likely Decreasing	81.70
Trophic level index	LRT000300	No	30	0	0.0081	0.20	Very Likely Increasing	95.32
	LRT000450	No	30	0	0.0096	0.24	Very Likely Increasing	94.58

Note: Trends of high confidence are identified in red (degrading trend) or blue (improving trend). The monitoring record start date varies depending on the parameter.

Table 15 Short-term (10-year) trend analysis of selected variables in Lake Rotorangi (2014 – 2024)

Measure	Site	Seasonal (Yes / No)	Proportion censored	Median Slope	Percent Annual Change	Trend	Confidence (%)
Chlorophyll *a* (photic zone)	LRT00P300	No	0.093	-0.083	-2.39	Likely Decreasing	71.53
	LRT00P450	No	0.11	-0.22	-7.78	Very Likely Decreasing	90.89
	Whole Lake	No	0.10	-0.18	-6.12	Likely Decreasing	87.23
E. coli (surface)	LRT00S300	No	0.029	-0.38	-1.74	Indeterminate	58.73
	LRT00S450	No	0.11	0.049	1.64	Indeterminate	58.74
	Whole Lake	No	0.072	0.21	3.05	Indeterminate	58.73
Total phosphorus (epilimnion)	LRT00E300	No	0	-0.0011	-4.27	Very Likely Decreasing	94.49
	LRT00E450	No	0	-0.012	-6.35	Very Likely Decreasing	98.87
	Whole Lake	No	0	-0.0013	-5.77	Very Likely Decreasing	99.15
DRP (epilimnion)	LRT00E300	No	0.20	-0.00045	-10.58	Very Likely Decreasing	99.08
	LRT00E450	No	0.25	-0.00026	-8.80	Very Likely Decreasing	98.75
	Whole Lake	No	0.23	-0.00039	-13.10	Very Likely Decreasing	99.08

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Measure	Site	Seasonal (Yes / No)	Proportion censored	Median Slope	Percent Annual Change	Trend	Confidence (%)
Ammonia (epilimnion)	LRT00E300	No	0.091	-0.000064	-0.30	Indeterminate	59.19
	LRT00E450	No	0.27	-0.00046	-6.54	Very Likely Decreasing	98.22
	Whole Lake	No	0.18	-0.00031	-2.82	Likely Decreasing	85.40
Total nitrogen (epilimnion)	LRT00E300	No	0	-00020	-0.32	Indeterminate	55.55
	LRT00E450	No	0	0.0086	1.38	Likely Decreasing	70.63
	Whole Lake	No	0	0.0036	0.57	Indeterminate	56.77
Nitrite/nitrate (epilimnion)	LRT00E300	No	0	-0.013	-2.78	Likely Decreasing	81.59
	LRT00E450	No	0.023	0.00063	0.14	Indeterminate	55.55
	Whole Lake	No	0.11	-0.0064	-1.36	Likely Decreasing	72.22
Secchi Depth	LRT00E300	No	0	-0.022	-1.02	Indeterminate	62.75
	LRT00E450	No	0	-0.036	-1.21	Likely Decreasing	77.61
	Whole Lake	No	0	-0.046	-1.70	Likely Decreasing	76.20

Note: Trends of high confidence are identified in red (degrading trend) or blue (improving trend)

4. Discussion

The Council undertook state of the environment monitoring at Lake Rotorangi on four occasions each year during the 2021-2024 period. The results of this monitoring are discussed here.

Over the three-year monitoring period, stratification in Lake Rotorangi varied between sites, seasons and years. Generally, with stratification, the lower layer, the hypolimnion, will be colder with lower dissolved oxygen levels than the top layer, the epilimnion. Anoxic conditions (where DO concentrations are less than $0.5g/m^3$) were noted on several occasions. All of the surveys which recorded DO concentrations during February and March found depleted dissolved oxygen near the lakebed. However, due to equipment issues, there were occasions where these measurements could not be taken.

Anoxic conditions in the lower hypolimnion have the potential to result in the release of nutrients from the lakebed sediments. The results from water samples collected from the water column near the lakebed show that the concentrations of ammoniacal nitrogen were elevated relative to the hypolimnion during many of the February and March sampling occasions. Nitrite/nitrate concentrations were elevated in the water column near the lakebed on one occasion, whereas there were no pronounced increases in DRP concentrations observed near the lakebed. It is unclear whether the increase in ammonia results from hypoxic nutrient release or simply occurs due to anoxia causing the reduction of nitrate in the water column to ammonia. A lack of hypoxic nutrient release would indicate that nutrient concentrations in the lakebed sediments remain relatively low (Burns 2006).

Lake water quality during the monitoring period was generally comparable to the long-term record, though there was notable inter-annual variability in the concentrations of some parameters. For total nitrogen, the 2021/22 annual median concentrations were close to, or exceeded the highest annual median concentrations previously recorded for each respective site and sampling depth. Annual median concentrations were comparable to their respective historic medians in 2022/23, and markedly lower than historic medians in 2023/24 (including the lowest annual median concentration on record for the hypolimnion at LRT000450). A similar pattern was observed for nitrate/nitrite concentrations and chlorophyll *a*. For chlorophyll *a*, a new maximum annual median concentration was recorded at LRT000300 in 2021/22, and the second lowest annual median concentrations were recorded at both sites in 2023/24. Total phosphorous and dissolved reactive phosphorous concentrations were not markedly elevated in 2021/22, however a number of phosphorous results in 2023/24 were equal to, or below, the lowest annual median concentrations previously recorded.

This inter-annual variability in key water quality parameters was also reflected in the Trophic Level Index (TLI) scores. In 2021/22, overall TLI scores exceeded, or were close to, the highest previously recorded at both sites. In 2022/23, TLI scores still exceeded the historic median at both sites but were comparable to previous results. In 2023/24, overall TLI scores were the lowest ever recorded at either site. These scores corresponded to the upper end of the eutrophic range in 2021/22, the lower end of the eutrophic range in 2022/23, and near the middle of the mesotrophic range in 2023/24. Historically, the TLI for Lake Rotorangi has tended to sit very close to the mesotrophic-eutrophic threshold.

Based on the assessment criteria set out under NOF in the NPS-FM, the concentrations of water quality parameters recorded during the monitoring period were indicative of varying levels of degradation or disturbance. It should be noted that these assessments do not strictly adhere to the data requirements set out in the NPS-FM (due to sampling frequency), and as such they should be interpreted as indicative gradings.

- Ammoniacal nitrogen concentrations fell within band A, corresponding to minimal toxicity impacts on aquatic life.
- Total nitrogen concentrations achieved band C, corresponding to moderate trophic impacts on aquatic life.

- Total phosphorous concentrations fell within band C at the upper lake site, and band B at the lower lake site. These grades correspond to moderate to low trophic impacts on aquatic life.
- Median chlorophyll *a* concentrations fell within band A at both sites, which indicates that lake ecological communities are healthy and resilient, similar to natural reference conditions. However, maximum concentrations only achieved bands C (moderately impacted) and B (slightly impacted) at the upper and lower lake sites, respectively.
- Lake bottom and mid-hypolimnetic dissolved oxygen concentrations at both sites fell within band D which is below the national bottom line, indicative of significant stress on fish species and the potential for nutrient release from lakebed sediments.
- *E. coli* concentrations achieved band A, corresponding to a low risk of infection arising from swimming and other water sports.

Long-term trend analyses found strong evidence of increasing (degrading) trends in total phosphorous concentrations. However, decreasing trends in dissolved reactive phosphorous concentrations were also observed. This would suggest that increases in total phosphorous may be associated with increasing suspended sediment loads related to soil erosion in the contributing sub-catchments. However, previous attempts to correlate total phosphorous with total suspended sediment have been inconclusive due to the high number of censored values (TRC, 2021). There is evidence of a long-term decreasing trend in Secchi depth, however, this is confounded by an increasing trend chlorophyll *a* concentrations, which will also be contributing to reduced visual clarity.

Long-term trend analyses also found strong evidence of decreasing (improving) trends in ammoniacal nitrogen concentrations, with a rate of annual change corresponding to -1.1% at the upper lake site, and -3.8% at the lower site. Similar decreasing trends have been observed at several long-term river water quality monitoring sites around the region (TRC, 2022). This may be associated with a reduction in point sources discharges over time, with dairy effluent and other wastewater discharges now transitioning to land. However, further analysis is needed to better understand the drivers behind these trends.

Long-term trend analyses of the lake trophic level index data found strong evidence of degrading trends at both lake monitoring sites. However, the rate of annual change is low, with an average increase in TLI of 0.2% per year.

Short-term trend analyses (covering the most ten-year period from 2014-2024) found no evidence of degrading trends across any of the eight water quality parameters assessed. The parameters with evidence of consistent long-term and short-term trend directions include DRP (improving over both time periods at both sites), ammonia (improving over both time periods at one site), total nitrogen (improving over both time periods at one site), and Secchi depth (degrading over both time periods at one site). The parameters with evidence of contrasting long-term and short-term trend directions include chlorophyll *a* (degrading to improving at all sites) and TP (degrading to improving at one site). The remaining combinations of sites and parameters showed evidence of a trend over one time period and were indeterminate over the other time period.

When comparing the April 2024 macrophyte survey results to the previous surveys, it is clear that the invasive Hornwort (*Ceratophyllum demersum*) has continued to spread throughout Lake Rotorangi. *C. demersum* is now the dominant macrophyte, with only one other macrophyte seen during the whole survey being *P. cheesmanii*. However, this was only found in a small density, approximately 1m^2. With this widespread abundance of *C. demersum* in Lake Rotorangi, which is popular for water sports, there is a risk of spread to other lakes where the effects may be severe. Appropriate warning signage regarding the potential problems caused by aquatic weeds and the responsibilities of recreational lake users are in place at the three principal boat ramps in Lake Rotorangi. These were updated in the 2015/16 monitoring year to include specific references to hornwort.

In 2022, RMA Science Ltd. developed the Simplified Contaminant Allocation and Modelling Platform (SCAMP) for Taranaki to estimate catchment contaminant loads and concentrations under a range of management scenarios relating to potential freshwater policy interventions (Cox et al. 2022). The SCAMP model estimates loads and concentrations of total nitrogen and total phosphorous at designated monitoring points, or nodes, in response to theoretical land use scenarios that are applied to the upstream catchment. Updates were carried out in 2024 to incorporate Lake Rotorangi into the model which enables the user to identify the major sources of contaminants entering the lake and estimate the relative loads under a range of theoretical scenarios (Cox 2024).

Total nitrogen and phosphorous loads entering Lake Rotorangi, and their respective sources, are estimated below in Table 16. Of note is the significant proportion of total nitrogen and phosphorus loads attributed to diffuse sources associated with land use. Based on these estimates, diffuse nitrogen losses from land where dairy farming occurs contributes more than 60% of the annual load of total nitrogen entering Lake Rotorangi, while diffuse phosphorus losses from land that is used for sheep and beef farming contributes approximately half of the annual load of total phosphorous.

Table 16 Estimated relative contributions of different sources of total nitrogen and total phosphorous to the overall loads entering Lake Rotorangi

Source	TN	TP
Native forest	1.6%	2.4%
Forestry	1.0%	1.0%
Dairy	62.9%	18.7%
Sheep and Beef	30.5%	50.5%
Urban	0.3%	0.3%
Observable Erosion P	n/a	20.0%
Point Sources	3.6%	7.0%

Note: Observable erosion P refers to the phosphorous that is generated through large scale erosion processes and is included in observed instream loads (see Cox et al. 2022 for further explanation).

Cox (2024) assessed a range of hypothetical management scenarios to determine water quality responses in Lake Rotorangi in order to support the development of the Council's Regional Land and Freshwater Plan (Table 17). Four scenarios were assessed, with the first two corresponding to the continuation of current management options promoted by Council (i.e. the riparian planting programme and redirecting dairy effluent discharges to land). Scenario three included a broad range of established mitigation options, generally accepted as good farm management practices. Scenario four included a range of developing mitigation options that are anticipated for wider uptake by the year 2035.

Table 17 Mitigation scenarios and estimated water quality responses in Lake Rotorangi (from Cox 2024)

Scenario	Lake Rotorangi water quality response (reduction in median concentration)
1. Eliminating all direct discharge of farm dairy effluent (FDE) into waterways (redirecting these discharges to land);	TN: -1% TP: -3% Chl *a*: -2%
2. Completion of the Riparian Management Programme (RMP), in addition to the removal of direct FDE discharges to waterways.	TN: -4% TP: -5% Chl *a*: -5%
3. 'Established' mitigation options (widely accepted good farm management practices), as at 2015 (see Monaghan et al. 2021)	TN: -10% TP: -11% Chl *a*: -11%
4. 'Established' and 'developing' mitigation options (including recently developed novel mitigation practices), anticipated for 2035 (see McDowell et al. 2021)	TN: -32% TP: -21% Chl *a*: -25%

In summary, greater water quality responses were observed progressively through scenarios one to four as the breadth of mitigation options increased. While the Council's riparian programme has been highly effective since commencing 1993, the extensive fencing and planting already established means that there is little room for further improvement (though the current auditing phase is expected to identify where opportunities for enhancing the effectiveness of existing fencing and planting can be achieved). These results highlight the importance of good land management practices to help mitigate impacts on downstream receiving environments.

5. Recommendations

The following recommendations are based on the results of the 2021-2024 water quality and biological monitoring programmes and the contractual requirements of the resource consents held by Manawa Energy Ltd for the Pātea Hydro Electric Power Scheme on Lake Rotorangi. It is recommended:

1. THAT the Lake Rotorangi physicochemical and biological water quality monitoring programme continues on an annual basis as a component of the Council's State of the Environment monitoring programme, with every third year of the programme also undertaken in conjunction with the Pātea Hydro Electric Power Scheme – aquatic monitoring plan (next scheduled for 2026/27).
2. THAT in the future, the Lake Rotorangi physicochemical and biological water quality monitoring programme continues to be reported on a triennial basis, in the year in which the triennial biological components are undertaken (next scheduled for 2026/27).

Glossary of common terms and abbreviations

anoxia	absence of dissolved oxygen (defined as dissolved oxygen concentrations less than $0.5g/m^3$)
aquatic macrophyte	water plants
benthic	bottom of lake
Secchi disc	measurement of visual clarity (metres) through the water (/vertically)
Chlorophyll *a*	productivity using measurement of phytoplankton pigment (mg/m^3)
DO	dissolved oxygen measured as g/m^3 (or saturation (%))
DRP	dissolved reactive phosphorus
E. coli	*Escherichia coli*, an indicator of the possible presence of faecal material and pathological micro-organisms. Expressed as the number of organisms per 100ml
epilimnion	lake zone above the thermocline (surface layer)
g/m^3	grams per cubic metre, and equivalent to milligrammes per litre (mg/L). In water, this is also equivalent to parts per million (ppm), but the same does not apply to gaseous mixtures
hypolimnion	zone below the thermocline in a stratified lake
L/s	litres per second
NH_4	ammonium, normally expressed in terms of the mass of nitrogen (N)
NO_3	nitrate, normally expressed in terms of the mass of nitrogen (N)
pH	a numerical system for measuring acidity in solutions, with 7 as neutral. Numbers lower than 7 are increasingly acidic and higher than 7 are increasingly alkaline. The scale is logarithmic i.e. a change of 1 represents a ten-fold change in strength. For example, a pH of 4 is ten times more acidic than a pH of 5
photic zone	upper section of lake penetrated by light
physicochemical	measurement of both physical properties (e.g. temperature, clarity, density) and chemical determinants (e.g. metals and nutrients) to characterise the state of an environment
plankton	small and microscopic plants and animals living in the water column
resource consent	refer Section 87 of the RMA. Resource consents include land use consents (refer Sections 9 and 13 of the RMA), coastal permits (Sections 12, 14 and 15), water permits (Section 14) and discharge permits (Section 15)
RMA	Resource Management Act 1991 and subsequent amendments
thermocline	zone of most rapid temperature change in stratified lakes
TLI	trophic level index, a method of measuring the trophic level of a lake
trophic level	amount of nutrient enrichment of a lake
water column	water overlying the lakebed

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Appendix I

Macrophyte survey results

To	Job Manager, Chania Hattle
From	Freshwater Scientist, Amirah Norhayati
Document	3266201
Date	23 April 2024

Macrophyte assessment surveys in Lake Rotorangi are currently undertaken every three years as a requirement of consent 0489-2 (commencing in 2012). Additional surveys have been carried out, dating back to 1987. The previous survey was conducted in April 2021 and the current survey was carried out on 16 April 2024. The survey was undertaken by three Taranaki Regional Council personnel under contract to Manawa Energy. The survey began at 08:30 at the Pātea dam boat ramp and concluded back at the boat ramp at 15:10 (NZST).

The true right of the lake was surveyed on the way to Mangamingi, while the true left of the lake was surveyed on the return to the Pātea dam. The survey was completed in collaboration with the South Taranaki Coastguard skippers and vessel. The boat travelled at approximately 10km/h, which was determined as a speed that allowed personnel to observe macrophytes, while also ensuring the survey was complete before it was too dark to continue. On occasions where there was uncertainty about a macrophyte identification, the boat was turned around to inspect macrophytes further. In addition to this, on occasion, a sample was collected to inspect closer. Larger arms of the lake were entered to identify the macrophytes present, while smaller arms were not entered when they were too shallow for boat access. Despite these arms making up a small proportion of the lake area, they are generally shallower than the main body of the lake and as such provide a disproportionately large habitat for macrophytes. In addition, the arms were more sheltered allowing for less disturbance, which may have influenced the macrophyte community. As macrophytes were passed, the species was called out by observers and this, as well as the location, which was obtained by a "Garmin InReach", was recorded. The dominant macrophyte species within each area were then colour-coded and mapped. Distributions of dominant macrophyte species are shown in Figure 1, with previous data displayed in Figure 2. This survey was carried out on an overcast day with little wind and no rain, which helped increase the ability for observers to see further below the surface of the lake. However, the northern side of the lake had higher turbidity, increasing the difficulty of seeing through the water column, and therefore some macrophyte species may have been disproportionately missed.

Based on Figure 2, there have been large changes in the Lake Rotorangi macrophyte community from when the surveys were first conducted in 1987. In the first survey, in 1987, *Lagarosiphon major* was the dominant species, with *Egeria densa* being the next most common. Following on from that, up until 2005, *E. densa* was noted as the most dominant species. In 2005 and 2008, *L. major* was the most dominant species, however, in 2012 it switched back to *E. densa*. Also in 2012, the macrophyte survey first picked up the highly invasive *Ceratophyllum demersum*, also known as hornwort. As predicted in a report prepared by NIWA (Wells 2012), the distribution of hornwort has increased markedly. In 2015, hornwort became more prolific and dominated the middle reaches of Lake Rotorangi, as well as being the only dominant species on the true left bank downstream of the Hāwera water ski club rooms. In 2018, hornwort was the dominant macrophyte in the upper reaches of the lake, however, it should be noted that although the 2018 survey recorded no macrophytes through the mid-section of the lake, it may have been present but obscured by high turbidity. In the previous survey (2021) hornwort was the dominant macrophyte throughout the entirety of the lake, with the exception of a small section at the northern end of the lake that was <2km in length, and in small sections down one arm on the east side of the lake, which were instead dominated by *E. densa*.

The current survey suggests that hornwort has taken over and has become the dominant species throughout the whole lake. Apart from hornwort, there was only one other macrophyte recorded in this year's survey, *Potamogeton cheesmanii*, a native pondweed (Table 1). However, *P. cheesmanii* was only found in a small density, approximately $1m^2$.

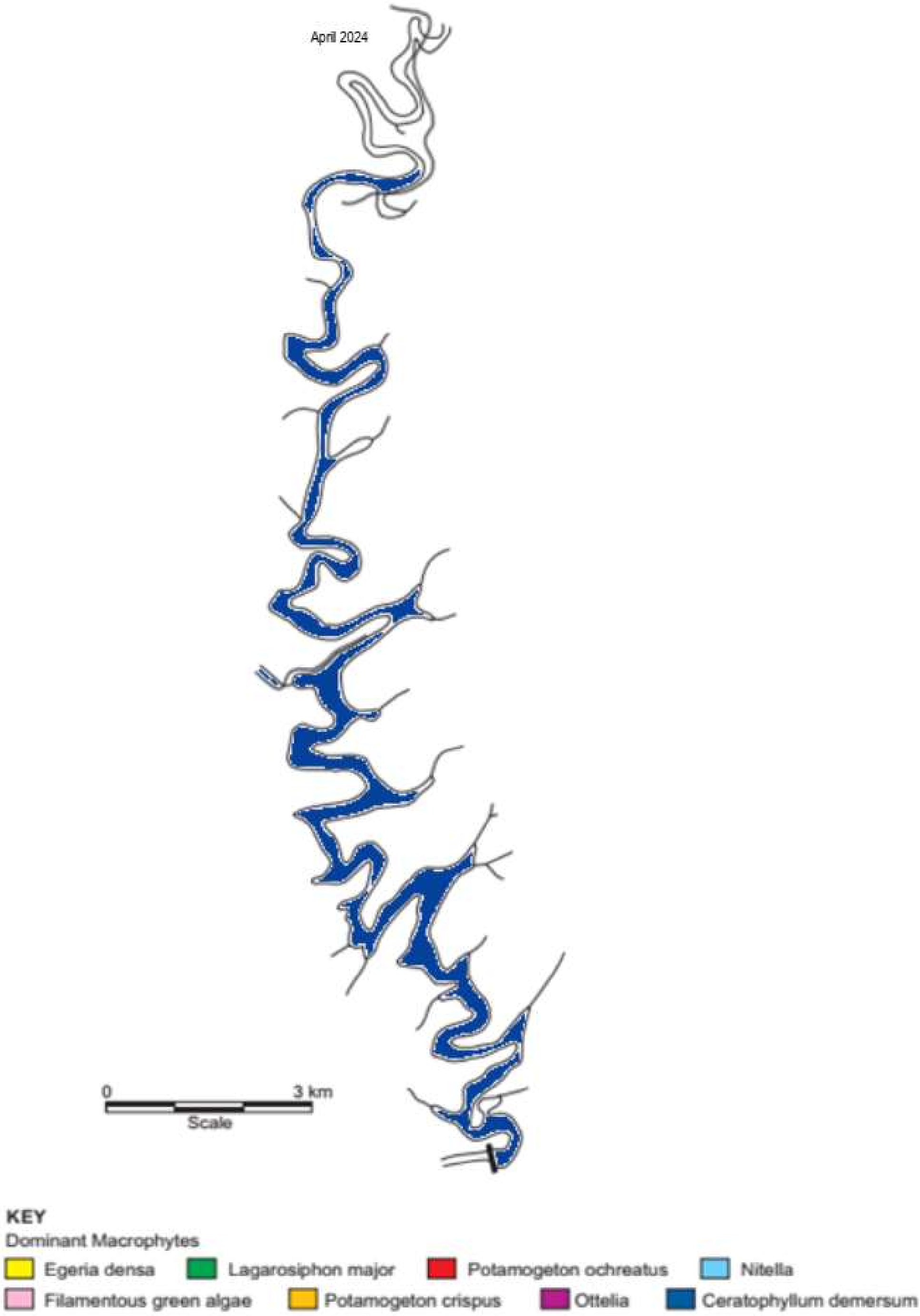


Figure 1	Dominant macrophytes recorded in Lake Rotorangi on 16 April 2024

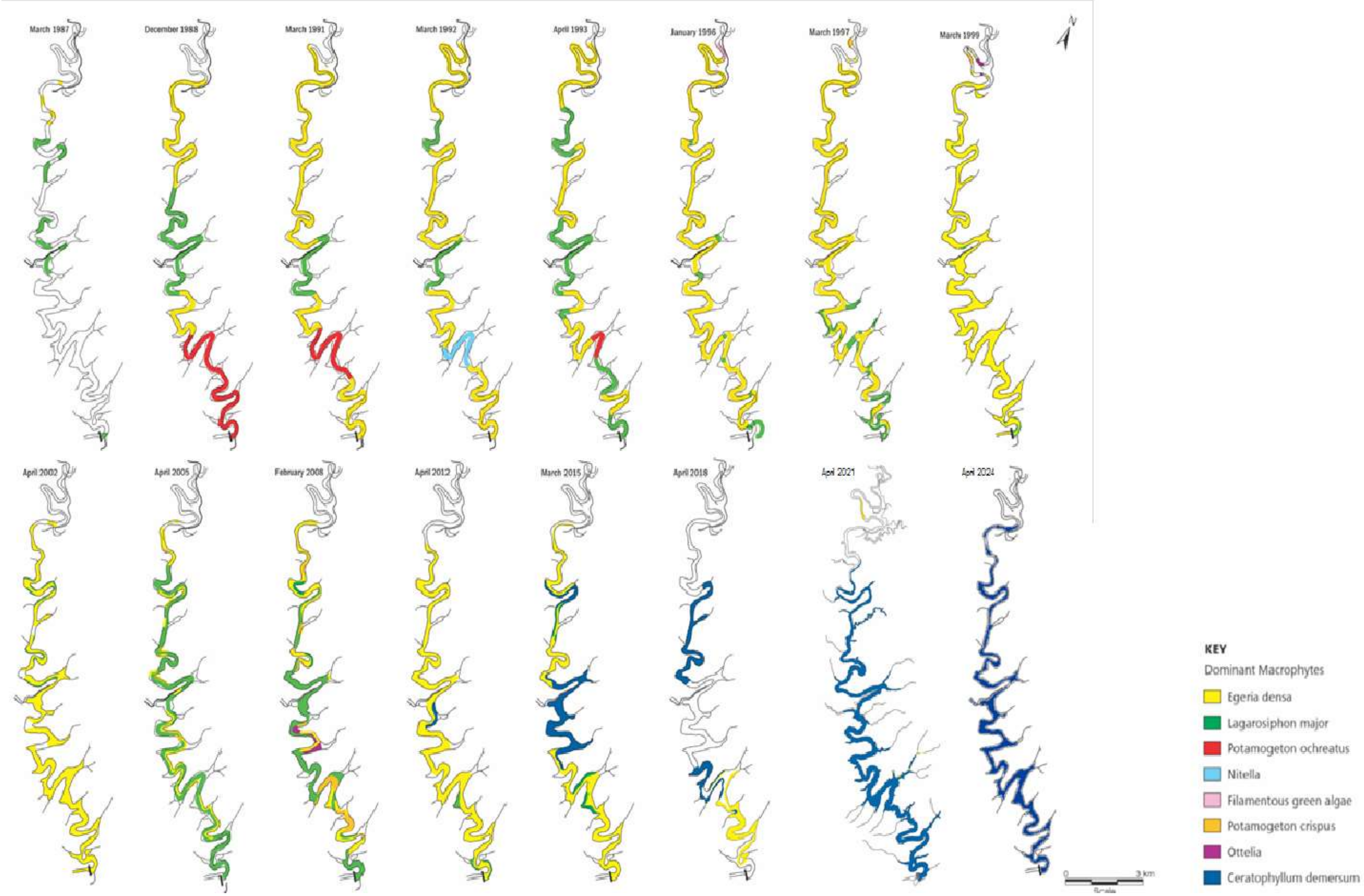


Figure 2 Dominant macrophytes recorded in Lake Rotorangi from 1987 to 2024

Actual coverage of macrophytes throughout the lake remains restricted to the edges of the lake and extends further into the middle of the lake only on the inside of large wide bends where shallow areas permit the spread of these macrophytes. In areas where the banks drop away quickly, the macrophytes have been previously recorded in patches rather than large continuous thick growths. However, the presence of *C. demersum* is causing this to change, as this species can grow taller and in deeper water than *E. densa* and L. major, enabling it to colonise more of the lakebed. NIWA state that *C. demersum* can grow >10m in depth, and there have been reports from Wells et al. of *C. demersum* growing up to 14.5m, and, based on the DOC website (2022), *C. demersum* has been observed growing in water as deep as 16m. Despite this, in the areas with the steepest banks, there are still patches of lakebed clear of macrophytes.

A summary of the aquatic macrophyte species found in Lake Rotorangi in the summer-autumn surveys performed between 1986 and 2021 is presented in Table 1.

Table 1 Aquatic macrophytes recorded in Lake Rotorangi between 1986 and 2024.

Species	Date																
	Mar 86	Mar 87	Dec 88	Mar 91	Mar 92	Apr 93	Jan 96	Mar 97	Mar 99	Apr 02	Apr 05	Feb 08	Mar 12	Mar 15	Apr 18	Apr 21	Apr 24
Aponogeton distachyon	✓	✓															
Ceratophyllum demersum													✓	✓	✓	✓	✓
Chara australis													✓*				
Egeria densa	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	
Elodea canadensis												✓					
Glossostigma elatinoides													✓	✓	✓		
Lagarosiphon major	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	
Lilaeopsis ruthiana													✓*				
Nasturtium officinale						✓											
Nitella cristata													✓*				
Nitella hookeri					✓											✓	
Ottelia ovalifolia				✓		✓			✓	✓	✓	✓		✓			
Potamogeton cheesmanii	✓	✓	✓														✓
Potamogeton crispus	✓	✓		✓		✓		✓		✓	✓	✓		✓			
Potamogeton ochreatus				✓	✓	✓										✓	
Potamogeton pectinatus	✓	✓															
Filamentous green algae				✓	✓	✓	✓		✓	✓	✓		✓	✓			

* Recorded by NIWA in April 2012

A total of 16 aquatic macrophytes have been recorded in Lake Rotorangi over the 38-year record. The introduced *E. densa* and *L. major* have been the most commonly observed macrophytes, both of which were not observed in the current survey. Another species frequently recorded is *Potamogeton crispus*, with this species even dominating parts of the lake in 2008. However, in the 2015 survey, this species was recorded only at the head of the lake, and not in abundance. It has not been recorded in the most recent two surveys. *Potamogeton ochreatus* was recorded in the previous survey, although this was only noted in one small patch and was not dominant in any part of the lake. Similarly, *Potamogeton cheesmanii,* was recorded in the current survey, but only in a small patch, and it was not dominant. However, it is important to note that just because no other macrophyte species were identified, it does not mean they were not present.

Some species may be present in small densities that are easy to miss, or some species may not reach as high in the water column making them more difficult to observe. However, personnel took precautions to ensure accuracy by travelling at slow speeds and sampling on a day with suitable weather conditions i.e.

with no rain and little wind, to ensure the water surface remained unbroken and reasonably flat, which increased clarity. There were also three observers on the boat to maximise the certainty of noticing any other macrophyte species. In addition, personnel stopped at small inlets to observe macrophyte species. Large amounts of debris, including fragmented macrophytes, logs, and rubbish were observed in these small inlets (as seen in Figure 3). These fragments allowed us to see what other species may be present in the lake. However, the only macrophyte observed in these inlets was hornwort.

Figure 3 Small inlet where debris washes in, and extra stops were made to investigate the macrophyte species

While on the survey, marginal edge wet-adapted species were also observed, these included:

- *Persicaria* Spp. (exotic)
- *Juncus* Spp. (exotic)
- *Carex* Spp. (all species were natives)
- *Juncus articulates* (exotic)
- *Callitriche* Sp. (likely the invasive species Callitriche brutia var. hamulata) (exotic)
- *Salix fragilis* × *S. euxina* Crack willow (exotic)
- *Cyperus ustulatus*
- *Isolepis prolifera*
- *Hesperantha coccinea* Scarlet river lily (exotic)
- *Typha orientalis* Raupō

The Department of Conversation (DOC) collected environmental DNA (eDNA) samples from Lake Rotorangi on 8 February 2023. This picked up a strong signal of hornwort at all six sample locations. There were also other aquatic plants detected including *E. densa*, which had a weak signal in one sample. *Glossostigma elatinoides*, a small mud mat that is popular in the aquarium trade, but native to New Zealand was also detected in a weak signal at one location. *Lotus* was also detected in a weak signal but at two locations. To reduce eDNA sample contamination, DOC personnel used a 10% bleach solution on gear, as per the Wilderlab guidelines. It is important to note, that there may be contamination of DNA through vessels entering Lake Rotorangi from other waterways, as they do not go through the same thorough decontamination process carried by DOC. Conversely, although eDNA is a great tool for assessing the presence of species, it is unlikely it will pick up every species in a water way.

In the current survey, two fish species, rudd (*Scardinius erythrophthalmus*) and *Perca fluviatus* (Perch) were also seen. Approximately 50 rudd and 20 perch were seen, which would have been a very small proportion of the actual lake population. The distribution of *Potamogeton* spp. may be influenced by the large rudd population in the lake. A 2002 study by Lake et al. found that rudd preferred grazing on *P. ochreatus* over *E. densa* and *L. major*, while *C. demersum* was least preferred. Although *P. crispus* was not included in this study, its similarities to *P. ochreatus* indicate that it also would be preferentially consumed by rudd, explaining the reduced abundance of *Potamogeton* spp. in Lake Rotorangi in recent years.

A survey undertaken by NIWA in 2012 recorded four macrophyte species that had not previously been recorded in Lake Rotorangi. It is unlikely that these species were new additions to the lake. Rather, these species were either not widespread or had growth habits that caused them to be relatively discreet e.g. low-growing plants that inhabit deep water. These species were only recorded when the boat was stationary (*G. elatinoides*) or by divers (*C. australis, L. ruthiana and N. cristata*). It is unlikely that these species will ever become abundant.

C. demersum is considered highly invasive, and as predicted by NIWA (Wells, 2012) has become dominant in the lake. Extensive weed beds like the ones seen in the current survey can result in deoxygenated water, which can then cause nutrient release from the lake bottom. However, Lake Rotorangi has steep littoral gradients, meaning that this deoxygenating process is less likely to occur. However, this deoxygenation of the lake bottom and nutrient release is a possibility for surrounding lakes that have a high risk of hornwort being spread to. In addition, Wells (2012) stated that hornwort may displace native submerged vegetation, which is evident through the current survey results.

Already in 2012, Wells stated that hornwort was too widespread in Lake Rotorangi to the point where containment and eradication were no longer possible. However, they did state that grass carp could be a viable option if they were contained above the dam. But otherwise, the herbicide diquat would be the best option for aquatic weed control. However, Wells (2012) states that spray results should be monitored one month after treatments so the efficacy of the treatment is recorded. Another recommendation was that there should be control around the boat ramps to reduce the spread to surrounding water bodies.

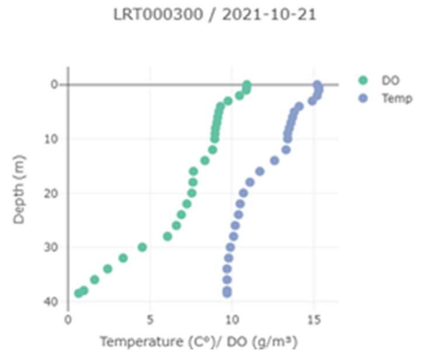
With the increased prevalence of hornwort at Lake Rotorangi comes a greater potential for spread to nearby lakes where impacts could be much more severe. In 2021, hornwort was recorded in Lake Herengawe, south of Lake Rotorangi, for the first time. Considering the proximity of Lake Rotokare to the Glen Nui boat ramp, it may be worthwhile controlling *C. demersum* in the vicinity of the Glen Nui boat ramp to help prevent its spread. The usefulness of this may be subject to further investigation. In addition, the use of better signs may encourage recreational water users to take steps to prevent the transfer of hornwort. Wells (2012) also says that hornwort near boat ramps will increase the ability of it to spread to other lakes.

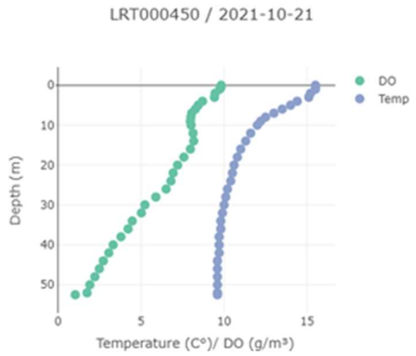
Overall, it is clear that hornwort has increased dramatically since 2012 and is now the dominant macrophyte in Lake Rotorangi. Hornwort negatively impacts the hydroelectric power scheme and can spread to surrounding lakes and dominate the macrophyte communities resulting in negative ecological implications. Although eradicating hornwort in Lake Rotorangi is no longer feasible, steps should be taken to mitigate the spread to surrounding water bodies.

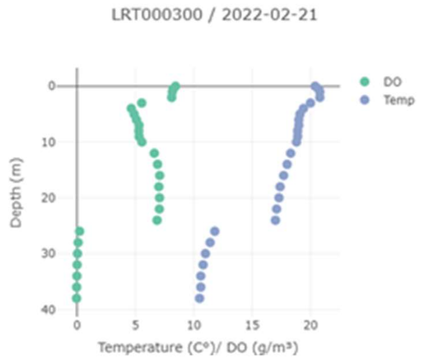
Appendix II

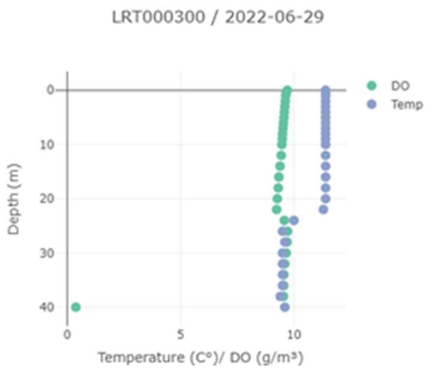
Depth profiles

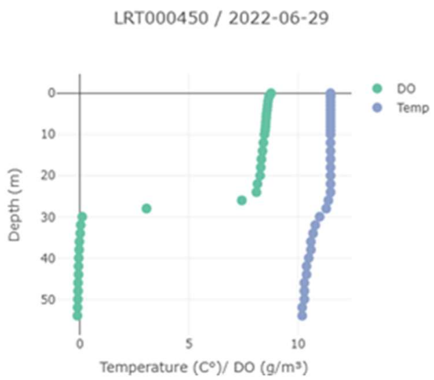
Depth profiles of dissolved oxygen and temperature (2021/22)



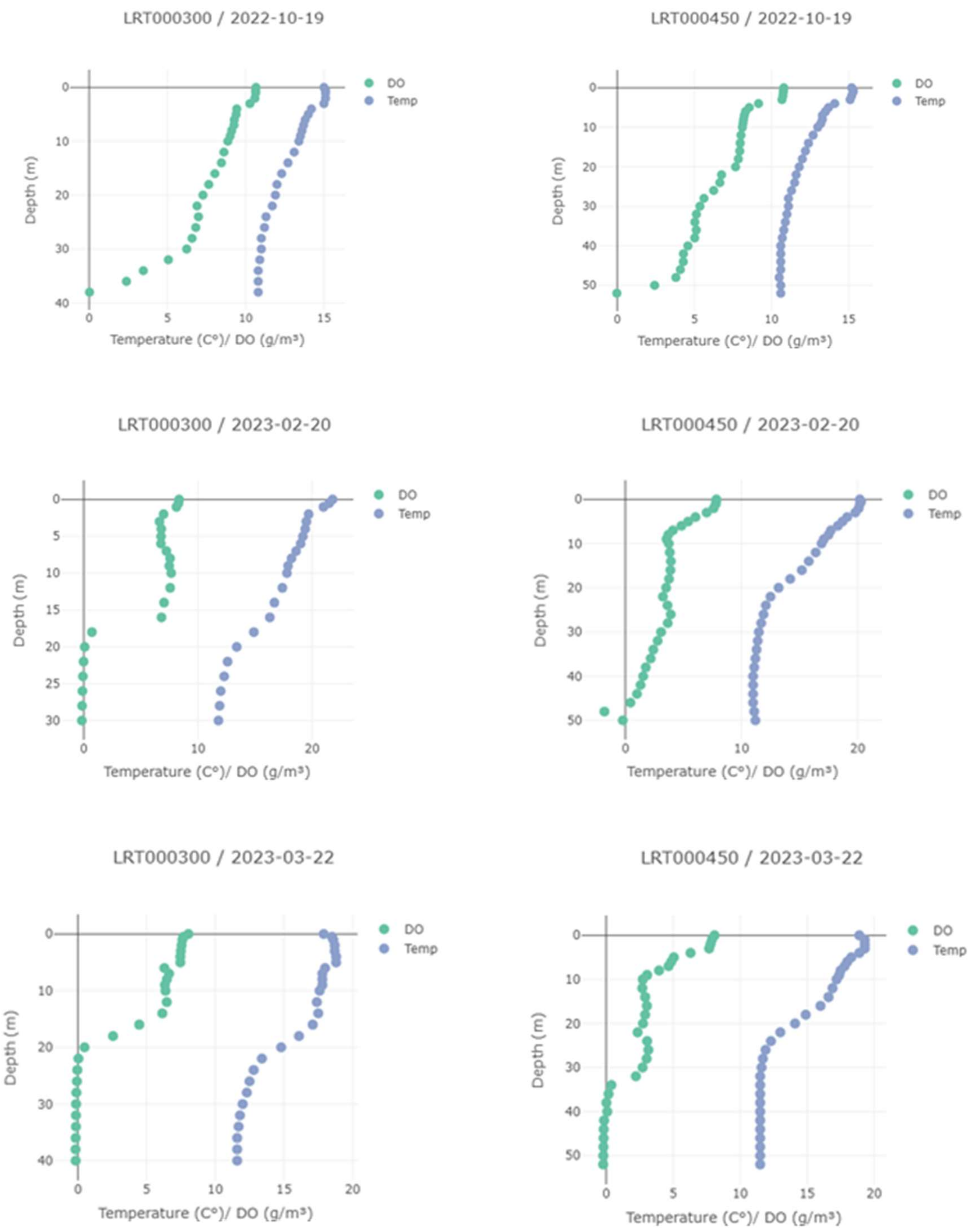


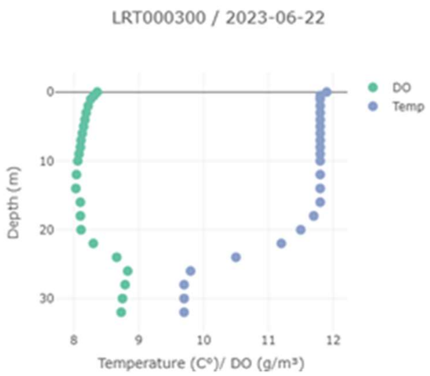


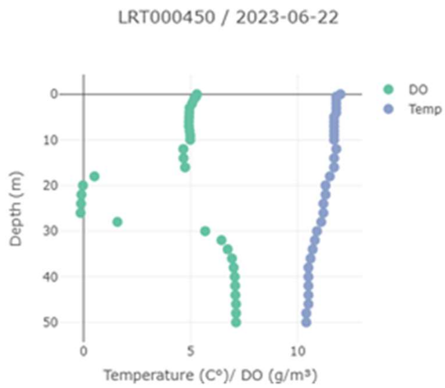




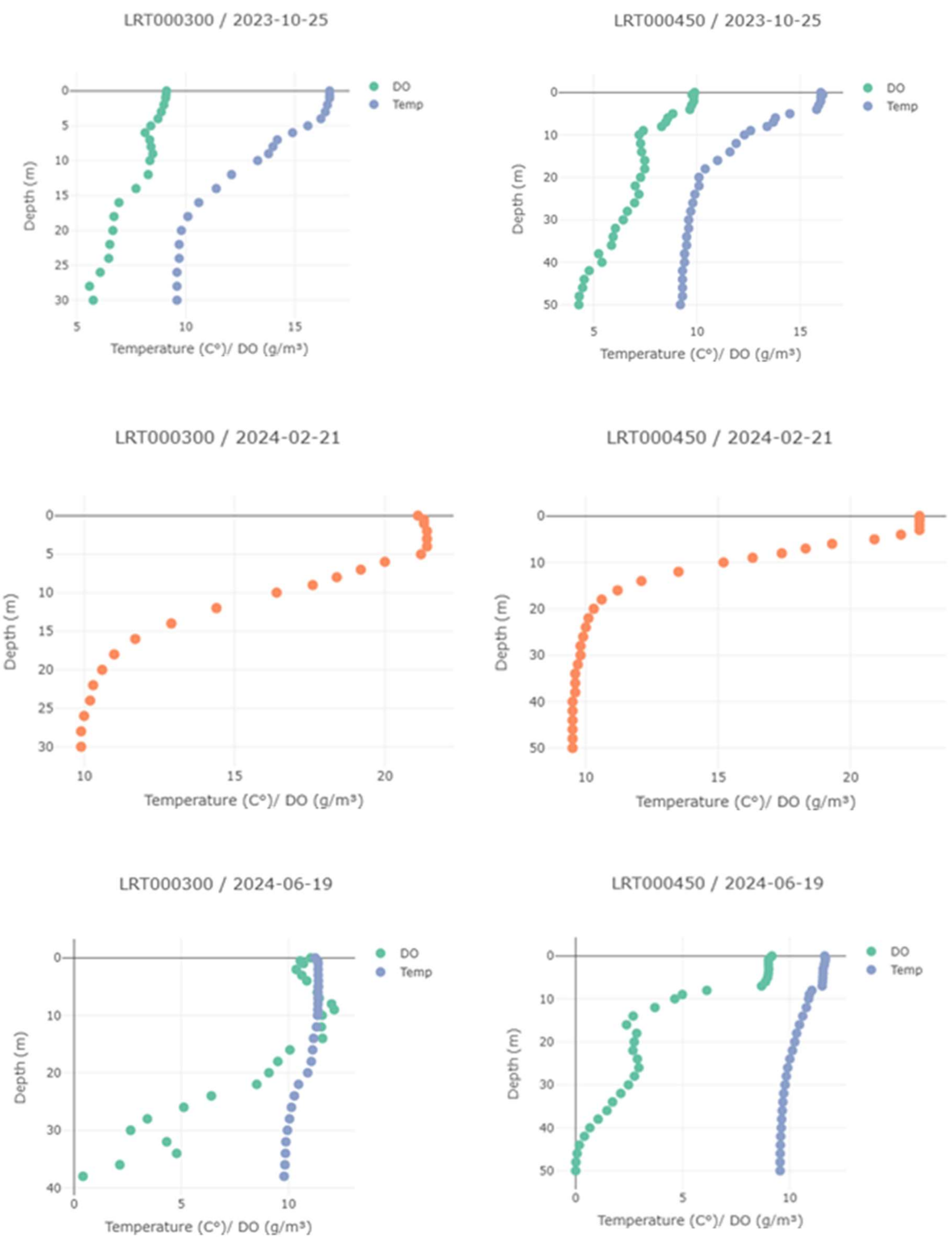
Depth profiles of dissolved oxygen and temperature (2022/23)




LRT000300 / 2023-06-22
DO
Temp
Depth (m)
Temperature (C°)/ DO (g/m³)
0
10
20
30
8
9
10
11
12


LRT000450 / 2023-06-22
DO
Temp
Depth (m)
Temperature (C°)/ DO (g/m³)
0
10
20
30
40
50
0
5
10

Depth profiles of dissolved oxygen and temperature (2023/24)



Appendix III

Summary of current water quality results and long-term statistics

Parameter	Site	Sampling depth	Previous annual median minima	Previous annual median maxima	Long-term annual median	2021/22 annual median	2022/23 annual median	2023/24 annual median
Total nitrogen (g/m^3)	LRT000300	Epilimnion	0.30	0.99	0.61	0.93	0.66	0.48
		Hypolimnion	0.65	0.97	0.77	**0.98**	0.77	**0.65**
	LRT000450	Epilimnion	0.45	0.84	0.56	**0.88**	0.63	**0.41**
		Hypolimnion	0.40	0.88	0.73	0.84	0.81	0.64
Nitrite/ nitrate (g/m^3)	LRT000300	Epilimnion	0.16	0.69	0.33	0.57	0.40	0.20
		Hypolimnion	0.07	0.79	0.53	0.70	0.48	0.51
	LRT000450	Epilimnion	0.17	0.58	0.329	**0.58**	0.41	0.23
		Hypolimnion	0.21	0.77	0.61	0.71	0.66	0.51
Ammoniacal nitrogen (g/m^3)	LRT000300	Epilimnion	0.0068	0.027	0.014	0.014	**0.0053**	0.014
		Hypolimnion	0.0022	0.110	0.029	0.018	0.022	0.0032
	LRT000450	Epilimnion	0.001	0.028	0.0083	0.0059	0.0024	0.0033
		Hypolimnion	0.0003	0.015	0.0017	0.0006	0.0011	0.00065
Total phosphorous (g/m^3)	LRT000300	Epilimnion	0.012	0.068	0.022	0.028	0.027	0.019
		Hypolimnion	0.014	0.11	0.022	0.023	0.031	**0.011**
	LRT000450	Epilimnion	0.010	0.050	0.018	0.025	0.020	**0.010**
		Hypolimnion	0.010	0.076	0.017	0.017	0.019	**0.008**
Dissolved reactive phosphorous (g/m^3)	LRT000300	Epilimnion	0.0002	0.009	0.0051	0.0043	0.0018	0.0018
		Hypolimnion	0.0033	0.013	0.0073	0.0041	0.0059	**0.0026**
	LRT000450	Epilimnion	0.0002	0.011	0.0037	0.0042	0.0017	**0.0002**
		Hypolimnion	0.0006	0.012	0.0059	0.0058	0.0054	0.003
Secchi depth (m)	LRT000300	Surface	0.72	3.9	2.54	1.46	1.15	2.48
	LRT000450	Surface	0.43	4.42	3.2	1.40	1.73	3.35
Chlorophyll a (mg/m^3)	LRT000300	Photic zone	1.25	5.05	2.48	**5.57**	3.60	**1.05**
	LRT000450	Photic zone	1.25	8.70	2.23	2.09	2.40	1.35
E. coli (per 100mL)	LRT000300	Surface	<1	184	21	26	13	18
	LRT000450	Surface	1	6	4	5	**9**	2
TLI	LRT000300	n/a	3.98	4.93	4.17	**4.94**	4.48	**3.80**
	LRT000450	n/a	3.73	4.97	3.98	4.62	4.20	**3.40**

Note: Colours denote annual median results in the current monitoring period that exceeded, or were equal to the lowest (blue) or highest (orange) annual medians previously recorded. TLI is calculated as an annual average score, not an annual median.

MEMORANDUM
Policy & Planning

Date: 4 February 2025

Subject: **Awatuna Constructed Wetland**

Author: C Pickford, Team Leader - Environmental Data

Approved by: AJ Matthews, Director - Environment Quality

Document: TRCID-1492626864-225

Purpose

1. The purpose of this memorandum is to provide the Committee with a summary of findings following the conclusion of an investigation 'Contaminant reduction performance of constructed wetlands intercepting farm runoff', which included the Awatuna Constructed Wetland in Taranaki.
2. This investigation was overseen by NIWA, in partnership with councils, rural industry groups and farmers; and funded by a four-year MPI Sustainable Land Management and Climate Change (SLMACC) Freshwater Mitigation contract 406368 'Quantifying constructed wetland contaminant attenuation' from July 2020 to June 2024.
3. A copy of the final report, along with an output of the project: the 'Constructed Wetland Practitioner Guide: Design and Performance Measurements', developed by DairyNZ and NIWA, is included as an attachment to this agenda memorandum.

Recommendations

That the Taranaki Regional Council:

a) receives the report titled Awatuna Constructed Wetland, and accompanying documentation
b) notes the findings of this investigation.

Background

4. Diffuse-source contaminants from agricultural land-use, including sediment, nutrients, and bacteria from faecal material degrade water quality and present a significant challenge to maintaining and improving freshwater throughout Aotearoa New Zealand. Addressing diffuse-source discharges is a key focus for the Council as it develops its Proposed Regional Land and Freshwater Plan.
5. Council is currently investigating potential management approaches and mitigation measures to help achieve targets for freshwater improvement. To ensure farmers and landowners are equipped with knowledge and information, the Council has partnered with scientists, industry groups and farmers to investigate a range of interceptive eco-technologies. Constructed wetlands are one possible mitigation measure, designed to intercept and treat farm runoff before contaminants enter waterways.
6. NIWA, supported by funding from MPI, has recently concluded a nationwide project, supported by several regional councils, rural industry groups and farmers, to better quantify the ability of constructed wetlands to reduce contaminant loads by intercepting farm runoff.

7. Awatuna Constructed Wetland, one of the project's four constructed wetland reference sites, was one of the first such reference sites to be built in Taranaki. Intensive monitoring of constructed wetland performance at these sites has recently concluded and NIWA has now published their findings, with an overview provided below.

Discussion

8. The Awatuna Constructed Wetland was established on Donna and Philip Cram's dairy farm in South Taranaki over the summer of 2019/20. NIWA designed the wetland and provided flow and water quality monitoring instrumentation, with funding provided by DairyNZ to support its installation. Co-funding from the Council's 'Wetland Consent Fund' supported aerial surveys, weir construction, earthworks, wetland plants and sample analysis.
9. Design of the wetland began in 2019/20. This was predominantly a quantity surveying exercise, mapping out and repurposing an area of marginally productive pasture for the construction of the wetland. Initial establishment of the constructed wetland was supported by the Land Management and River Management teams, with ongoing monitoring and site maintenance carried out by Council's Environmental Data team.
10. Prior to construction, Council staff consulted with Te Korowai o Ngāruahine on wetland design aspects, including impacts on fish and koura and incorporation of local plant species into the wetland planting, throughout the resource consenting process.
11. Construction began in June 2020. Contractors were employed to build a multi-cell, surface flow constructed wetland, with each cell separated by a rock weir (Figure 1).

Figure 1 Awatuna Constructed Wetland viewed from upstream looking downstream.

12. Each wetland cell serves to firstly capture sediment in an initial 1.5m deep pond, then successively absorb nutrients as flows travel through the shallow (0.3-0.6 m deep), densely vegetated wetland cells. The wetland has an internal wetted area of 0.44 hectares, approximately 2.3% of the 18 ha dairy

catchment that flows into the wetland. Inflows are primarily via a surface drain fed by sub-surface drainage, groundwater and storm runoff. The wetland discharges to an unnamed tributary of the Oeo Stream.

13. During construction the Councils' Environmental Data (ED) team, in consultation with NIWA, designed and installed V-notch weirs at the inlet and outlet of the wetland for the purpose of capturing continuous flow, nitrate and turbidity levels. These measures of flow, contaminants and sediment would ultimately help determine the performance of the wetland.
14. The wetland was planted out with native wetland grasses under the guidance of the Councils Land Management and Biodiversity teams, in consultation with Ngāruahine Iwi.
15. Continuous monitoring instrumentation was installed by NIWA and Council staff directly above the V-notch weirs at the inlet and outlet of the wetland. Each site, upstream and downstream, consisted of a stilling well, optical sensors and autosamplers. Water levels were measured at each stilling well; as the V-notch weir is a calibrated structure we were able to determine flow using level information only. Optical sensors measured nitrate and turbidity (a water clarity measure of which suspended sediment is a proxy). Autosamplers were also deployed to take discrete samples which were then sent to a laboratory for analysis to validate the instrumentation. The upstream site also had a rain gauge installed to quantify rainfall. The performance of the wetland was assessed using suspended sediment (SSC), total phosphorus (TP), dissolved reactive phosphorus (DRP), total nitrogen (TN), nitrate-N, ammonium-N, and the faecal indicator bacteria *Escherichia coli*. Data were obtained from continuous monitoring instrumentation, autosamplers and spot sampling by Council staff, and analysed by NIWA.
16. During the next four years, continuous data from these sites was telemetered to the Council and NIWA every 30 minutes, enabling remote checks on performance and the identification of possible problems. The Councils ED team maintained the instrumentation and assured data quality with fortnightly visits during this entire time. Supplementary discrete measures and observations of wetland performance were provided by the Environmental Assurance and Biodiversity teams.
17. This investigation concluded in July 2024, although monitoring at Awatuna has continued until just recently to complete a further full season of data collection. NIWA presented their findings following analysis of the collected data. Results are presented in the final report and summarised below, with Table 1 providing a summary of the four constructed wetlands included in the investigation, including Awatuna. It is important to note the relative wetland area as a percentage of the catchment it serves.

Table 1 Summary of wetland and catchment area, percent shallow vegetated zones, and main flowpaths intercepted at the SLMACC constructed wetlands.

Parameter	Awatuna	Fish Creek	Maniatutu	Pongakawa
Wetland area (ha)	0.44	0.32	1.92	1.01
Catchment area at outflow (ha)	19.34	26.25	71.32	48.71
Wetland size as a proportion of catchment area (%)	2.3	1.2	2.7	2.1
Vegetation coverage within wetland (%)	70	60	70	80
Month and year wetland planted	Feb 2020	Nov 2020	Mar 2022	Mar 2022
Type of wetland configuration	On-line	On-line, internal high flow bypass	On-line, internal high flow bypass	On-line
Main flowpaths intercepted	Subsurface & surface drainage & groundwater	Surface runoff & groundwater	Surface drainage	Groundwater & drain floods
Catchment land-use	Dairy	Dairy	Dairy, Kiwifruit	Kiwifruit, Maize, Dairy

18. Table 2 compares load reduction performance of the four constructed wetlands in comparison with the modelled load reduction which this investigation seeks to quantify. These results support modelled predictions and clearly illustrate how load reduction is directly related to wetland size in relation to the catchment area. Essentially the larger the wetland area relative to the catchment area served the greater the load reduction achieved.

Table 2 Comparison of SLMACC constructed wetland load reduction performance. Modelled predictions are shown in parentheses.

Parameter		Fish Creek CW catchment ratio 1.2%	Pongakawa CW cathment ratio 2.1%	Awatuna CW catchment ratio 2.3%	Maniatutu CW catchment ratio 2.7%
Total Nitrogen	Avg %	29 (26)	39 (36)	35 (38)	75 (42)
	Range %	27-33 (22-34)	13-70 (30-44)	28-47 (32-46)	75 (34-50)
Total Phosphorus	Avg %	16 (28)	90 (36)	41 (38)	86 (40)
	Range %	12-19 (20-36)	77-99 (25-46)	9-62 (26-48)	86 (27-52)
Suspended Sediment	Avg %	33 (52)	1 (66)	12 (66)	3 (73)
	Range %	13-55 (35-80)	1 (45-99)	4-18 (48-95)	3 (51-99)

19. This investigation found that the average removal rate of total nitrogen achieved by the Awatuna Constructed Wetland was very close to what would be expected for a wetland of this size in this type of climate (35% based on the investigation compared to 38% based on the previous model). The range of performance was also very similar to what was modelled. The three other constructed wetlands achieved an average removal rate of total nitrogen of between 29 and 42%.
20. The average removal rate of total phosphorus was also very similar to what had been modelled previously (41% and 38%, respectively). However, the range of performance was more variable than what was expected. The other three wetlands achieved an average removal rate of total phosphorous of between 16 and 90%.
21. For suspended sediment, the average removal rate was much lower than expected (12% compared to 66%). It should be noted that relatively small amounts of sediment were intercepted by the wetlands during the study period, particularly during dry years. As a result, the overall range of performance observed during the investigation was lower than predicted.
22. Load reduction performance of the constructed wetland should not be considered in isolation. It is important to also consider the absolute yields and removal rate of these contaminants. It is this measure that affects the mass balance of the system and demonstrates the overall mass of different contaminants that are prevented from entering our waterways. This is shown in Table 3.

Table 3 Annual summary of catchment specific yields and wetland performance standardised by catchment area for TN, TP, and SS

Parameter	Awatuna		
	2021-2022	2022-2023	2023-2024
Total Nitrogen			
Combined catchment N yield (kg ha y)	37.6	38.1	16.4
TN load removal efficiency (%)	47%	34%	28%
Annual TN mass balance removal rate per ha of catchment (kg ha)	17.7	13.0	4.6
Total Phosphorus			
Combined catchment TP yield (kg ha y)	1.3	0.6	0.5

Parameter	Awatuna		
	2021-2022	2022-2023	2023-2024
TP load removal efficiency (%)	62%	9%	52%
Annual TP mass balance removal rate per ha of catchment (kg ha)	0.8	0.06	0.2
Suspended sediment			
Combined catchment SS yield (kg ha y)	224.9	247.2	140.5
SS load removal efficiency (%)	15%	4%	18%
Annual SS mass balance removal rate per ha of catchment (kg ha)	35.7	9.9	25.3

23. Several factors affect the performance of constructed wetlands in their ability to remove contaminants. This includes changes in farm practice which directly affects the yield of contaminants, hydrological conditions including rainfall rate, flow rate / residence time in the wetland, climate including La Niña versus El Niño weather patterns, vegetation cover and vegetation maturity.

24. In addition to the ability of wetlands to intercept and treat diffuse farm runoff it is important to note that there are many associated benefits to the establishment of wetlands. Wetlands provide a habitat for many native flora and fauna to thrive, and they also add to the natural beauty of the landscape (Figure 2).

Figure 2 Awatuna constructed wetland and Phil's pier

25. As valuable data continued to be collected, useful resources were compiled to guide landowners in the establishment of their own constructed wetlands. The 'Constructed Wetland Practitioner Guide' developed by DairyNZ and NIWA is freely available to interested parties. A copy is included as an attachment to this agenda memorandum.

26. This study demonstrates that the establishment of constructed wetlands remains a viable mitigation measure in helping reach freshwater targets. The wetland continues to be used as a demonstration site for rural landowners and catchment community groups in Taranaki.

Financial considerations—LTP/Annual Plan

27. This memorandum and the associated recommendations are consistent with the Council's adopted Long-Term Plan and estimates. Any financial information included in this memorandum has been prepared in accordance with generally accepted accounting practice.

Policy considerations

28. This memorandum and the associated recommendations are consistent with the policy documents and positions adopted by this Council under various legislative frameworks including, but not restricted to, the Local Government Act 2002, the Resource Management Act 1991 and the Local Government Official Information and Meetings Act 1987.

Climate change considerations

29. The current extent and condition of wetlands in Taranaki, and their effectiveness at intercepting nutrients may be affected by climate change in the future, particularly in relation to changing hydrological conditions. We are considering these potential impacts as part of our State of the Environment monitoring and reporting, and policy development programmes.

Iwi considerations

30. This memorandum and the associated recommendations are consistent with the Council's policy for the development of Māori capacity to contribute to decision-making processes (schedule 10 of the Local Government Act 2002) as outlined in the adopted Long-Term Plan and/or Annual Plan.
31. Council sought input from Te Korowai o Ngāruahine on various aspects of the design of the Awatuna Constructed Wetland during the resource consenting process.

Community considerations

32. This memorandum and the associated recommendations have considered the views of the community, interested and affected parties and those views have been recognised in the preparation of this memorandum.

Legal considerations

33. This memorandum and the associated recommendations comply with the appropriate statutory requirements imposed upon the Council.

References

Goeller B, Tanner C, McKergow L, Vincent A, Sukias J, Robb J, Corkery M, Wright L, Scott K, Butler P. 2024. *Contaminant reduction performance of constructed wetlands intercepting farm runoff: SLMACC Freshwater Mitigation project 406368*. Technical paper No. 2024/26 prepared for Ministry of Primary Industries by NIWA.

Appendices/Attachments

Document TRCID-1492626846-227: Constructed Wetland Practitioner Guide: Design and Performance Measurements.

Document TRCID-1492626864-226: Contaminant reduction performance of constructed wetlands intercepting farm runoff: SLMACC Freshwater Mitigation project 406368.

Constructed Wetland Practitioner Guide

Design and Performance Estimates

NIWA Taihoro Nukurangi

DairyNZ

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1. Getting started

Steps to develop a constructed wetland

1. Consider your goals.

Is nitrogen a big problem in your catchment or is it phosphorus? Do you need to control sediment or slow flood flows? Do you want to improve the aesthetics or biodiversity of your farm, support a particular native species, or connect better with mana whenua? Is a good duck hunting site one of your motivations?

2. Find the expertise you need.

Some organisations offer support for wetland development. Your regional council's land or freshwater management team is a good place to start. Landcare Trust, DairyNZ, Fish and Game or your farm advisor may also be able to help. A good digger driver and nursery that can supply appropriate plants will also be important for a successful project.

3. Identify the location and a basic design concept.

This will give you a good starting point. If you haven't already, connecting with local iwi at this point is a good idea. There may be local considerations or important species to look out for.

4. Check on consenting requirements.

You may need a consent, or ideally, you may be able to avoid triggering one. Some examples of potential triggers for a consent include proximity to watercourses and natural wetlands; the amount of soil you are moving; fish passage requirements; and mana whenua concerns.

5. Develop a detailed plan and costing.

By this point you'll know how big the job is, labour requirements and expertise needed. If you are employing someone to construct your wetland, involve them early to ensure your goals are met.

2. About this guide

Purpose

This guide provides design and performance information for people wanting to establish a surface-flow constructed wetland to specifically reduce contaminant loss (nitrogen, phosphorus and sediment) from subsurface tile drains, shallow groundwater outflows from seeps and springs, and surface drains and small streams in pastoral farming landscapes. Wetlands can also provide a wide range of other benefits, including flood management and habitat for birds, fish, invertebrates and plants. They also enhance the natural beauty of farm landscapes and support cultural values such as mahinga kai and recreational activities such as bird watching and hunting. For further information on incorporating these additional values, see the websites of Department of Conservation, Fish and Game New Zealand, The National Wetlands Trust and your regional council.

The information provided in this guidance is based on advice from water quality scientists, regional councils, non-government organisations, wetland practitioners and farming experts, and draws on NIWA's "Technical guidelines for constructed wetland treatment of pastoral farm run-off" (Tanner et al. 2021) and a review of New Zealand and international performance data (Woodward et al. 2020).

The wetland performance estimates for reduction of sediment, nitrogen and phosphorus have been reviewed and endorsed by a technical advisory group established to help deliver this guide.

A general, high-level overview and summary of surface-flow constructed wetlands and their benefits is provided in DairyNZ (2021). These guidelines do not address protection and restoration of natural wetlands. Further guidance on the contaminant attenuation capabilities of natural seepage wetlands on pastoral land is described in McKergow et al. (2016) and Rutherford et al. (2017). Advice on the protection and restoration of natural wetlands is provided in Peters and Clarkson (2010) and Taura et al. (2017).

Keeping it legal

If you want to construct a new wetland and it involves excavation or damming water, disturbance to waterways, adding structures to waterways and/or water diversion, you may need a resource consent. Always contact your local regional council or rural professional for advice and assistance on the local regulations before any earthworks commence.

Regional or territorial councils have rules regarding earthmoving near natural waterways and wetlands, the height of embankments and dams, the amount of the water impounded and the total volume or area of earthworks. Fish passage may also need to be maintained in natural and modified waterways where suitable habitat exists upstream for these species. Specific resource consent may be required depending on local regulations.

Regional councils can also help you identify potential funding, and ensure your plans are compliant.

3. About surface-flow wetlands

What are they

Surface-flow wetlands are the most common type of constructed wetland (CW) applied to pastoral land because of their simple design and lower-cost relative to other wetland types. Water flows horizontally over the surface of a shallow, vegetated treatment basin before discharge through an outlet structure or weir (**Figure 1**).

They are suitable across a range of farm types and landscapes, are robust under variable flow conditions and can, with the incorporation of appropriate sediment traps, withstand moderate rates of sediment loading. Their ability to remove sediment and nutrients from diffuse agricultural runoff over the long term is also well established (Woodward et al. 2020).

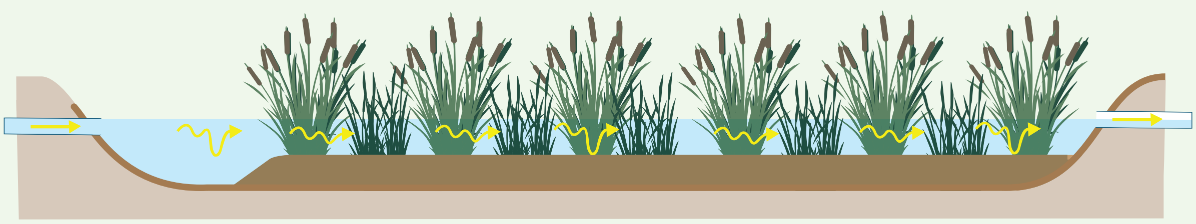


Figure 1. Simple diagram showing surface water flow through a shallow, vegetated wetland basin.

How they function

Constructed wetlands remove contaminants through a combination of physical, chemical and biological processes. A constructed wetland aims to provide an environment in which these processes are optimised to maximise treatment rates. The most important processes are shown in **Figure 2**.

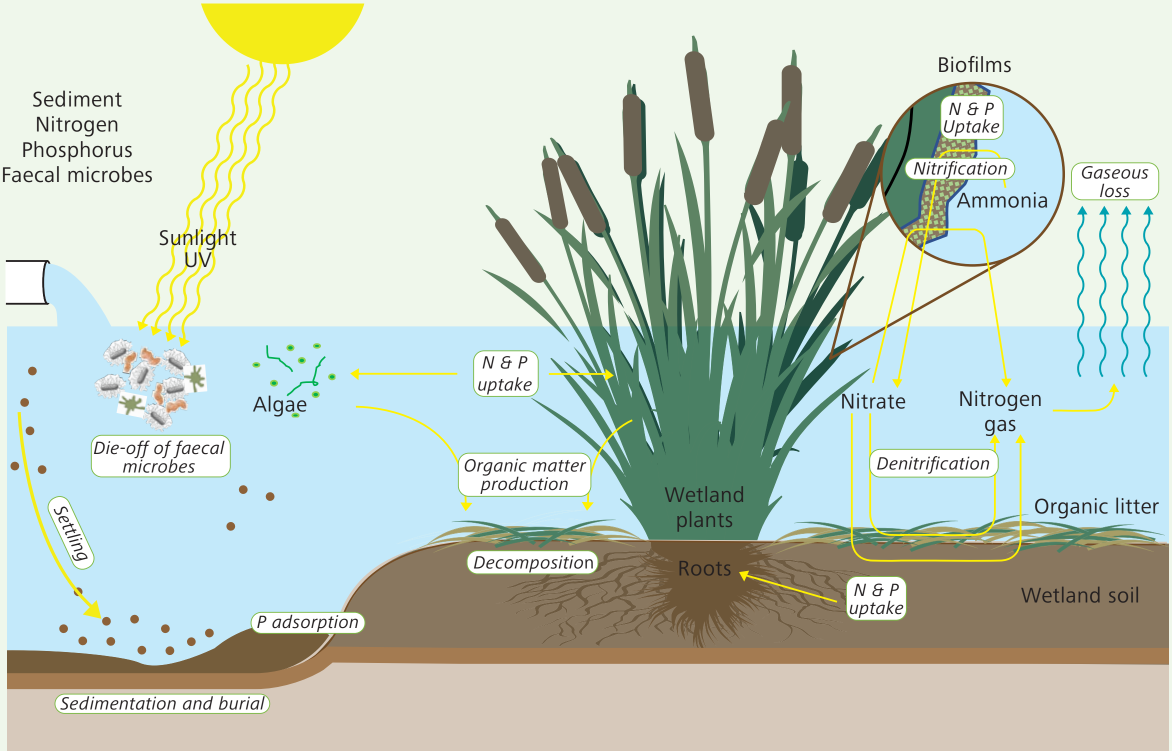


Figure 2. Key contaminant removal processes in surface-flow wetlands.

Wetlands are effective for removing sediment and sediment-bound or particulate contaminants through physical settling processes. Gravitational settling occurs when water velocities are low and hydraulic retention times are long. Fine suspended sediment may also adhere to sticky biofilms that form on plant and litter surfaces underwater and can be filtered from the water column as water flows through wetland vegetation beds. A deep-water column or dense vegetation cover prevents sediment and associated particulate contaminants from being resuspended back into the water column under high flow conditions or as a result of wave action in the wetland.

Microbial denitrification is the key process by which nitrogen (N) is removed in well-established wetlands. In this process, naturally occurring denitrifying bacteria and fungi typically found in wet soils and decomposing vegetation convert nitrate in water into harmless atmospheric nitrogen gas (N_2) as part of their respiration process. A small proportion may be converted to nitrous oxide (N_2O) if the process is incomplete, but recent work by AgResearch has shown that the risk of such pollution swapping (e.g., nitrogen in water being converted to the greenhouse gas nitrous oxide) in wetlands is small (Simon and de Klein, 2021). Wetlands generally provide optimal conditions for denitrification to occur due to permanent waterlogged conditions, low oxygen levels and a good supply of decomposing organic material which acts as a carbon food source for the denitrifying bacteria and fungi.

The uptake of dissolved nitrogen and inorganic phosphorus by wetland plants is also an important nutrient removal pathway, particularly in newly established wetlands, where the environmental conditions for maximising bacterial denitrification processes are not yet optimal. Nutrients taken up by the plant are transformed into plant biomass and are either remineralised or accumulate in wetland soil following decay processes. In some instances, wetlands may act as a source of dissolved phosphorus and work is underway to determine where this is most likely to be a risk. In general, it is best to avoid using P-rich soils in constructed wetlands (further guidance is provided in the wetland design section, see page 17).

Bacterial contaminants are likely to die off naturally in wetlands that have long water retention times or where there is sufficient exposure of microorganisms to sunlight, although wetlands can also be a source of *E.coli* due to the enhanced bird habitat they provide. This can be minimised by avoiding open water zones close to wetland outflows.

4. Contaminant removal performance estimates

There are many reasons to restore and construct wetlands, including: water quality and flood management, wildlife habitat, biodiversity and aesthetics. However, these guidelines focus on the contaminant reduction function of constructed wetlands, in particular removal of nitrogen and sediments. They provide design guidance based on robust scientific research, for the creation of sustainable wetland systems that can effectively reduce pollutant loads.

The performance of different sized constructed wetlands relative to the size of their contributing catchments was assessed by Woodward et al. (2020) using information derived from local and international field-scale monitoring and modelling studies. This information was integrated with expert opinion to derive contaminant reduction estimates for constructed wetlands in the New Zealand context.

Performance estimates were further refined to generate conservative estimates of long-term performance for appropriately designed, constructed, vegetated and maintained constructed wetlands. The performance was assessed and endorsed by a technical advisory group comprising experts from regional and national regulatory agencies and wetland practitioners. Performance estimates were limited to small-scale, edge-of-field and sub-catchment situations; discharge from streams of first-order or less, involving waterways generally smaller than one metre wide and 30cm deep at base-flow, which receive flow from catchments no larger than about 50ha in extent. They assume normal New Zealand pastoral farming conditions and management practices on flat to rolling landscapes (average slopes of 15° or less) with annual rainfall of 800-1600mm. They do not apply to areas with highly permeable soils where groundwater is the dominant flow pathway and therefore hard to intercept on-farm. Some additional limitations are noted below for specific contaminants and flow pathways.

Performance estimates for sediment

Figure 3 shows the expected long-term performance estimates for removal of suspended sediments by a constructed wetland built according to the recommendations in this guidance, including the incorporation of a sediment pond. As relative wetland area increases from 1 to 5% of the catchment area, the long-term average total suspended sediment removal is expected to increase from 50 to 90%. The shaded areas in **Figure 3** show the inter-annual and inter-site range of performance expected.

Sediment which might be transported in surface drains or overland flows (e.g., off raceways) will comprise a range of size fractions from fine clays and silts to larger aggregates of soil and potentially clumps of dung. High intensity rain events will transport larger particles, while low intensity events will mainly transport medium to fine particles. The estimates for removal are based on annual performance of wetlands, thus during high intensity events when lots of large particles are mobilised, high removal rates will occur, but predominantly for the coarse particles. In contrast, during less intense events, less sediment will be mobilised, but greater capture of finer particles will occur. Because of insufficient performance information relevant to catchments dominated by clay soils these performance estimates are only applicable to catchments with soils having < 35% clay content.

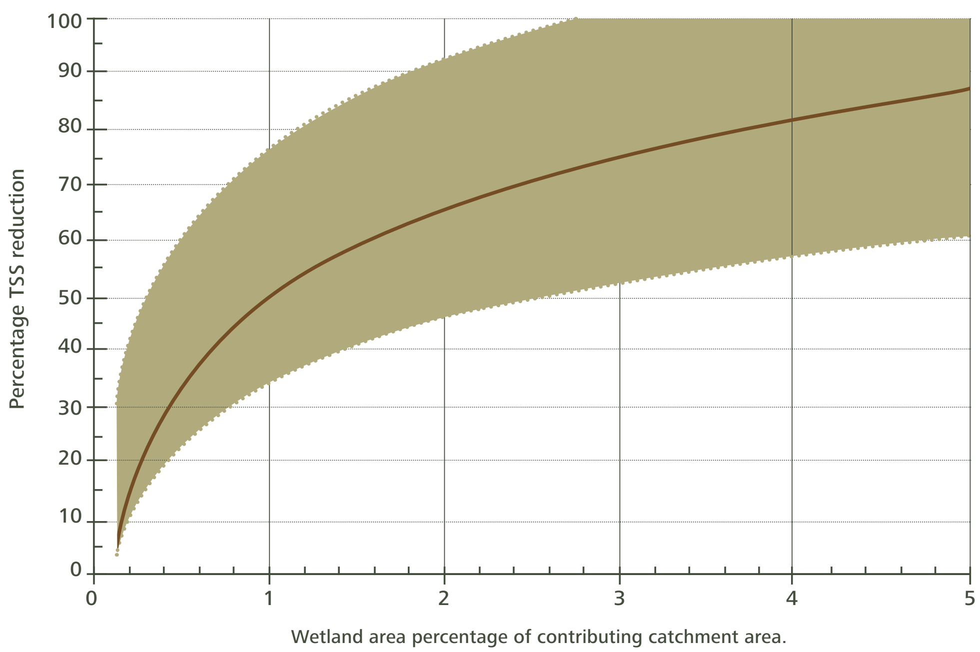


Figure 3: Long-term median annual performance expectations for reduction of total suspended solids (TSS). Performance is for appropriately constructed wetlands receiving surface drainage and run-off from pastoral farmland in New Zealand with catchment rainfall of 800-1600mm/year. Not applicable to areas with clay soils (>35% clay content). Solid line shows expected median. Shaded area shows expected inter-annual and inter-site range of performance.

Performance estimates for nitrogen

Nitrogen in agricultural drainage water is normally present in dissolved nitrate-N form. This is primarily removed in constructed wetlands via biological processes (microbial denitrification and plant uptake). Removal rates generally decrease as temperature decreases. Different performance estimates are therefore provided for warmer (average annual air temperatures ≥12°C) and cooler (average annual air temperature 8-12°C) regions of New Zealand (**Figure 4**).

Based on long-term conditions, the median proportion of total nitrogen (TN) removed from constructed wetlands in warm climate zones increase from 25 up to 50% as relative wetland area increases from 1 to 5% of the catchment area (**Figure 5**). For cool climate zones (e.g., the South Island) the median nitrogen removal rates increase from approximately 20 to 40% for the same relative wetland areas.

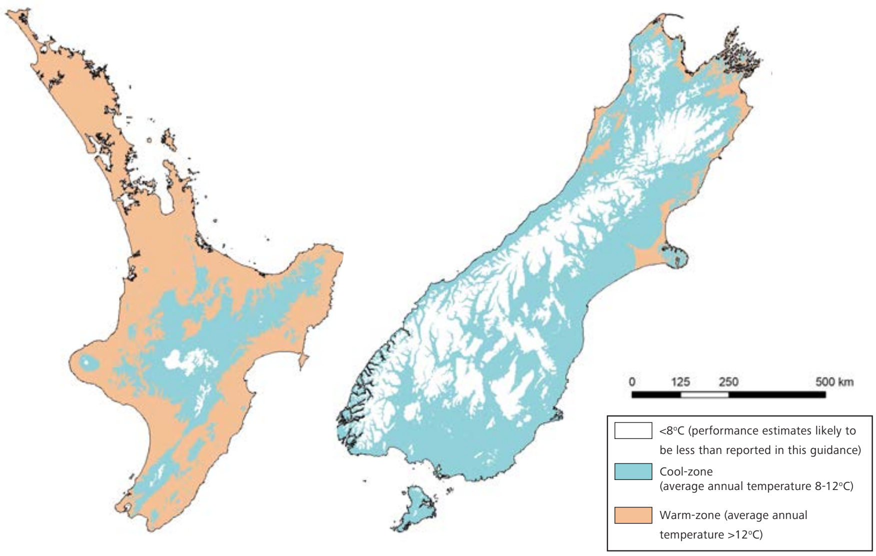


Figure 4. Warm and cool regions in New Zealand. Warmer temperatures support higher rates of N removal.

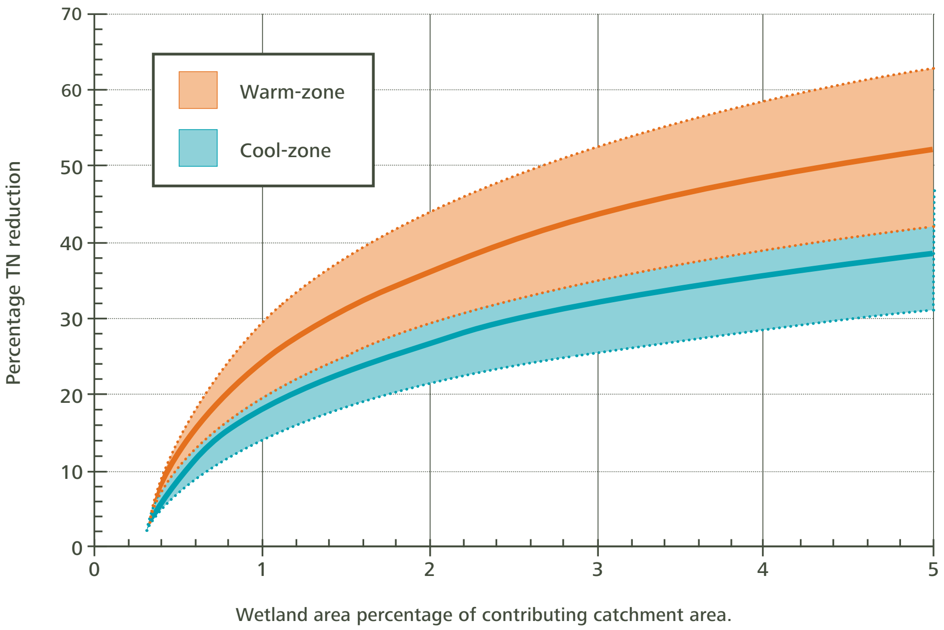


Figure 5. Long-term median annual total nitrogen (TN) reduction performance expectations. Performance is for appropriately constructed wetlands receiving surface drainage and run-off from pastoral farmland for warm (average annual temperature >12°C) and cool (average annual temperature 8-12°C) climatic zones in New Zealand with catchment rainfall of 800-1600mm/year. Solid lines show expected medians for each zone; shaded areas show inter-annual and inter-site range of performance expected.

Performance estimates for phosphorus

Performance estimates for removal of total phosphorus (TP) are applicable to constructed wetlands receiving surface run-off and drainage flows where P is predominantly associated with particulates (suspended sediments), and in catchments not dominated by clay soils (i.e., <35% clay content). The average proportion of phosphorus removed by these wetlands over the long term is estimated to increase from 25 up to 50% as relative wetland area increases from 1 to 5% (**Figure 6**).

Phosphorus in subsurface drainage water is mainly in dissolved forms and its removal is not covered by the treatment estimates provided here. There is potential for dissolved P release from constructed wetlands when P-rich agricultural soils are used as growth media. Therefore, soils with low potential for P release (e.g., allophanic soils) or use of subsoils alone or mixed with topsoil should be selected for use in the base of the wetland. Where Phosphorus reduction is a specific goal or soils are known to have high P status, it is recommended that soil tests are carried out to assess the risk. Information available at present suggests there is significant potential for wetland P release when the soil TP/anion storage capacity ratio is 0.2 or more.

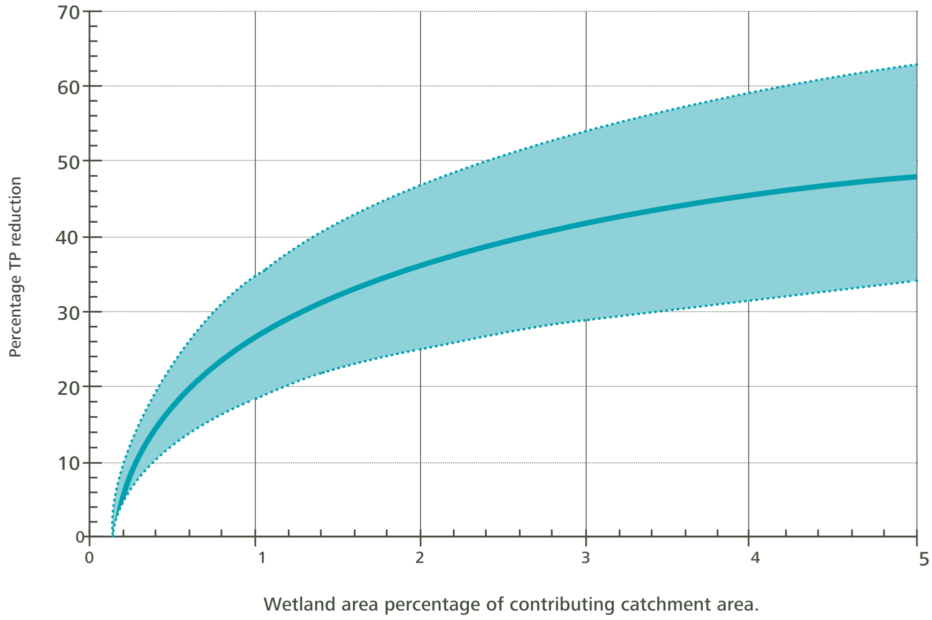


Figure 6. Long-term median annual total phosphorus (TP) reduction performance expectations. Performance is for appropriately constructed wetlands receiving surface run-off and drainage from pastoral farmland in New Zealand with catchment rainfall of 800-1600mm/year. Solid line shows expected median; shaded area shows inter-annual and inter-site range of performance expected. These predictions do not apply for constructed wetlands whose main source of flow is subsurface drainage containing predominantly dissolved forms of phosphorus.

5. Wetland design

Design basics

It is important to emphasise that the contaminant removal estimates shown in the previous section only apply to well designed and maintained wetlands constructed according to the design principles outlined in this guide. To maximise contaminant removal, it is important to target the dominant sources and transport pathways off contaminant loss in the landscape.

The main principles of effective wetland design for managing agricultural drainage and run-off are to:

1. Capture, slow down, spread out, and retain water and contaminant flows in the wetland for as long as possible without compromising upslope drainage and flood risk.
2. Create conditions which mimic those found in a natural wetland, particularly high coverage of emergent wetland plants.
3. Provide co-benefits including flood protection, ecological habitat, plant and animal biodiversity, and mahinga kai.

Diffuse agricultural contaminant flows are highly variable from day-to-day, season-to-season and even year-to-year. The treatment performance of wetlands will vary according to the distribution, intensity, and duration of rainfall and how this interacts with soils, slopes, and vegetation across landscapes to generate surface and subsurface drainage and run-off. Seasonal temperatures also impact both microbial and plant uptake of nutrients in wetlands.

The key components of an effective constructed wetland are:

1. A sedimentation zone.
2. A deep-water inlet (dispersion) zone.
3. A shallow vegetated wetland zone.

These wetland components (or zones) are described in **Table 1** and illustrated in **Figure 7**. Wetlands can either be configured with a separate or integrated sedimentation pond (**Figure 7A and B**, respectively). Wetlands receiving tile drain flows with minimal sediment load may not need sedimentation ponds - check whether the flow goes murky during storm flows. **Figure 8** provides an example of how these wetland components are typically integrated into the landscape and **Figures 9A and B** shows how different configurations can be used to suit natural landscape features and topography. The timeline for the stages of wetland construction are given in **Appendix 1**.

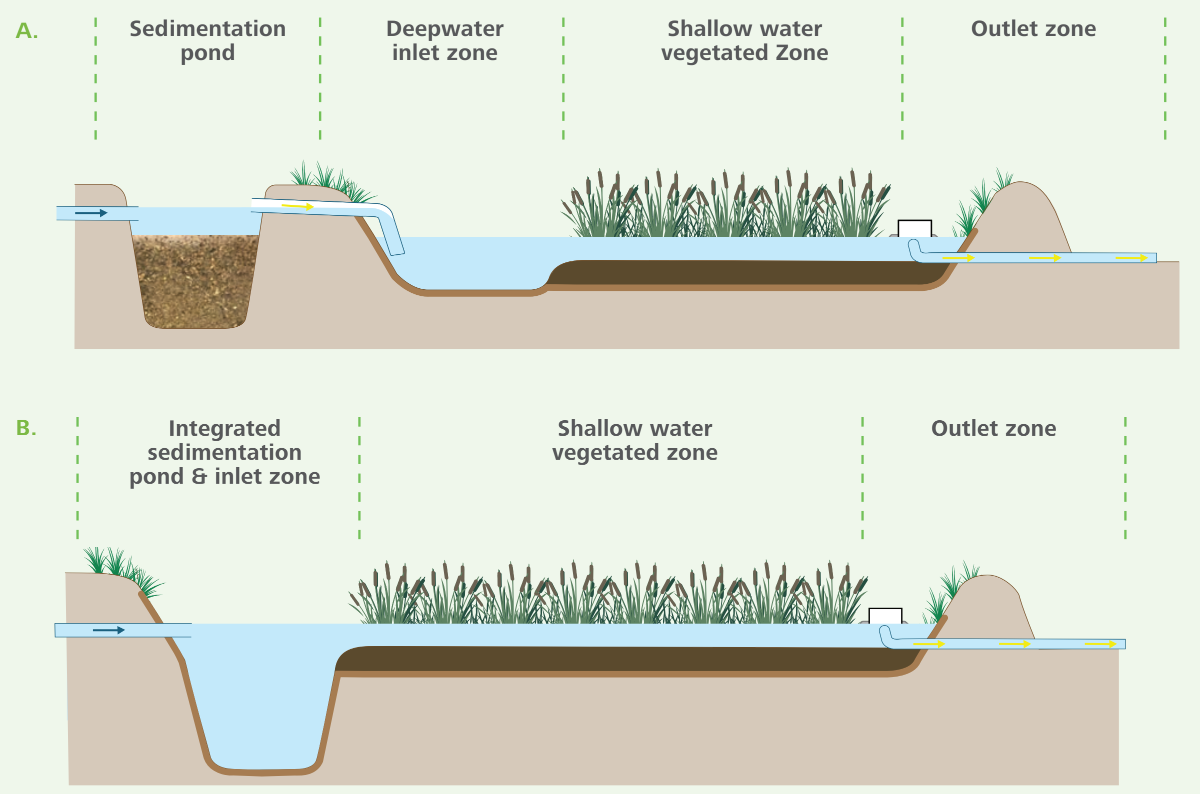


Figure 7. Surface-flow constructed wetland treatment cells in side view. Option (A) features a separate sedimentation pond, deep inlet and shallow treatment/planted basins while (B) integrates these components into a single inlet-sedimentation zone and shallow treatment zone. Note: Embankment slopes are exaggerated.

Table 1. Constructed Wetland design basics for managing pastoral farm drainage and run-off. See Appendix 1 for recommended construction timeline.

SIZE AND SHAPE	
Wetland type	Surface-flow, also known as free-water surface constructed wetlands.
Size	1-5% of contributing catchment area - bigger areas provide greater contaminant reduction. Larger areas (≥2%) are recommended in regions that experience high intensity storm events. Wetland size should be determined at normal water level, not at the top or outside of the embankments.
Shape	Elongated or multi-wetland cell systems with inlet and outlet at opposite ends and overall length:width ratio ideally 5:1 to 10:1 (minimum 3:1).
Performance	A well-designed wetland that is 2% of catchment will typically remove between 46 - 92% of sediment (from soils with low clay content); 28 - 44% of nitrogen in warm zones (22 - 33% in cool zones), and 25 - 46% of particulate phosphorus.
WETLAND COMPONENTS	
Initial deep sedimentation pond (>1.5 m depth)	Should be included wherever there is potential for sediment transport into the wetland. Size up to 20% of the wetland area, taking account of expected peak flows based on local rainfall intensity. Provide for digger access to enable periodic clean-out of accumulated sediment to maintain at least half the original pond depth.
Deep (>0.5m) open water dispersion zone at inlet	Up to 20% of the wetland size located at the inlet of each vegetated wetland zone, and up to 30% of the total wetland area can be deep zones.
Shallow (average 0.3 m depth) densely vegetated zone	At least 70% of wetland area, including the final 20% of wetland area closest to the outlet should be vegetated. This is to reduce the impacts of disturbance and faecal inputs by waterfowl.
PLANTING	
Shallow zones	70% cover of native wetland sedges and bulrushes. Ideally, plant in spring-early summer at 2 - 4 plants/m^2.
Embankments	Hardy riparian plants. Plant in winter-early spring at ~1 - 2 plants/m^2.
Protection	Control weeds mechanically or with an approved herbicide before planting and during initial 18 months of establishment. Protect new plantings from grazing by pūkeko and Canada geese. Fence the wetland to exclude livestock.

A well-functioning wetland should have:

- Low sediment accumulation rates in the main vegetated wetland zone.
- Well-established, flourishing and evenly distributed wetland plants.
- Uniform flow, with no signs of channelisation or short-circuiting.
- Outflow water which is generally clear, with low odour.
- Appropriate water levels for plant survival and treatment function.
- Minimal cover of invasive weedy plants in the vegetated treatment cell.
- Well-maintained embankments and margins – fenced to exclude livestock, without erosion or dominance by weeds.

Figure 8. Features of a surface flow constructed wetland in the landscape: (1) A deep sedimentation pond (more than 1.5m deep), size will depend on rainfall intensity and topography but generally up to 20% of wetland size, (2) Deep (over 0.5m) open water zones at the inlet of each cell to help dispersion and mixing, and even out the flow, (3) shallow (average 0.3m deep), densely vegetated zones (at least 70% of the total area). The shallow zone is where most of the nitrogen removal happens via microbial denitrification, fuelled by decaying plant leaf litter. Sunlight penetration in deep open-water areas can promote die-off of faecal microbes in inflowing waters, but shallow water with dense plantings is recommended in the final 20% of the wetland to limit faecal contamination and sediment disturbance in the final outflow by waterfowl.

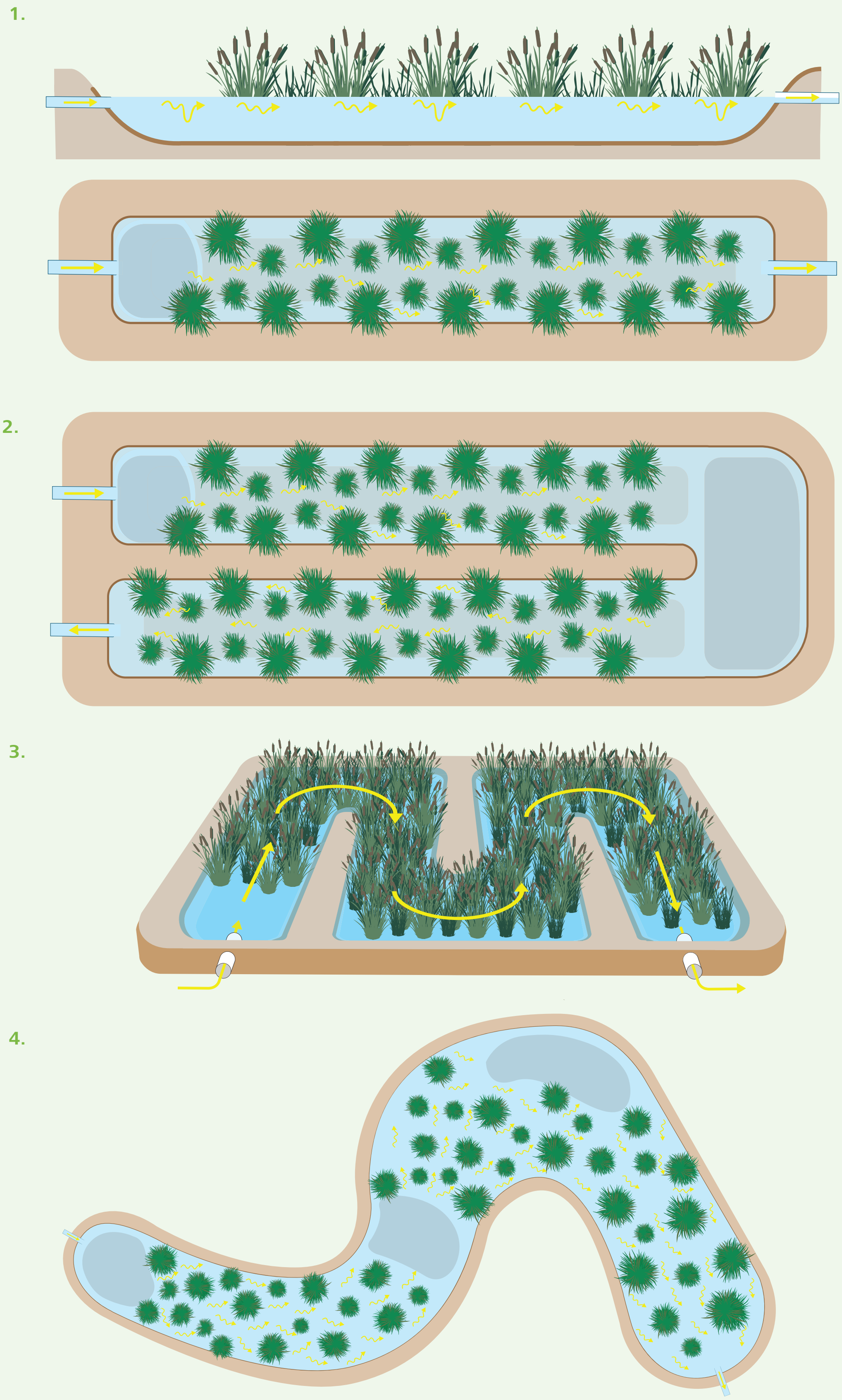


Figure 9A. Different design configurations of surface-flow constructed wetlands for flat land. Wetland length:width ratios can be increased by having multiple cells in series or using bunds to create a serpentine flow path.

Wetland size

Wetlands intercepting agricultural runoff and drainage flows generally need to comprise between 1-5% of their contributing catchment (i.e., 100-500m^2 of wetland per hectare) to meet the expected treatment performance described in **Table 1**. The performance of constructed wetlands depends to a large extent on the residence time of water within them, so larger relative wetland areas will provide higher contaminant removal. Larger areas (≥2% of contributing catchment) are recommended for areas that experience frequent high intensity/duration storm events (e.g., Northland, Bay of Plenty, Gisborne, Nelson, Tasman and the West Coast) to ensure that sufficient residence time is achieved. Graphs of estimated long-term median annual performance in relation to relative wetland size (measured at the normal water surface), and expected range of variability, are provided for sediment, nitrogen and phosphorus in the previous section. Use these performance estimates along with information about your farm nutrient budget and landscape attributes, and water quality targets and limits developed for your catchment to determine the most appropriate wetland size.

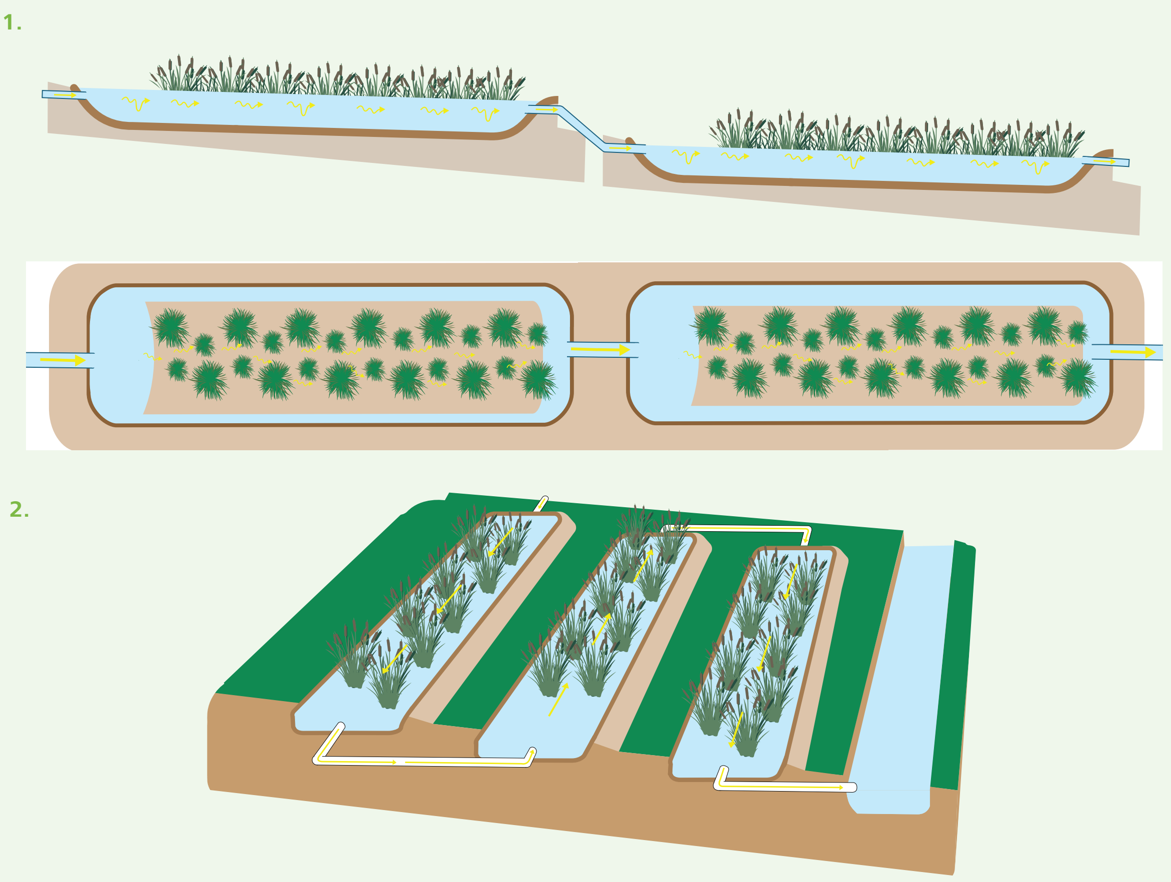


Figure 9B. Different design configurations of surface-flow constructed wetlands for contoured or steeper land. Wetland length:width ratios can be increased by stepping a series of cells down the slope.

Flow path positioning

Depending on the landscape and catchment, surface-flow wetlands can be constructed to intercept a range of different flow paths:

- Sub-surface tile drains prior to discharge into open channels or streams.
- Groundwater seeps or springs (e.g., at the toe-slope of hills).
- Drainage ditches.
- Small streams or creeks, where a proportion of the flow can be maintained in the natural channel for fish passage and a proportion diverted to an off-line wetland constructed adjacent to the water course (**Figure 10B**) or where fish passage can be maintained through the wetland (**Figure 10A**).
- Ephemeral flow paths which receive periodic surface runoff. These typically need to have at least a portion of more permanent inflow from shallow groundwater to sustain wetland plantings.

Focus on flow paths that carry significant contaminant loads. Flows that occur consistently or frequently during wet periods of the year will provide the greatest contaminant reductions and be the most able to sustain a wetland.

Maintenance of fish passage is legally required for rivers, streams and modified natural watercourses. Some artificial drains and canals also provide valuable fish habitat which should be maintained. Consult the Fish Passage Guidelines available on the Department of Conservation (DoC) and NIWA websites for further information (Franklin et al. 2018). Examples of fish-friendly inlet and outlet structures are provided in the wetland outlet and spillway section below. A suitably designed off-line wetland has the benefit of retaining flow along the watercourse to provide for fish passage. It can also be engineered to accept the majority of flow during normal flow conditions, while allowing a proportion of the water to bypass the wetland during higher flow periods. This approach provides more consistent flows to the wetland resulting in stable treatment performance and avoids damage to the wetland during flood flows. However, water and associated contaminants that do not pass through the wetland will not be treated.

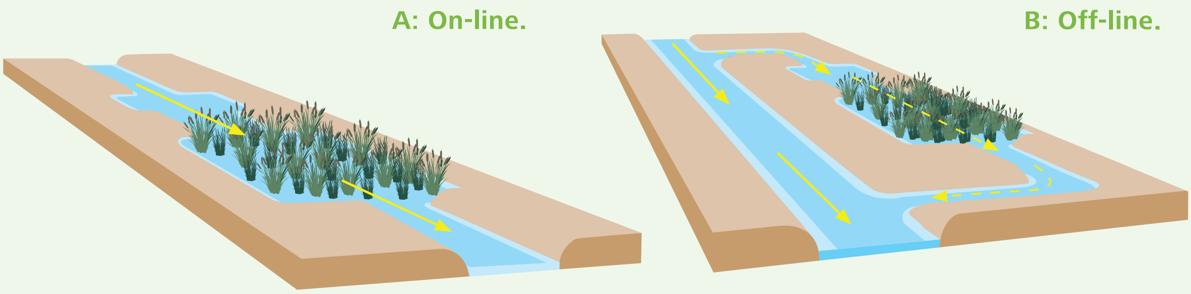


Figure 10. Diagram showing (A) on-line and (B) off-line wetland options.

Wetland shape and arrangement

The shape and form of the wetland should aim to promote uniform flows throughout the treatment beds, so as to avoid dead-zones and maximise the amount of time water spends in the wetland being treated. Often the best location for a constructed wetland is on low-lying areas of the farm where natural wetlands may have existed historically prior to modification of the landscape through drainage, and pastoral production is generally lower.

Contaminant removal performance is influenced by how evenly water flows through the wetland. This means the best shape for a constructed wetland is elongated or with multiple cells to avoid short-circuiting between the inlet and the outlet. Even flow distribution across the full width of a wetland, and consequent wetland treatment effectiveness, is improved where the overall length to width ratio of the wetland channel is between 5:1 and 10:1 (minimum 3:1). Suitable length-to-width ratios can be achieved by a single long and narrow wetland cell (**Figure 9A: 1**), or by using internal bunds to create longer flows path where space is constrained (**Fig 9A: 2 and 3**). More naturalised shapes that fit into the natural landscape can also be used as long as they achieve suitable length to width ratios and avoid creating dead-zones (**Figure 8 and 9A: 4**). Open water areas orientated across the width of the wetland or on the outer edge of corners can be used to redistribute flow and add diversity (**Figure 9A: 4**). Channels oriented along the flow path should be avoided as they promote preferential flow and short-circuiting.

Constructed wetlands can also be split into a series of separate cells to minimise the amount of excavation required on sloping sites. Land slope and site characteristics will generally dictate whether a single (**Figure 9A**) or multi-stage wetland is preferable (**Figure 9B**). It is generally more practical to build a series of smaller wetland cells down a slope, keeping the fall between each cell to no more than ~1-2m to avoid the need for large bunds/embankments and extensive excavation. Where an embankment must be constructed between cells, this should be constructed using well-compacted subsoil with a high clay content, keyed into the substrate beneath.

Sedimentation pond

Including a sediment pond as the first stage of a wetland complex helps capture coarse sediment fractions and extend the lifetime of a wetland (**Figure 11**). Accumulated sediment will need to be mechanically removed periodically from the sedimentation pond, so it is important to maintain digger access. General principles for construction of a sedimentation pond can be found in the Ministry for Agriculture Forestry coarse sediment trap guidelines (Hudson 2002) and are summarised in Tanner et al. (2021). Sizing of sedimentation ponds should consider regional storm frequency and intensity, but a general rule is that the sedimentation pond should comprise 10 to 20% of the size of the wetland and be excavated to a depth of 1.5m below the outlet level. Its length (minimum of 5m) should be greater than its width. Gently sloping the margins of ponds can enhance shallow-water habitat for waterbirds.

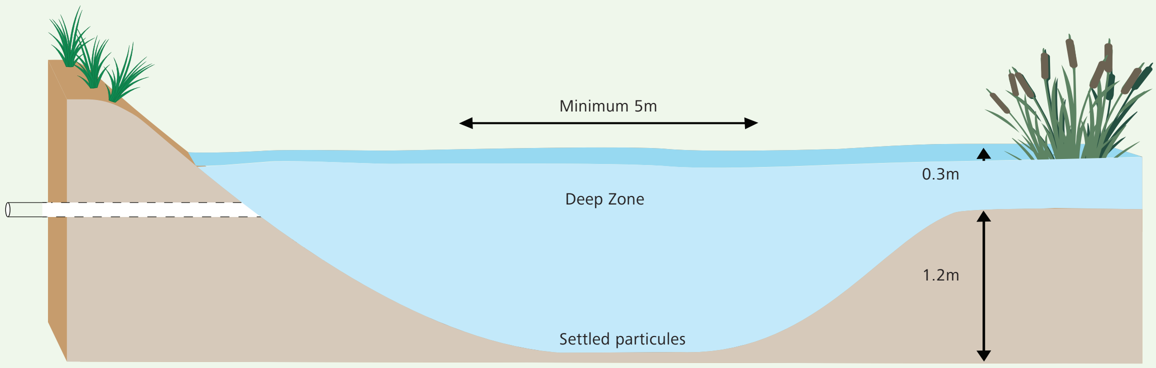


Figure 11. Integrated sedimentation pond configuration and functioning. Sediment ponds can either be separate from the wetland, or integrated into the inlet (as shown), where they also function as the dispersion zone (also refer to Figure 7).

Inlet structure

The performance of constructed wetlands is optimal when water flows uniformly through the wetland to utilise the full available volume. Deeper, non-vegetated, open water zones are recommended in the inlet zone to dissipate the energy of the inflowing plume and distribute it across the width of the wetland. If the inlet enters in a pipe it can be directed downwards using an elbow (**Figure 12A**) or laterally to both sides of the pond-zone using a T-fitting (**Figure 11**). The inlet piping needs to be able to function effectively for long periods without the need for frequent maintenance. An open channel (**Figure 12B**) inflow will be appropriate where fish passage is required through the wetland. Consult **Figures 15** and **16**, and the NIWA/DoC Fish Passage Guidelines for further information on fish passage options (Franklin et al. 2018).

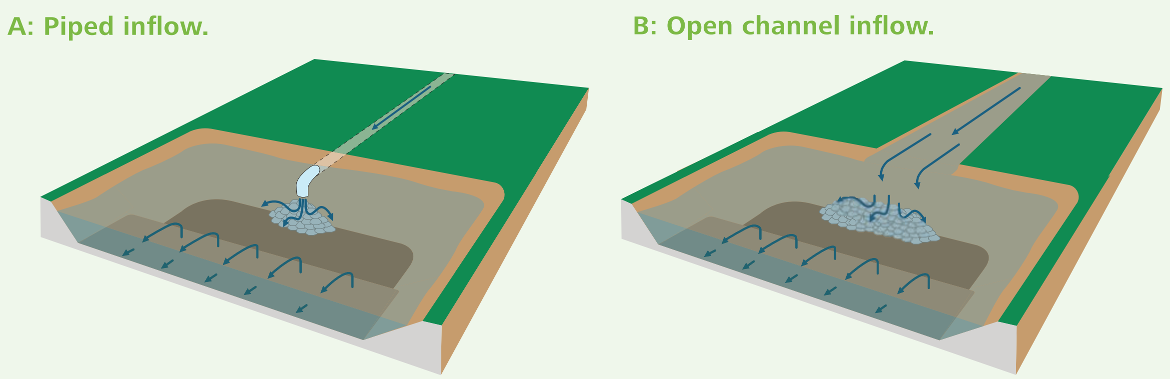


Figure 12. The inlet to sedimentation ponds can be (A) piped (e.g., from a tile drain) or (B) via an open channel. Fish passage should be provided where required; see **Figure 15** for guidance.

Embankment design, lining, and growth media

Where soils in the base of the wetland are highly permeable (e.g., sands) or the wetland receives only intermittent (or ephemeral) flows, a liner may be required in the base of the wetland (e.g., compacted clay or buried plastic sheeting) to reduce water loss and prevent the wetland drying out. Where consistent flows are expected over much of the year and subsoils in the base of the wetland have a clay content of >10%, it is unlikely that leakage will be a problem. Once organic matter has built up in the base of a wetland, nitrate-nitrogen should be very effectively removed in any groundwater seepage through the base or sides of the wetland.

Embankments should be constructed using subsoils compacted in shallow layers, so they are structurally stable and watertight. They need to be keyed into the subsoil and battered at an angle of around 3:1 (2:1 maximum slope) to reduce the potential for bank slumping and erosion. Gently sloping the inner embankments can promote greater plant diversity and shallow-water habitat for wading and dabbling birds.

Some councils have limits on bund height above which professional engineering designs and resource consents may be required. Consenting requirements that relate to specific wetland designs and locations should be identified prior to construction.

In the shallow areas identified for planting, a layer of approximately 0.3m of friable lightly compacted soil is required to promote plant root growth and anchorage (**Figure 13**). Farm topsoil that has received fertiliser for many years is likely to contain high levels of phosphorus which could leach into the water column once the soil is permanently saturated in the wetland. To manage this risk, a 50:50 mixture of topsoil and subsoil is recommended in the shallow planting areas (not required in the sedimentation pond or in deeper, non-vegetated, flow-dispersion zones; see page 9 for further guidance on assessing P-loss risk).

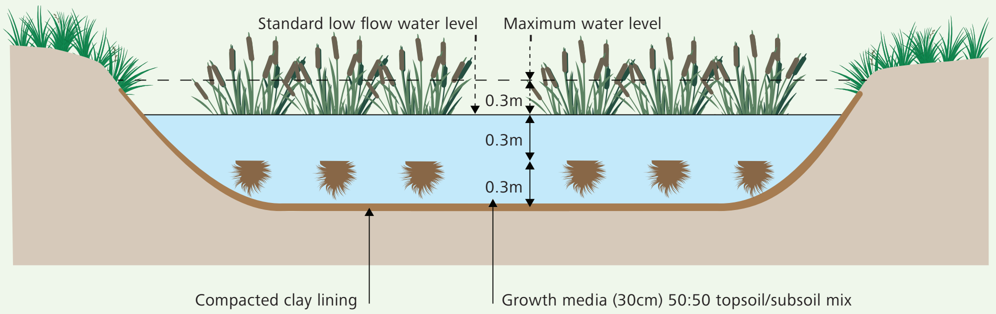


Figure 13. Cross-sectional view of shallow planted zone of a constructed wetland. A compacted clay liner is recommended where the wetland is constructed in permeable soils and/or receives only intermittent flows.

Wetland outlet and spillway

Outlet and spillway structures provide control of water levels within the wetland to maintain treatment functioning and to manage flood risk. Ideal water depth for most emergent wetland plants is around 0.3m. Water depth in the vegetated zones is controlled by the height of the outlet – the interior base of an outlet pipe (known as the invert), or the crest of an outlet weir.

The embankment should be made first to ensure it is properly compacted, and then excavated to fit the outlet pipe or weir structure at the appropriate depth (so that the water level can be adjusted to 0.3m above the wetland base once the topsoil layer has been added to the wetland). Anti-seep collars should be fitted where necessary to stop water leaking around the pipe.

Provision for maintenance of a shallower water level during plant establishment and for future adjustment of the outlet height as sediment and plant material build up in the wetland is also required. For smaller wetlands not requiring fish passage, this can be done by adding a 90° pipe bend that can be swivelled to adjust the level of the outlet (**Figure 14A**) or adding another section to the riser pipe (**Figure 14B**). For larger wetlands, an adjustable outlet weir (**Figure 14C**) or outlet pipes set through the embankment at the establishment water level (that are subsequently able to be capped) are likely to be more practical.

A form of spillway or overflow is required to manage large storm flows and protect the wetland and its embankments against flood damage. The spillway may be configured in the outlet system or comprise a slightly lower, armoured section of the wetland bund, enabling over-topping without damage to the bund. The lip of the spillway needs to be sufficiently wide and shallow to keep flow velocities low to minimise the risk of erosion. The spillway crest, chute and exit need to be suitably armoured with geotextile and rock riprap or concrete to resist erosion and avoid undermining of embankments. In-line wetlands may need a diversion channel to route extreme flows around the wetland or provide an armoured pathway through the wetland.

It is recommended that suitable expertise is sought early in the design process to address potential engineering requirements for the wetland. Fish passage will also need to be considered for some outlet and inlet structures and for where a weir is constructed to divert water into an off-line wetland. **Figure 15** provides guidance on where fish passage structures are required and **Figure 16** provides guidance for maintaining fish passage using gently sloping concrete-lined ramps with rocks inserted as roughness elements. Consult the Fish Passage Guidelines available on the DoC and NIWA websites for detailed design information (Franklin et al. 2018).

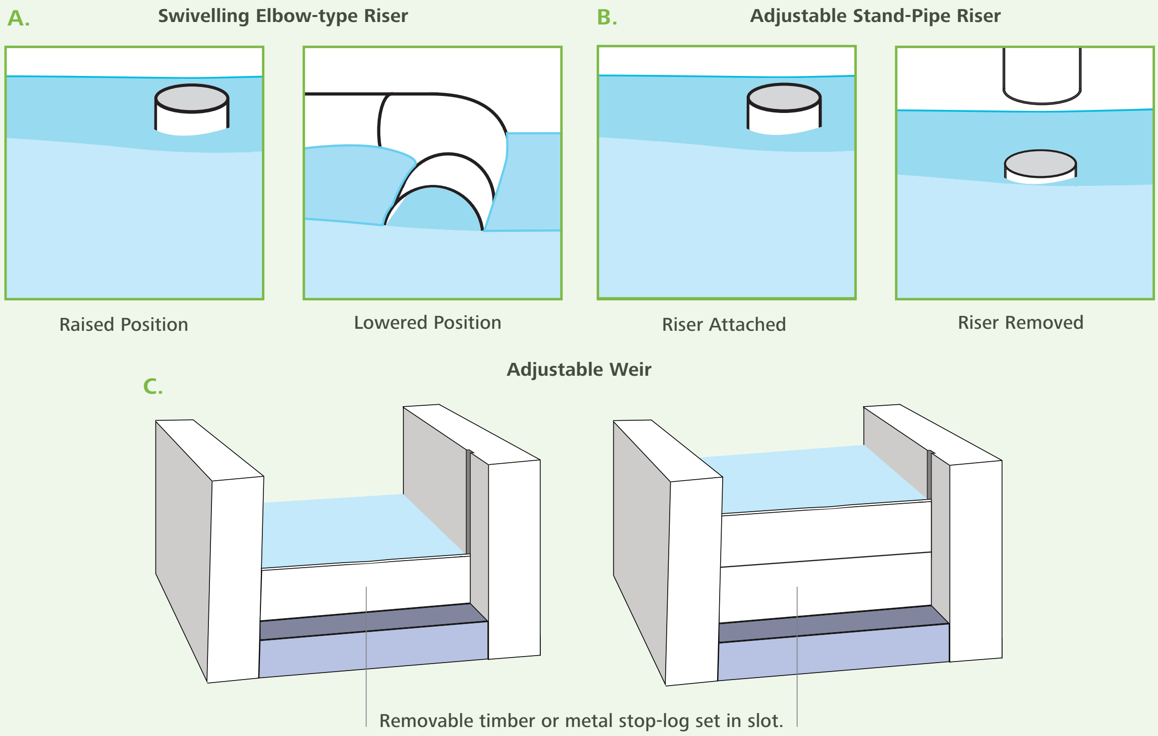


Figure 14. Examples of outlet structure design where providing for fish passage is not required. (A) swivelling elbow-type riser, (B) adjustable riser piper suitable for small wetlands, and (C) adjustable weir suitable for larger constructed wetlands.

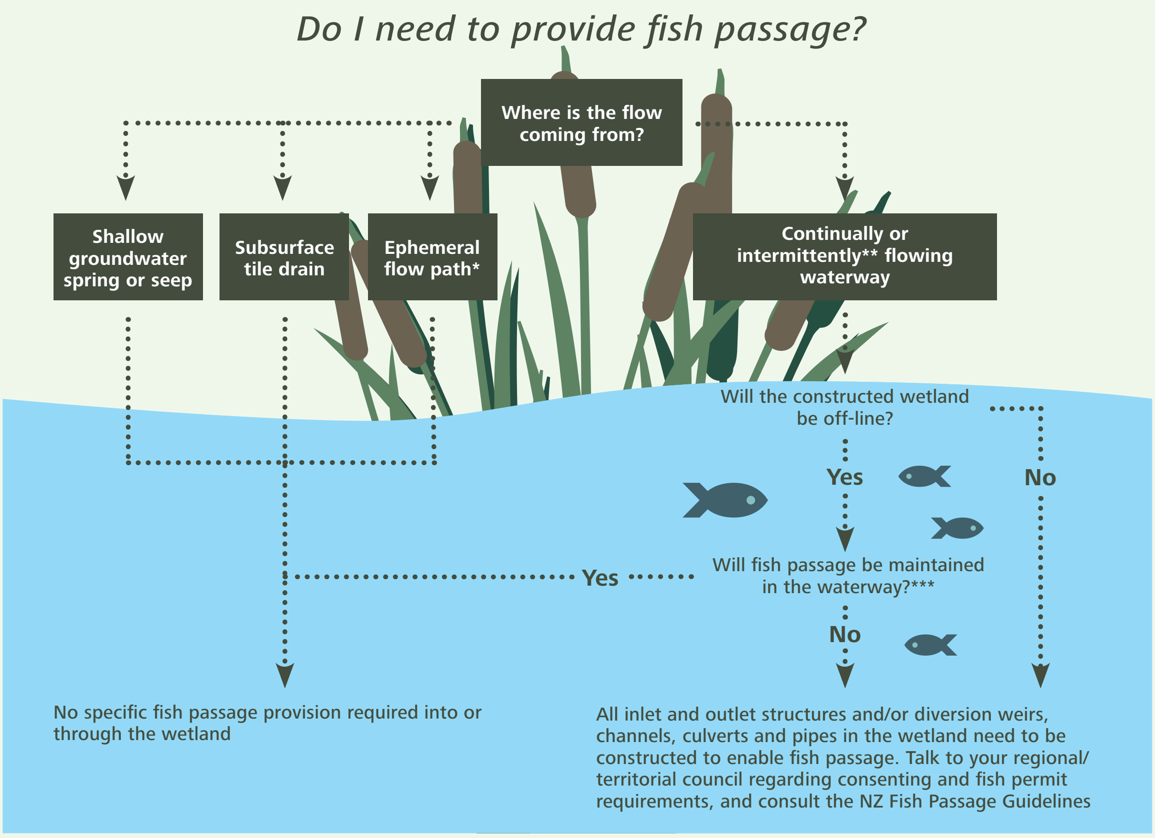
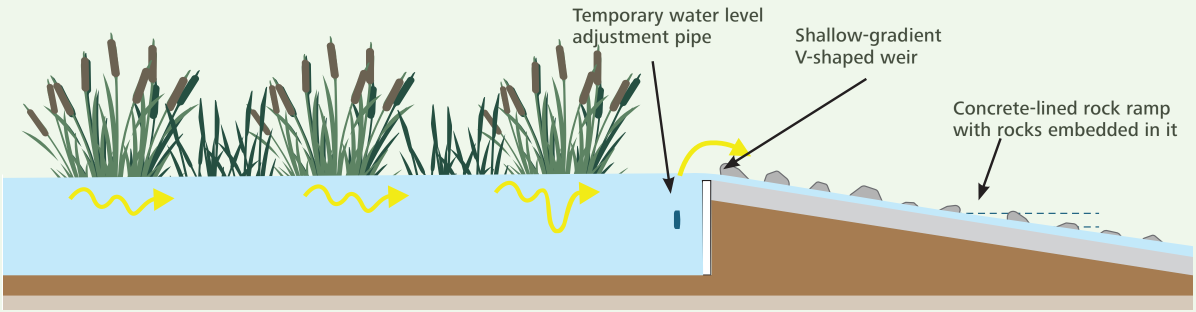


Figure 15. Decision support diagram to help determine whether fish passage is required for inlet and outlet structures of constructed wetlands. *Ephemeral flow paths only flow temporarily after significant rain events (e.g., for 48 hours). **Intermittent flow paths flow seasonally within defined stream banks. ***Fish passage should continue to be maintained under low-flow conditions.



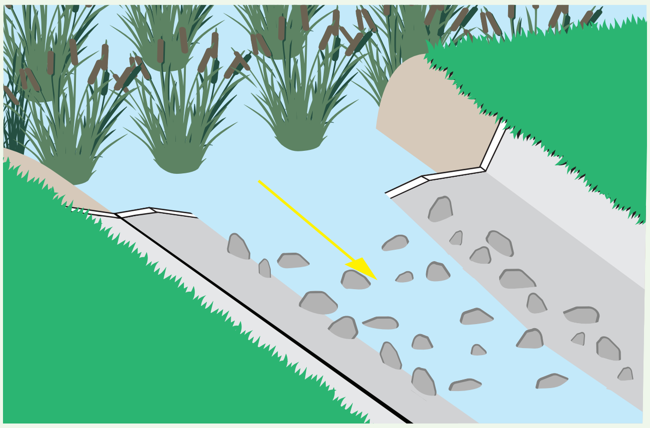


Figure 16. Recommended rock-ramp design to provide fish passage in and out of wetlands and between cells. The water level control weir should be broad, with a shallow V shaped profile (5-10° lateral slope). The rock ramp should have a low gradient (<1:10 for fall heights of ≤1m, <1:15 for heights of 1-4m; and 1:30 for weakly-swimming species such as inanga). Mixed grade rocks (150-200mm diameter) should be securely embedded in the concrete-lined ramp to approximately half their depth to create zones of calmer flow at the margins and a low-flow channel at the centre suitable for the movement of fish. A low level pipe is recommended to enable control of water level during initial plant establishment or wetland maintenance. A swivelling elbow or standpipe can be added to adjust water levels during these periods. This pipe should be capped once the plants are sufficiently grown to cope with deeper water levels (3-4 months).

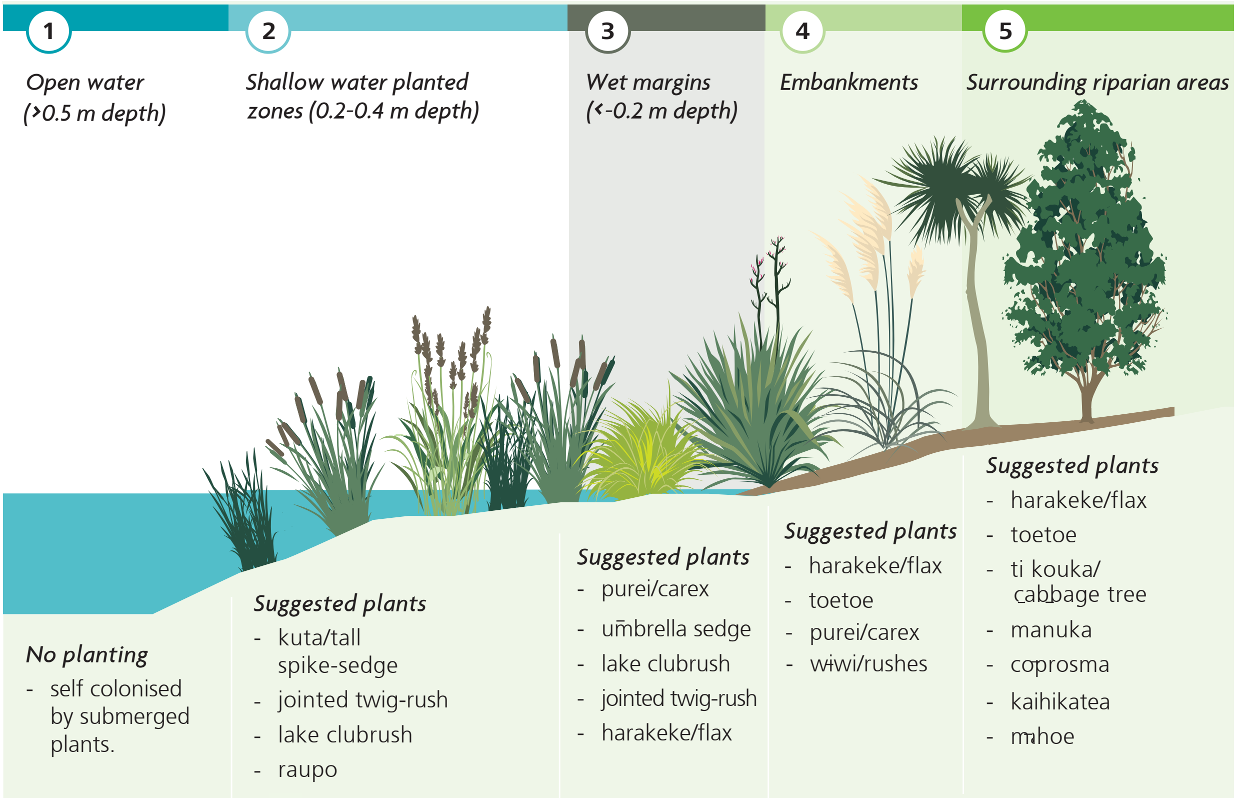


Figure 17. Planting zones and typical plant species.

6. Wetland vegetation

Plants are important in the overall functioning of wetlands, particularly through their support for microbial processes, for example by providing carbon-rich organic matter, and helping disperse flows within wetlands. Plants also promote the settling and filtration of suspended solids and take up nutrients for their growth and oxygenate water and sediments which supports aquatic life.

The plants in the flooded zone are primarily responsible for water treatment, while the plants on the margins and embankment stabilise the edges, help exclude weeds, contribute organic matter (carbon) and promote biodiversity (**Figure 17**).

It is recommended that at least 70% of the wetland is shallow water (0.2-0.4m deep) to support dense growths of emergent plants (e.g., sedges and bulrushes). Deep unvegetated open water areas (>0.5m depth) are recommended at the inlet to disperse the flow uniformly through the shallower, densely planted zones.

Plant selection

A range of plant species suitable for treatment wetlands is shown in **Figures 18** and **19**. Native species are preferable. Plant selection should consider the following:

- What grows naturally in shallow water wetlands in the region.
- Likely exposure to frost (some species die back when exposed to frost).
- Hydrological conditions, i.e., whether the wetland is likely to be permanently wet or have periods or sections likely to dry out over summer.
- Range of water depths.

An example of plant selection and their relative contribution in a 0.5ha constructed wetland in the Waikato is show in **Table 2**.

More detailed planting advice is provided in Tanner (2021).

Table 2: Example of plant selection for a constructed wetland in the Waikato. Note: Relative quantities of plants needed for wet margins, embankments and riparian zones will vary with wetland shape and size. A range of additional species will also colonise naturally over time.

Species	Common names	Percentage of constructed wetland area (approx)	Number of plants/ sq m†	No. of plants/ ha constructed wetland
Within the constructed wetland				
Deep open water	No planting	**30%**	0	0
Shallow water (0.2-0.4 m depth)		**60%**		
Schoenoplectus tabernaemontani	kapungawha, lake club-rush	25%	3	7500
Machaerina articulata	mokuāūtoto, joined twig-rush	20%	3	6000
Eleocharis sphacelata (deeper water)	kuta, tall spike-rush	15%	2	3000
Wet margins (0-0.2m depth)		**10%**		
Carex secta (shallow edge)	pūrei/makura, carex	4%	1	400
Cyperus ustulatus	toetoe upokotangata, giant umbrella sedge	4%	2	800
Bolboschoenus fluviatilis	riwaka, marsh clubrush	2%	3	600
Surrounding the constructed wetland				
Embankments*		**6%***		
Phormium tenax	harakeke, flax	4%*	1	400
Carex secta	purei/makura, carex	2%*	1	200
Astroderia toetoe	toetoe	2%*	1	200
Riparian margins*		**12%***		
Phormium tenax	harakeke, flax	10%*	1	1000
Cordyline australis	tī kōuka, cabbage tree	2%*	1	200

* Additional to wetland area at standard water level. † Based on well grown PB1-grade (~600ml pot) plants

Typha orientalis

raupō, bulrush
(planting depth 0-40cm)

Machaerina articulata

mokuāūtoto, jointed twig-bush, baumea
(planting depth 0-40cm)

Eleocharis sphacelata

kuta, tall spike-rush, spike-sedge
(planting depth 20-60cm)

Schoenoplectus tabernaemontani

kāpūngāwhā, kūwāwā, lake club-rush
planting depth 0-40cm

Figure 18. Key native plants in the shallow vegetated zone.

Bolboschoenus fluviatilis and B. medianus, purua grass, kukuraho, ririwaka, river bulrush, marsh clubrush

Carex secta, pūrei, makura

C. germinata, C. lessoniana and C. virgata, rautahi, carex

Austroderia richardii, A. fulvida, A. toetoe, toetoe

(New Zealand native species only, not to be confused with introduced pampas grasses)

Cordyline australis, tī kōuka, cabbage tree

*Cyperus ustulatus***,** toetoe upokotangata, giant umbrella sedge

Phormium tenax, harakeke, New Zealand flax

Avoid invasive introduced species such as *Glyceria maxima,* reed sweetgrass

Figure 19. Plant selection for the wet margins and embankments.

Plant placement and establishment

Planting densities for most wetland species should be between 2 and 4 plants per square metre, or at a spacing of between 0.5m and 0.7m apart. Larger plants such as *Carex secta* and raupō can be planted slightly further apart (approximately 1m). Best establishment and subsequent spread are usually achieved using nursery stock grown from locally eco-sourced seed. Plants with well-developed roots and rhizomes grown up in 0.5-1.8L pots (PB1-3) are recommended. Larger plants are less risky, especially if planting late in the growing season.

Most wetland species, especially those that grow in the permanently wet zones, are best planted in clumps or bands of the same species across the full width of the wetland channel. This is to prevent plant losses due to competition between species and also to encourage vegetative regeneration from the rhizomes of wetland species that can reproduce this way.

Wetland plant establishment should be relatively rapid and simple if it is carried out correctly right from the start. However, problems can multiply and become difficult to overcome where plant establishment is compromised by factors such as:

- Planting at the wrong time of the year e.g., too late in the season.
- Insufficient or excessive water levels.
- Competition and suppression by weeds.
- Damage by livestock or waterfowl, such as pūkeko and Canada geese.

Although most of the wetland species used for treatment wetlands are able to thrive in open water (tolerances range from water depths of 0.2 to 0.5m) seedlings grown in a nursery will not survive being planted directly into open water. Successful establishment of plants into new wetlands requires an ability to control the wetland water level for the first 2 to 3 months following planting. Seedlings are best planted into damp but not waterlogged substrate and then the wetland water level lifted gradually over several weeks to allow the plants to acclimatise.

For shallow flooded zones, planting needs to occur soon after earthworks are completed. Most wetland plants do not grow much during winter and for many species the above-ground portions die back over this period. Ideally planting should take place in spring or early summer (September–December) to promote rapid establishment and to enable growth of a tall dense cover that can outcompete weeds. However, planting at this time is often difficult in practice, where ground conditions remain too wet for construction.

Planting later in summer (January–February) is possible if larger plant grades are used and a supplementary water source is available to keep the wetland moist. Planting smaller plants later in the season, or when the availability of supplementary water cannot be guaranteed, is not recommended. Instead, it is better to wait until the following spring to undertake planting.

During establishment, the water level should be maintained at 10-15cm above the wetland soil surface, once plants are established and have acclimatised. Plants can be initially planted into dry topsoil provided enough water can be supplied to cover the topsoil immediately after planting. If inflow to the wetland is insufficient during the initial establishment period, supplementary water may be necessary to avoid desiccation of young plants.

Flooding every 5–10 days or periodic spray irrigation may be used to maintain moist conditions. It is important that the water level is not raised above the height of the establishing plant shoots, as these act like a snorkel, conveying oxygen to the submerged portions of the growing plant. As the plants grow, the water level can gradually be raised. Pre-planting weed and pest control is important – this gets much harder once the wetland is flooded.

Once properly established (generally after two growth seasons), tall-growing wetland species should be sufficiently resilient to water level fluctuations, predation by wildfowl and other stressors.

7. Wetland costing

Construction cost can vary substantially depending on the site characteristics. The main costs are earthworks (cut and fill) to form the wetland channel, plant purchase and planting, and fencing.

Indicative construction and establishment costs per hectare for a treatment wetland are summarised in **Table 3**. Approximate costings are also provided for range of case studies below. This costing assumes that all work is undertaken by professional contractors charging at commercial rates. It also assumes a favourable site (low permeability substrate, no woody vegetation to clear, relatively level ground surface, contours favourable to wetland construction without excessive earthworks, sufficiently deep topsoil that can be re-laid on the excavated wetland base, a simple wetland shape that does not require extra fencing, and the assumption that cattle but not sheep need to be fenced out. This costing also assumes that no resource consent is necessary to construct a wetland but it is important to note that in some regions, a consent may be required, and will carry a cost.

Table 3: Indicative cost per hectare (2020) to establish a new treatment wetland if all work is undertaken by contractors at commercial rates.

Cost item	Indicative cost	$/ha (excl GST)	Notes/Explanation
Site survey and wetland design	Lump sum	$3,000 - $7,000	Survey of wetland site and design, including positioning of inlet and outlet structures, treatment basins and estimate of excavation works.
Earthworks	$6.25/m^2 of wetland surface area for initial site clearance. $15/m^3 for excavation.	$110,000 - $130,000	Includes excavation and re-laying of topsoil to form wetland base for planting, and construction of a suitable weir and outlet structure at downstream end. Excludes provision for fish passage structures.
Fencing	$5 - $10 /linear metre (plus gate)	$1,000 - $5,000	Two or four-wire electric fence on 2 or 4 sides of wetland; assumes optimised wetland shape to minimise fence length.
Plant purchase	$1.80 - $5 /plant	$25,000 - $60,000	2.04 plants per square metre (0.7 m spacings) within the wetland area to be flooded; all plants purchased from commercial nurseries.
Planting	$2 - $3/plant	$28,000 - $43,000	Assumes planting is done by commercial planters.
Replacement planting (blanking)	$1.80 - $5/plant	$2,500 - $5,000	5% mortality assumed; includes plant purchase and planting.
Project /construction management	$1.00/m^2 of wetland	$10,000	Earthworks and planting supervision.
Resource consent	Variable.	Variable.	Dependent on regional council.
Maintenance/weed control	Lump sum	$2,000 - $4000	Per annum. Assumes bi-yearly clean-out of sedimentation pond.
Total construction cost/ ha		175,000 - $260,000	Assumes all work is done by professional contractors at commercial rates. Excludes resource consent costs.

Opportunities to reduce cost

The costs of constructed wetlands can be reduced in a number of ways. Excavation costs can be minimised by locating wetlands in natural depressions that may already exist as natural drainage channels or represent historical wetland areas that have been drained and are not subject to protection as natural wetlands under current legislation. In this situation less earth will need to be moved to create a wetland if part of a natural channel already exists.

The greatest potential to reduce wetland costs lies with planting. Planting costs can be reduced on-farm by using staff, community groups and family to do the planting. Initial supervision and instruction by a professional with wetland planting experience is necessary but otherwise planting can be carried out by people with minimal experience.

Some wetland plant species suitable for wetland margins and riparian zones, especially rushes i.e. *Juncus* may already be present in grazed seepage wetlands or wet farm depressions that don't need excavation. Simply removing grazing pressure while controlling any weed species may be sufficient to enable those remnant plant populations to thrive and expand across the wetland area naturally. Sourcing plants from other parts of the farm can also be considered although it is generally recommended to use high quality plants sourced from nurseries for newly constructed systems, to ensure successful plant establishment. Note that species such as rushes, which grow in wet pastures will generally not survive in water depths >100mm for more than a few weeks.

8. Maintenance

A well-established wetland will have only minor maintenance requirements (**Table 4**), provided that wetland plants establish rapidly and the potential for invasive weed species to enter the wetland and become a nuisance is minimised. Common "weeds" in wetlands include pasture species such as Yorkshire fog (*Holcus lanatus*), mercer grass (*Paspalum distichum*) and wetland weeds such as reed sweetgrass (*Glyceria maxima*). Manual removal or chemical control should be done before the weeds become well established. Herbicides used should only be formulations that are permitted for use in or near waterways. Although both glyphosate and diquat are permitted by the EPA, local regional council rules may also apply and should also be checked before using herbicides. A number of other herbicides can be used with care around wetlands and under dry conditions providing there is low risk of water contamination.

Once wetland vegetation has established, wetland maintenance involves periodic checking of inlets and outlets, and clearance of any blockages; checking structural integrity of any embankments, dams and high-level overflows; weed management around the wetland; and maintenance of gates and fences.

Removal of accumulated sediments from the sedimentation trap/pond will be necessary periodically. The frequency of sediment removal is highly dependent upon the size of the sedimentation pond and the quantity of incoming sediment. Sediment removal should be undertaken when the pond is about half full so it keeps working optimally and does not resuspend sediment during stormflows.

Table 4: Requirements during and after wetland establishment.

Fortnightly action list for first three months	
Plants	Visual inspection of plant health and damage by pūkeko or other birds/animals. Check water level and adjust as appropriate (particularly during dry periods or periods of low inflow). Control weeds in wetlands and surrounds by hand-weeding, careful herbicide application, and/or temporary water level increases.
Inlet	Visually check for adequate inflow and identify any blockages or damage.
Outlet	Adjust outlet height so plants are not drowned. Check for blockages and damage. Clear any plants or debris away from outlet to maintain unrestricted flow and optimal water level.
Embankments	Inspect for weeds, erosion, and damage by pūkeko, rabbits or other birds/animals.
Seasonal action list once established	
Plants	Visual inspection of plant health, weed and pest problems, take remedial action as necessary.
Inlet	Visually check for adequate inflow and identify any blockages or damage.
Outlet	Check for blockages and damage, clear any plants or debris away from outlet. Check water level and outflow quantity (is it normal based on recent rainfall levels?).
Embankments	Where required, control weeds on inner embankments by hand-weeding or herbicide application, mow, or graze with sheep to control grass on embankments and wetland surrounds but avoid damage to any native plantings.
Sedimentation pond(s)	Check accumulation of sediment. If the pond is more than 1/2 full of sediment, it requires emptying.

9. Constructing effective wetlands to reduce contaminant loss from dairy farms: case study examples from Northland to Southland

The following case studies, located throughout New Zealand, provide examples of constructed wetlands that have been developed to improve water quality and provide wetland habitat. They encompass a range of wetland designs, contaminant reduction performance, and construction costs.

Case Study 1: Titoki

Location:	Maungatapere, Northland	
River catchment:	Mangakahia	
Year constructed:	2000	
Wetland configuration:	On-line two-celled constructed wetland	
Treatment area:	900m^2 (1.6% of catchment)	
Wetland catchment area:	5.65ha, irrigated dairy pasture	
Scope:	The farm is a 1000-cow, 300ha dairy farm. The wetland receives subsurface tile drainage from pastures irrigated with dairy shed wastewater as well as dam water during dry spells. Monitoring in the first 3 years showed a high annual drainage yield of ~ 800mm/yr with annual nitrogen losses 72-109kg/ha. The first cell is deeper, up to 1.3m, with open water areas. The second cell is shallower (0.2-0.4m) and fully vegetated with a mix of native sedges.	
Additional information:	Use of fertile agricultural topsoils in the wetland resulted in dissolved P release relative to low inflowing concentrations from tile drainage. Monitored for 3 annual periods (2001-4) by NIWA.	
Approximate cost*:	$ (Farmers undertook construction and planting themselves)	
Wetland Performance:**	Nitrogen - 18-38% reduction	Phosphorus – variable with overall small-moderate increase
	Sediment – not monitored	Faecal indicator bacteria – small increases during normal flows, but large reduction (>99.99%) recorded during 5 days of accidental inflow from burst effluent irrigation pipe
*** $ < $20,000 $$ $20,000-$80,000 $$$ > $80,000; $$$$> $200,000** ****Average annual proportion of contaminants removed relative to receiving load**		

Two-stage constructed wetland soon after construction and planting (top) and one year later when plants have established (bottom). Arrows show inflow of subsurface tile drainage and its passage through the wetland, finally discharging to the stream behind.

Case study 2: Whangamaire

Location:	Taupiri, Waikato
River catchment:	Tributary of the Mangawara Stream, Waikato
Year constructed:	2019
Wetland configuration:	Four 0.3m deep cells in series, each planted with a single species of wetland plant. The inflow is diverted from a nearby surface drain with excess flows able to pass down the existing drain.
Treatment area:	0.27ha (0.6% of catchment)
Wetland catchment area:	43ha
Scope:	This wetland is situated on the Walker farm and is placed in an area of native trees and shrubs which had previously been retired from grazing. The system was designed as a New Zealand interpretation of the Integrated Constructed Wetland concept developed in Ireland and the UK. The wetland cells are irregularly shaped and sized to fit within previously planted native trees, which resulted in a natural appearance. The design and construction were jointly managed by Manaaki Whenua Landcare Research and NIWA as a demonstration site. Scientific assessment of performance was undertaken over a one-year period. Funding was provided by the Ministry for the Environment's Community Environment Fund, with contributions from landowners, Manaaki Whenua Landcare Research and NIWA.
Additional information:	Initial establishment of plants in two wetland cell was poor. This allowed some growth of algae and floating macrophytes in the open water areas. These areas have now been successfully replanted.
Approximate cost*:	$$
Wetland performance:**	Low intensity monitoring soon after wetland establishment showed phosphorus reduction was >50%. Apparent nitrogen removal was minimal, likely due to minimal build-up of leaf litter, associated with the early stage of development of this wetland and is expected to improve with time.
*** $ < $20K $$ $20-$80K; $$$ $80-200K; $$$$> $200K**	

The serpentine path of the wetland excavated into a boggy area previously planted with harakeke/flax and native trees is shown soon after planting (left) and from the opposite end once wetland vegetation was fully established (right).

Case Study 3: Toenepi

Location:	Kiwitahi, Matamata-Piako, Waikato	
River catchment:	Toenepi Stream, Piako River catchment	
Year constructed:	2000	
Wetland configuration:	In-line two celled, shallow (0.3m deep) elongated wetland cells in series.	
Treatment area:	260m^2 (1.1% of catchment)	
Wetland catchment area:	2.6ha	
Scope:	The wetland is situated on a 130 ha dairy farm. It receives subsurface tile drainage water and is vegetated primarily with raupō (*Typha orientalis*), with harakeke/flax plantings on the embankments. The wetland was designed by NIWA primarily to evaluate nitrate removal performance.	
Additional information:	The first and most studied agricultural constructed wetland in New Zealand, with 6 years of performance monitoring by NIWA (2001-6, 2010/11). Use of fertile agricultural topsoils in the wetland resulted in dissolved P release relative to low inflowing concentrations from tile drainage.	
Approximate cost*:	$$	
Wetland performance:**	Nitrogen - 30% reduction.	Phosphorus – variable with overall small-moderate increase.
	Sediment - not measured.	Faecal indicator bacteria - overall small-moderate increase.
*** $ < $20K $$ $20-$80K; $$$ $80-200K; $$$$> $200K**		
****Average annual proportion of contaminants removed relative to receiving load**		

Two-celled linear wetland soon after construction (left) and once plantings established (right). Flows from subsurface tile drains enter in the foreground and exit at the far end to a open farm drain. The wetland was built along the edge of the paddock so it was out of the way of farming operations and easy to fence off.

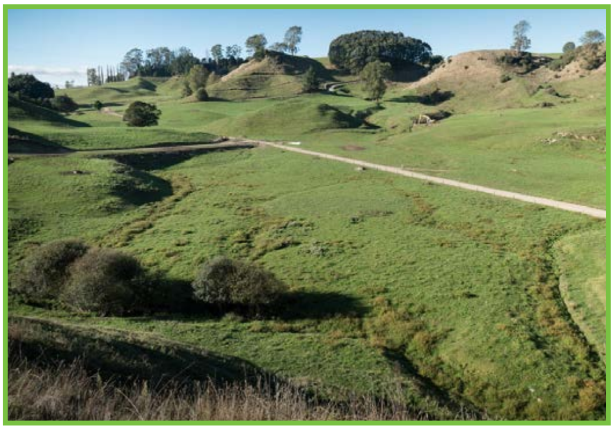
Case Study 4: Owl Farm

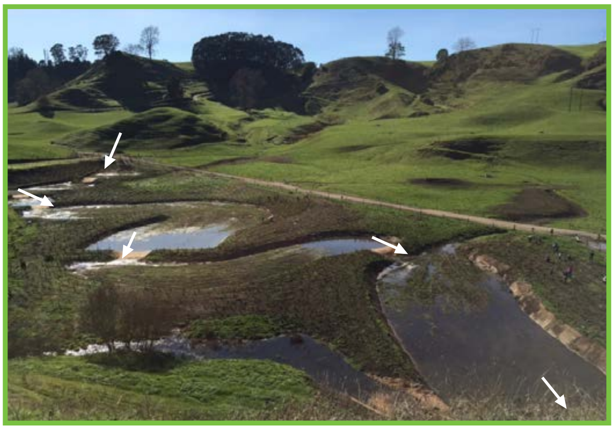
Location:	St Peters School Farm, Cambridge, Waikato	
River catchment:	Waikato	
Year constructed:	2016	
Wetland configuration:	In-line multi-celled, linear configuration	
Treatment area:	0.34ha (4.5% of catchment)	
Wetland catchment area:	7.6ha, predominantly dairy	
Scope:	A 160ha, 400 dairy cow demonstration farm, joint venture between St Peter's School and Lincoln University. The wetland receives approximately equal inputs of diffuse groundwater and tile drained groundwater and is vegetated with a mix of native sedges, with self-established raupō in patches. It was designed and constructed by Opus Consultants, with funding for construction from the Waikato River Authority and Waikato Regional Council, and in-kind support from The Livestock Improvement Corporation, PGG Wrightson Seeds, DairyNZ, Ballance Agri-nutrients, Fonterra Farm Source, Lincoln Agritech and Westpac Bank.	
Additional information:	Extensive riparian planting and fencing around the wetland. Monitored for 4 years (2008-12) by NIWA. Wetland visited and performance reported as part of focus days for farmers and rural professionals and at open-days for the public. The school uses the area as part of its education programme.	
Approximate cost*:	$$	
Wetland performance:**	Nitrogen - 50% reduction.	Phosphorus - 15% reduction.
	Sediment - 45% reduction.	Faecal indicator bacteria - increase due to resident wildlife in wetland.
*** $ < $20K $$ $20-$80K; $$$ $80-200K; $$$$> $200K** ****Average annual proportion of contaminants removed relative to receiving load**		

Wetland receiving tile drainage and shallow groundwater seepage in the foreground before flowing though a series of cells to a surface drain leading to the Waikato River just over the hill.

Case Study 5: Baldwins

Location:	Lichfield, South Waikato	
River catchment:	Ngutuwera Stream, Pokaiwhenua/Karapiro catchment	
Year constructed:	2015	
Wetland configuration:	On-line multi-celled with initial sediment pond and seven wide, shallow (0.3 to 0.5m deep) interconnected basins.	
Treatment area:	0.642ha (1.2% of catchment). Total area of 1.1 ha including final cell of wetland (not monitored) and riparian plantings.	
Wetland catchment area:	52ha	
Scope:	Design, construction and scientific assessment of a 0.5ha constructed wetland on a 267ha dairy farm. Part of a 5-year research project to provide greater knowledge on wetland design, performance, and practicality to Waikato dairy farmers. Led by DairyNZ and undertaken in partnership with Baldwin Family Trust, the Waikato River Authority, Opus International Consultants (Hamilton), Waikato Regional Council, Hill Laboratories, and NIWA. Project included extensive monitoring of water flows and contaminant concentrations to determine wetland performance over several seasons. Protection, restoration, and scientific monitoring of three adjacent shallow groundwater seepage wetlands was also undertaken.	
Additional information:		
Approximate cost*:	$$$	
Wetland performance: **	Nitrogen - 60% reduction	Phosphorus - 20% reduction
	Sediment - 70% reduction	Faecal indicator bacteria - 80% reduction
*** $ < $20K $$ $20-$80K; $$$ $80-200K; $$$$> $200K**		
****Average annual proportion of contaminants removed relative to receiving load for 0.642 ha proportion of wetland area monitored**		





Site before (left) and after (right) wetland construction in a low-lying valley. A sedimentation pond at the far inlet end is an important component sustaining the longer-term operation of this wetland. Arrows indicate direction of water movement through the wetland.

Case Study 6: Okaro

Location:	Lake Okaro, Te Arawa Lakes, Rotorua, Bay of Plenty	
River catchment:	Small un-named stream - the main surface inflow to Lake Okaro	
Year constructed:	2006/2007	
Wetland configuration:	Two-celled off-line constructed wetland	
Treatment area:	2.3ha (0.7% of catchment)	
Wetland catchment area:	359ha. Predominantly dairy, with beef and sheep grazing in headwaters.	
Scope:	The Birchall family provided 2ha of their farm and the Rotorua Lakes Council 0.3ha of lake-side reserve land for construction of the wetland. The wetland receives surface waters from a channelised stream. The stream is diverted into the wetland via a timber weir, which allows for bypassing of excess stormflows via the old stream channel. Earthen bunds are used to create a long serpentine path through the wetland. Construction and planting of the wetland was managed by NIWA and Opus Consultants, with funding from the Bay of Plenty Regional Council, as part of the Te Arawa Restoration Program. The wetland was planted throughout with a mix of native sedges, and the riparian zones with native plants such as harakeke/flax and toetoe, tī kōuka/cabbage tree and mānuka.	
Additional information:	The performance of the wetland was monitored for 3 years (2008-10) by NIWA with funding from BoPRC and the Pastoral 21 consortium. The catchment is rolling to steep with Rotomahana mud soils. A detainment bund has been recently constructed in the upper catchment to buffer stormflows and associated export of sediment and particulate phosphorus.	
Approximate cost*:	$$$$	
Wetland performance:**	Nitrogen – 12-41% reduction (77-80% of nitrate-N)	Phosphorus – 12-60% reduction
	Sediment – 71-88% reduction	Faecal indicator bacteria – 89-96% reduction
*** $ < $20K $$ $20-$80K; $$$ $80-200K; $$$$> $200K** ****Average annual proportion of contaminants removed relative to receiving load**		

Well established wetland at Okaro receiving diverted stream-flows showing native wetland and riparian plantings. Note the farmers house situated alongside the wetland.

Case study 7: Awatuna

Location:	Awatuna, South Taranaki
River catchment:	Unnamed tributary of Oeo Stream, Taranaki
Year constructed:	2019
Wetland configuration:	In-line, multi-celled, with an initial 1.5m deep sediment pond followed by three elongated, shallow (0.3-0.6m deep), densely vegetated cells in series. No high flow bypass constructed, since the wetland is in-line and occupies a widened section of an agricultural drainage ditch, with predominant inflows from subsurface drainage. The system has been planted with a mix of native sedges.
Treatment area:	0.44ha (2.2% of catchment)
Wetland catchment area:	18ha predominantly dairy
Scope:	Taranaki Regional Council, NIWA, and the Cram family initiated the construction of this wetland as a regional demonstration site in 2019. The Cram family agreed to retiring some marginally productive pasture, fencing the wetland, and maintaining long-term weed control in the wetland. Scientific assessment of nutrient, sediment, and *E. coli* load reductions have been initiated as part of a 4-year NIWA-led, MPI-funded Sustainable Land Management and Climate Change Freshwater Mitigation Fund Project, with in-kind funding from Taranaki Regional Council's Wetland Consent Fund and support from DairyNZ and Beef + Lamb NZ.
Additional information:	Taranaki Regional Council conducts a semi-annual biodiversity survey of the flora and fauna in the constructed wetland. The landowners maintain rat and stoat traps around the wetland for mammalian pest control.
Approximate cost*:	$$
Wetland performance:**	Monitoring in progress.
*** $ < $20K $$ $20-$80K; $$$ $80-200K; $$$$> $200K**	

Newly constructed and planted wetland (left) showing direction of flow through initial deep sedimentation pond and subsequent two shallow elongated cells. Plant cover after one year shown on the right.

Case study 8: Ashley Clinton

Location:	Southern Hawke's Bay
River catchment:	Unnamed tributary of Avoca Stream, Tukipo subcatchment of the Tukituki River
Year constructed:	2021
Wetland configuration:	Off-line, five interconnected cells, with initial sedimentation pond (>1.5m deep). Shallow planted zone 0.3-0.6m deep occupying 50-60% of wetland, with deep open-water zones at the inlets and outlets of each cell to disperse inflows and re-collect outflows before passage to the next cell. A high flow bypass channel routes storm flows around the wetland to the main waterway downstream of the wetland outlet. The final cell was left primarily as a shallow, densely planted zone 0.3m deep.
Treatment area:	1.6 ha (0.9% of catchment)
Wetland catchment area:	180ha dry-stock farm
Scope:	Design and construction funded by Hawke's Bay Regional Council and Fonterra in partnership with NIWA. The White family agreed to retiring some marginally productive pasture where the wetland was built, fencing the wetland and adjoining native forest patch, and maintaining long-term weed control in the wetland. Scientific assessment of nutrient, sediment, and *E. coli* load reductions have been initiated as part of a 4-year NIWA-led, MPI-funded Sustainable Land Management and Climate Change Freshwater Mitigation Fund Project, with in-kind funding from HBRC and support from DairyNZ and Beef + Lamb NZ.
Additional information:	The wetland location was identified by NZ Landcare Trust through a regional constructed wetland scoping initiative supported by Hawke's Bay Regional Council. A 7.5ha patch of remnant native forest (predominantly totara) is located adjacent to the wetland and will be fenced and placed under QEII Trust protection. A wetland of this size is expected to provide habitat for bittern, and the adjacent large trees in the forest patch might be suitable for bat roosts. At the request of the landowner, several of the open water areas were built large enough to be attractive for duck hunting.
Approximate cost*:	$$$
Wetland performance:**	Monitoring in progress.
*** $ < $20K $$ $20-$80K; $$$ $80-200K; $$$$> $200K**	

Establishing wetland plantings after six months growth. Arrows show flow path through the wetland cells. Flow enters in the top right from a stream that flows through the patch of native forest and from upwelling shallow groundwater. The dotted line shows high- level flow bypass channel.

Case study 9: Kaiwaiwai

Location:	Kaiwaiwai Dairies Ltd, Southern Wairarapa	
River catchment:	Otukura Stream/Lake Wairarapa	
Year constructed:	2014	
Wetland configuration:	Off-line, multi-celled: an area of wet pasture land (0.75ha) converted to wetland with a surface area of approximately 0.5ha and an average water depth of 0.3m. Comprising three multi-hairpin cells (6m wide) connected in series, providing a serpentine flow path.	
Treatment area:	~0.5ha	
Wetland catchment area	Unknown. Estimated at approximately 630ha, but wetland only receives a portion of total flow.	
Scope:	A wetland planted with native species was constructed at Kaiwaiwai Dairies Ltd (405ha dairy farm) on an area of wet pasture land adjacent to a remnant stand of kahikatea and tōtara trees. Water from a perennial drain (est. normal flow ~60L/s) is diverted through the wetland at a constant flow rate of 14L/s. The area is fenced to exclude livestock. Aquatic planting includes raupō (*Typha orientalis*), Lake clubrush (*Schoenoplectus tabernaemontani*) and a cutty grass (*Carex geminata*). Project led by Groundtruth Ltd, and administered by Sustainable Wairarapa, with shared funding from the Ministry of Primary Industry, DairyNZ, NIWA, Greater Wellington and Landcorp. In 2016 Sustainable Wairarapa were awarded a Sustainable Farming Fund project to continue monitoring to measure effectiveness of the wetland. This included monthly monitoring of water flows and contaminant concentrations to determine seasonal wetland performance.	
Additional information:	This wetland differs in its design from that recommended in the present guide. Its objectives were to improve water quality and biodiversity. The highly serpentine design with multiple bunds was employed to minimise double handling of excavated earth when constructing the wetland, and to provide a high proportion of land-water edge habitat for wildlife. It provides a very long path length, but around a third of the area is taken up by embankments reducing the effective treatment area.	
Approximate cost*:	$$	
Wetland performance:**	Total Nitrogen: 38% removal Nitrate: 56% removal	Total Phosphorus: 21% export Dissolved Reactive Phosphorus: 24% export
	Total suspended solids: 6% reduction	Faecal indicator bacteria – not analysed
*** $ < $20K $$ $20-$80K; $$$ $80-200K; $$$$> $200K** ***Average annual proportion of contaminants removed relative to receiving load (computed from monthly load removal rates)**		

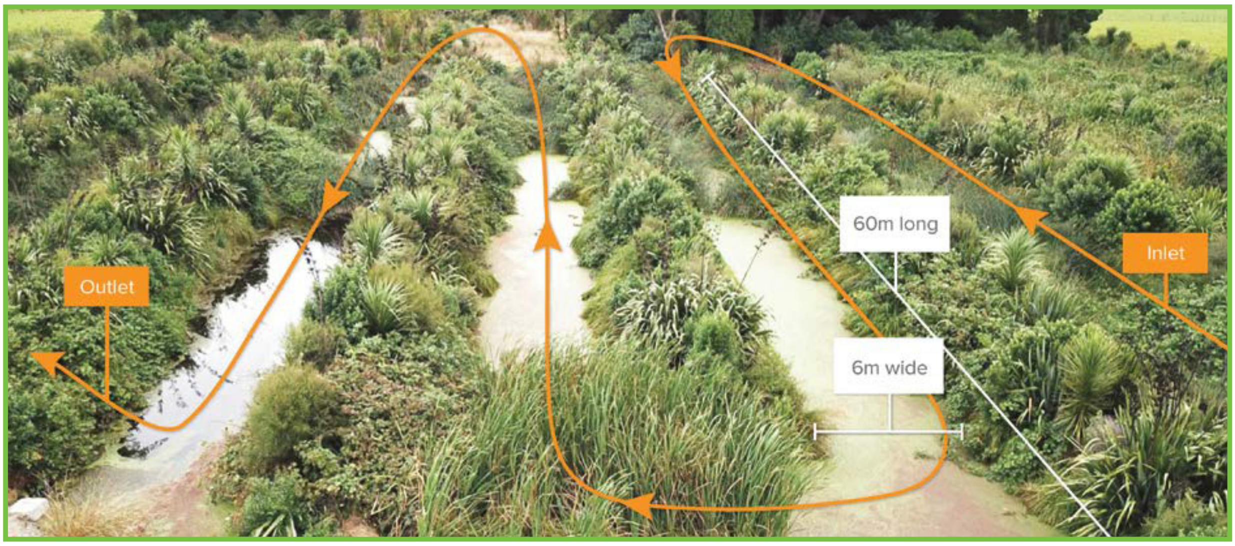
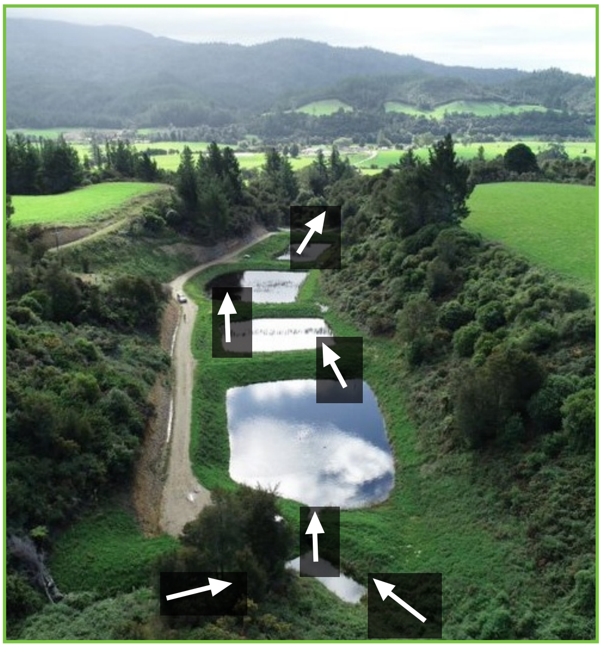


Photo shows serpentine flow-path though one section of the wetland. Shallower water depths would likely provide improved plant establishment and cover. Graphic courtesy of John-Paul Pratt (Groundtruth Ltd) and Neville Fisher (Kaiwaiwai Dairies).

Case study 10: Fish Creek

Location:	Takaka, Golden Bay	
River catchment:	Unnamed tributary of Fish Creek, Golden Bay	
Year constructed:	2020	
Wetland configuration:	In-line, four interconnected cells, with initial sedimentation pond (>1.5m deep). Shallow planted zone 0.3-0.6m deep occupies 70% of wetland with deep open-water zones at the inlets and outlets of each cell to disperse inflows (except for the final cell). An in-line high-flow bypass armoured with boulders and cobble is constructed between each cell to convey high storm flows through the wetland, since the catchment has very clayey soils and is subject to frequent periods of heavy rainfall (>2000mm annual rainfall). The system has been planted with a mix of native sedges.	
Treatment area:	0.3ha (1% of catchment)	
Wetland catchment area:	30ha predominantly dairy	
Scope:	Design and construction funded by Tasman District Council (TDC) in partnership with NIWA. The Page family provided the land in an unproductive gully and agreed to fence the wetland and maintain long-term weed control. Scientific assessment of nutrient, sediment, and *E. coli* load reductions have been initiated as part of a 4-year NIWA-led, MPI-funded Sustainable Land Management and Climate Change Freshwater Mitigation Fund Project, with in-kind funding from TDC and support from DairyNZ and Beef + Lamb.	
Additional information:	Focus on solar disinfection of faecal microbes to protect water quality of Waikoropūpū Springs during storm-flows, so wetland has ~40% deep, open water areas.	
Approximate cost*:	$$$	
Wetland performance:**	Low intensity monitoring soon after wetland establishment showed phosphorus reduction was >50%.	Apparent nitrogen removal was minimal, likely due to minimal build-up of leaf litter, associated with the early stage of development of this wetland and is expected to improve with time.
*** $ < $20K $$ $20-$80K; $$$ $80-200K; $$$$> $200K**		



Stepped series of wetland cells constructed in a natural gully viewed from the inlet (left) and outlet (right) ends. Wetland plantings are still establishing.

Case study 11: Warnock's

Location:	Warnock's Farm	
River catchment:	Waituna Lagoon, Southland	
Year constructed:	2015	
Wetland configuration:	In-line, open water constructed wetland positioned down-stream of a pre-existing duckpond	
Treatment area:	0.22ha. wetland (0.65% of catchment) below 0.42ha pond (total system 1.9% of catchment)	
Wetland catchment area:	34ha	
Scope:	Open wetland intercepting flow from a permanently flowing first-order stream on a 424ha dairy run-off farm in Waituna catchment, Southland. Built in 2015 based on guidance from NIWA, DairyNZ and Environment Southland, and planted with native emergent plants (tall spike rush/kuta, (*Eleocharis sphacelata*). Wetland intercepts discharge from a pre-existing duckpond. Performance monitored monthly (10 samples collected at 5 locations through treatment system, over years 2017, 2018). Parameters monitored: nitrate, total-N, ammonium, DRP, total-P, TSS, turbidity, DO, electrical conductivity, *E. coli*, temperature, turbidity, water clarity & flow. Nitrate comprised ~30% of total-N load. Median concentration 0.62mg NO^{3}-N/L). Average concentration 1.08 mg NO^{3}-N/L. Flows ranged <2 to 70L/s (median 2 L/s); HLR in wetland ranged 29-10^{3} m/yr (median 29m/yr).	
Additional design features:	Duckpond up-stream of wetland which functions as a sediment pond. Two experimental filter beds, one filled with limestone and the other with oyster shells, were constructed to further reduce phosphorus concentrations in the outflow. The additional P reduction measured was marginal.	
Approximate cost*:	$$ (excluding filter beds).	
Wetland performance:**	**Nitrogen :** Nitrate-N: Duckpond = 28% reduction. Wetland = 32% reduction. Collectively = 51% reduction. Total-N: Duckpond = 28% increase due to groundwater inflows. Wetland = 42% reduction. Collectively = 26% reduction.	**Phosphorus :** Dissolved reactive phosphorus (DRP): Duckpond = 33% reduction Wetland = 89% reduction Collectively = 92% reduction Total phosphorus: Duckpond = 44% reduction Wetland = 71% reduction
	Sediment (total suspended solids): Duckpond = 90% reduction TSS loads into wetland too low to detect change	*E. coli*: Duckpond = 73% reduction Wetland = 81% reduction Collectively = 95% reduction
*** $ < $20K $$ $20-$80K; $$$ $80-200K; $$$$> $200K**		
****Average annual proportion of contaminants removed relative to receiving load**		

Wetland viewed from the inlet showing emergent beds of kuta and island in the background. Greater plant coverage particularly on the margins would improve the performance of this wetland.

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New Zealand Landcare Trust: https://www.landcare.org.nz/

New Zealand National Wetland Trust: https://www.wetlandtrust.org.nz/

New Zealand Fish Passage Guidelines: https://niwa.co.nz/freshwater-and-estuaries/research-projects/new-zealand-fish-passage-guidelines

Appendix 1: Construction timeline

	Planning Period	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer	Autumn	Winter	Spring	Summer
Plan wetland - identify appropriate site, delineate catchment, determine appropriate wetland size and associated contaminant reductions, determine appropriate design configuration, get quotes for construction and planting.																
Check regulations with local Council. Discuss proposed design. Supply required information and apply for consent if required.																
Determine construction requirements and book contractor/machinery hire and any engineering oversight required.																
Pre-order plants.																
Construct wetland.																
Plant embankments.*																
Plant wetland.																
Control weeds, pre- and post-planting and manage pests. Irrigate plants if required.																
Check and maintain wetland inlets and outlets (water levels), embankments, sedimentation pond																

* Planting is optimal in spring and early summer, but construction generally has to occur in summer, requiring planting in late summer and early autumn, or in the following spring.

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Ministry for Primary Industries
Manatū Ahu Matua

Contaminant reduction performance of constructed wetlands intercepting farm runoff

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Contaminant reduction performance of constructed wetlands intercepting farm runoff

Final report

Prepared for Ministry for Primary Industries

November 2024

Climate, Freshwater & Ocean Science

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Cover image: *Council science staff and landowners admiring the Awatuna constructed wetland on a South Taranaki dairy farm. [Stuart Mackay, NIWA]*

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Executive summary

The delivery of diffuse-source contaminants from agricultural land-use, including sediment, nutrients, and faecal material, degrade water quality, mahinga kai (food gathering locations), and recreational values of waterways over significant areas of New Zealand. Interceptive eco-technologies are available for addressing these issues and complement on-farm, source controls of diffuse pollution losses. Constructed wetlands (CWs) are a versatile and robust eco-technology examined here.

NIWA worked in partnership with councils (Bay of Plenty Regional Council, Environment Canterbury, Hawkes Bay Regional Council, Taranaki Regional Council, and Tasman District Council), rural industries (Baygold, Beef + Lamb, DairyNZ, and Fonterra), and farmers to quantify and demonstrate the field-scale performance of CWs for reduction of sediment, nitrogen, and phosphorus diffuse pollution from mixed surface runoff and groundwater inflows. Our aim was to fill critical information gaps identified in a recent, systematic review of local and international field performance data that supported development of comprehensive New Zealand guidelines for constructed wetlands. This work was funded by a four-year MPI Sustainable Land Management and Climate Change (SLMACC) Freshwater Mitigation contract 406368 ‘Quantifying constructed wetland contaminant attenuation’ from July 2020 to June 2024.

Comprehensive monitoring of the flow and water quality at inflows and outflows at three pre-existing CWs and three new CWs (established for this study) in contrasting landscape settings was undertaken from 2021-2024. The CW sites are located in Canterbury, Golden Bay, Hawke’s Bay, Taranaki, and the Bay of Plenty. There are not yet any performance data for the on-farm CW in Hawke’s Bay to report, and case study findings from the off-line, floodplain CW in Canterbury are reported separately.

This report focuses on the four ‘on-farm’ CW in Bay of Plenty (2 CWs), Tasman, and Taranaki, where 1–3 site-years of telemetered, near-continuous high-frequency flow, turbidity, and nitrate data and regular and storm event-based water quality data were available for evaluation. Water quality variables monitored at each wetland were: suspended sediment (SSC), total phosphorus (TP), dissolved reactive phosphorus (DRP), total nitrogen (TN), nitrate-N, ammonium-N, and the faecal indicator bacteria *Escherichia coli*. The annualised load reductions (percent removal) for TN, TP, and SSC are reported here and compared against predictions based on the existing CW Practitioner Guidelines performance models.

Annual mass loads of SS, TN, and TP for the CW inflow and outflows were estimated using a range of modelling tools. Contaminant export and CW attenuation performance were therefore able to be determined. Groundwater mass loading to CW was determined based on approximately monthly grab sample data and water volumes estimated with annual mass balances (e.g., groundwater flow volume = surface outflow volume – surface inflow volume– net rainfall volume). Measured and flow-proportional concentrations and percentage reductions, mass removal (g m^{-2} CW yr^{-1}), and percentage mass removal were used to assess CW treatment efficacy of TN, TP, and SS on an annual basis. To provide better comparison with diffuse pollution losses from farming and demonstrate CW removal per unit catchment area, the surface and groundwater (combined) catchment inflow loading rates and annual CW load removal rates were also calculated as specific yields in kg ha^{-1} yr^{-1}.

The four studied CWs spanned a range of scales (e.g., CW sized between 1 – 3 % of their corresponding catchment areas) and landscape types, with annual rainfall totals varying from 1200 to

>3000 mm across wetlands and years. There were markedly different proportions of surface run-off (e.g., <5% to >95% of annual outflow volume across different wetlands and years), subsurface drainage, and groundwater hydraulic loading. These case studies add significantly to previous CW performance data for New Zealand, which was largely focussed on tile-drainage-dominated agricultural catchments. Seasonal catchment runoff yields and hence, CW inflows and outflows, were greatest from May to October each year, with surface inflow hydraulic loading rates varying from <1 to > 130 m across CW and years. Inflows showed high year-to-year variability, with wetter conditions during a La Niña year providing elevated hydraulic loading, followed by reduced hydraulic loading under drier conditions in an El Niño year.

Combining this high-resolution flow data with contaminant concentrations enabled us to quantify CW load reductions. This provides performance data across a much broader range of sites, regions, and farming systems over a range of annually and seasonally varying flows, than what has been previously quantified. Overall, the annual CW performance (annual % load reductions) determined here are consistent with previous New Zealand studies. Performance estimates for TN were consistently at or above predictions based on the provisional guideline values in Tanner et al. (2022). In contrast performance estimates of SS and TP varied substantially across the CW and year-year. SS performance was lower than anticipated, likely due to relatively low loads intercepted by the wetlands, as well as differences in the hydraulic loading rate in wet versus dry years.

Comparison of SLMACC CW annual load reduction performance against predictions from Tanner et al. (2022) based on wetland:catchment area. Wetlands are ordered according to increasing size relative to their catchments (CW:catchment area, %). Model predictions for the corresponding CW:catchment area annual load reduction efficiencies are shown in parentheses. Model predictions for TN are from the warm zone, and model predictions are for TSS not SSC.

Parameter		Fish Creek CW:catchment ratio 1.2%		Pongakawa CW:catchment ratio 2.1%		Awatuna CW:catchment ratio 2.3%		Maniatutu CW:catchment ratio 2.7%	
TN	Avg %	29	(26)	39	(36)	35	(38)	75	(42)
	Range %	27-33	(22-34)	13-70	(30-44)	28-47	(32-46)	75	(34-50)
TP	Avg %	16	(28)	90	(36)	41	(38)	86	(40)
	Range %	12-19	(20-36)	77-99	(25-46)	9-62	(26-48)	86	(27-52)
SS	Avg %	33	(52)	1^{*}	(66)	12	(66)	3^{**}	(73)
	Range %	13-55	(35-80)	1^{*}	(45-93)	4-18	(48-95)	3^{**}	(51-99)

Pongakawa SS*: the main inflow is groundwater with sediment concentrations ~laboratory limit of detection, so cannot directly compare to the guidelines which are for surface inflow wetlands
Maniatutu SS**: storm sample SSC data were missing for this period, so the estimate is very conservative and reflects baseflow with low sediment inputs (hence low removal)

This project established a 'demonstration network' of CWs, showing how they can improve attenuation of diffuse runoff in pastoral landscapes. The six SLMACC wetland demonstration sites established and promoted across the country serve as educational platforms that showcase the practical application, benefits, and fit of wetlands within a range of diverse farm systems and landscapes. Field days geared towards farmers and rural professionals were hosted at several of the wetlands to communicate interim project data, and the project was extensively communicated to stakeholders and next-users through over 50 science communication outputs.

Overall, building the scientific evidence base is crucial to provide farmers with reliable measures of CW efficacy. This provides confidence in CW cost-benefit as mitigation tools and accounting for their contaminant load reductions in farm nutrient budgets and environment plans. Some key recommendations for further work to improve confidence in the CW performance estimates presented are to:

- compile, verify, and analyse new, additional months and years of monitoring data collected after May 2024 to complete the annual periods of data available, and provide additional annual data records,
- calculate diffuse pollutant loading and attenuation with dynamic modelling that expands on the hydrological process-based models used to date,
- investigate the mass balance transformations of different forms of nitrogen and phosphorus,
- estimate *E.coli* attenuation. Note that it is more difficult to calculate *E.coli* attenuation due to fewer data (particularly no continuous data) and the uncertainty of the dynamics of *E.coli* within the wetland (e.g., Stott et al. 2023),
- quantify any seasonality in contaminant removal rates, or differences between base flow and storm flows, and
- investigate any trends in wetland performance over years since the wetland was established.

This work provides quantitative evidence of the performance of CW for reducing SS, TN, and TP loads from pastoral land. This information can be used improve national-scale mitigation systems modelling. The data also provide a robust evidence base for supporting implementation of CW in action plans and limit-setting processes. Farmers can also have confidence that the implementation of appropriately sized and designed CWs on their land will enable them to claim nutrient reductions to achieve required contaminant loss limits. The information will also be of use to industry and rural professionals, for them to confidently promote their use.

1 Introduction

1.1 Background

Diffuse-source agricultural contaminants, including nutrients, fine sediment, and faecal contaminants, degrade water quality, mahinga kai (food gathering locations), and recreational values of waterways over significant areas of New Zealand. To mitigate these adverse impacts, a range of eco-technologies can be implemented to intercept and attenuate contaminants (Tanner et al. 2020a). Among the different eco-technologies, constructed wetlands (CWs) are one of the top contenders for widespread implementation in New Zealand (Tanner et al. 2020a; Tanner et al. 2020b). Surface-flow CWs, comprised of vegetated shallow channels or a series of impoundments, are the most suitable and lowest-cost type of wetland to construct for intercepting diffuse farm runoff. They function with water flowing slowly through beds of emergent aquatic plants such as sedges and bulrushes (Figure 1-1). Their simplicity, passive and continuous functioning, and robustness under highly variable flow conditions make them widely applicable across a range of farm types and landscape settings.

Constructed wetlands can effectively reduce multiple contaminants from farm run-off (Crumpton et al. 2020, Kadlec 2012, Tanner and Sukias 2011). Provisional estimates from New Zealand studies suggest that, as their relative size increases from 1-5% of their contributing catchment, median annual removal efficacies will increase (Tanner et al. 2022). The range of performance increases from ~50 -90% for Total suspended solids (TSS), ~26-48% for total phosphorus (TP), and ~25-53% in for total nitrogen (TN) in warm regions and ~17-38% for Total Nitrogen in cool regions (Tanner et al. 2022). However, performance data for CWs receiving mixed surface run-off, surface and subsurface drainage, and groundwater inflows is very limited, particularly in situations relevant to pastoral farming systems and humid oceanic climates, such as New Zealand's (Woodward et al. 2020).

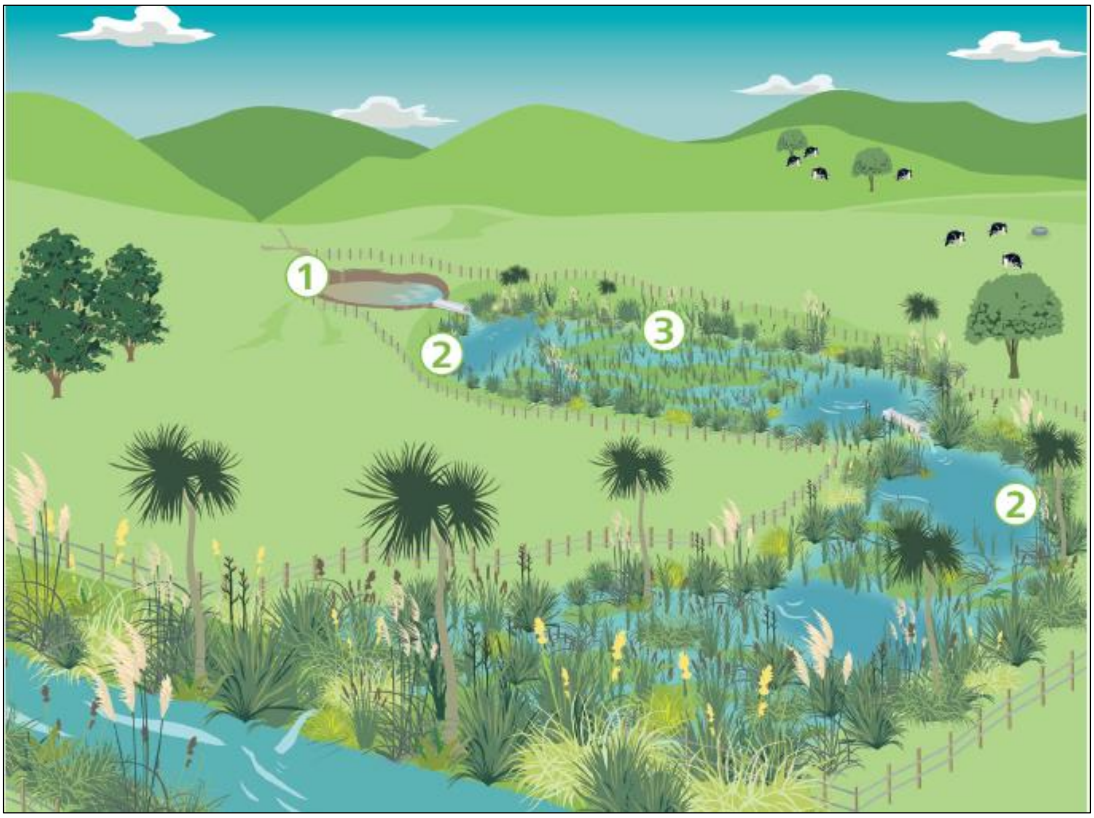

Figure 1-1: Features of a surface flow constructed wetland on the landscape (from Tanner et al. 2022). (1) A deep sedimentation pond (more than 1.5m deep), size will depend on rainfall intensity and topography but generally up to 20% of wetland size, (2) Deep (over 0.5m) open water zones at the inlet of each cell to help dispersion and mixing, and even out the flow (3) Shallow (average 0.3m deep), densely vegetated zones (at least 70% of the total area). This is where most of the nitrogen removal happens via microbial denitrification, fuelled by decaying plant leaf litter. Maintain dense plantings in the outlet zone to limit faecal contamination by waterfowl

Most of the overseas CW performance data are for arable agriculture and more extreme continental climates, focussing on nitrate removal from intensively tile drained areas. There are major knowledge gaps for removal of suspended sediment (particularly for clay-rich soils), phosphorus, and faecal microbial contaminants from surface run-off and drainage ditches (Woodward et al. 2020). Such flow paths predominate over substantial areas of pastoral farming in New Zealand (McDowell et al. 2008, Srinivasan et al. 2020, Wilcock 2008). Moreover, there is very limited field data on the flow regimes, and contaminant concentrations and loads, that occur at field and sub-catchment scale in these situations. Hence, growing and improving the scientific evidence base is crucial to provide farmers with reliable measures of CW efficacy. This will help assess CW cost-benefit as mitigation tools and apply and size CW appropriately. It is also needed to provide sufficient assurance for regulators to allow farmers to claim CW nutrient reductions to achieve required contaminant loss limits, and for industry and rural professionals to confidently promote their use.

1.2 Study aims

Our aim was to fill critical information gaps identified in a recent systematic review of local and international field performance data (Woodward et al. 2020) that underpinned development of comprehensive New Zealand guidelines for constructed wetlands (Tanner et al. 2022). To meet this aim, we quantified the field-scale performance of constructed wetlands at five demonstration sites for reduction of suspended sediment, nitrogen, and phosphorus from mixed surface runoff and groundwater inflows. This study was a collaborative project between NIWA, councils (Bay of Plenty Regional Council, Environment Canterbury, Hawkes Bay Regional Council, Taranaki Regional Council, and Tasman District Council), rural industries (Baygold, Beef + Lamb, DairyNZ, and Fonterra), and farmers/landowners.

1.3 This report

This is the final report of the *Quantifying Constructed Wetland Contaminant Attenuation Project*. It specifically addresses the following key objectives of the contract:

Objective 1: Methods undertaken to establish, instrument, and measure reductions in contaminant loads for six demonstration constructed wetlands are documented.

Objective 2: Annual contaminant removal performance for the constructed wetlands is reported.

Objective 3: Actions taken to report the results of the study and their implications to other researchers, MPI, industry, regulators, iwi, and end-users are documented.

Objective 4: Actions undertaken to demonstrate to farmers how they can use constructed wetlands to manage diffuse runoff from their farms are documented.

2 Study sites and methods

2.1 Constructed wetland locations

This study reports on CWs from six locations. Three of the CWs were constructed between 2019 and 2020 (Awatuna, Taranaki; Fish Creek, Tasman; Te Ahuriri, Canterbury;). A further three were constructed between 2021 and 2022 specifically for the SLMACC project (Maniatutu and Pongakawa, Bay of Plenty; Tukipo, Hawke's Bay) (Figure 2-1). The CW locations were identified by councils in collaboration with NIWA, DairyNZ, landowners, and other stakeholders. Except for the Te Ahuriri CW (Canterbury region), all other CW were designed as on-line systems intercepting mixed agricultural runoff, surface and subsurface drainage, and/or shallow groundwater from small catchments ~20-200 ha in size ('on-farm CW') (Table 2-1). Figure 2-2 illustrates the as-built constructed wetland designs and their relative sizes. Further details and a summary of the characteristics of each wetland and its catchment are provided in Appendix A: Descriptions of the on-farm constructed wetlands and their catchments .

Table 2-1: Summary of wetland and catchment areas, percent shallow vegetated zones, and main flowpaths intercepted at the SLMACC CW. Vegetation coverage within the wetland is the percent coverage at the end of summer 2024.

Parameter	Awatuna	Fish Creek	Maniatutu	Pongakawa	Te Ahuriri	Tukipo
wetland size (ha)	0.44	0.32	1.92	1.01	3.80	1.59
catchment area at outflow (ha)	19.34	26.25	71.32	48.71	36,200	182.92
wetland: catchment area (%)	2.3%	1.2%	2.7%	2.1%	0.01%	1.0%
vegetation coverage within wetland (%)	70%	60%	70%	80%	75%	50%
month & year wetland planted	Feb 2020	Nov 2020	March 2022	March 2022	Dec 2019	April 2021
month & year wetland planted	on-line	on-line, internal high flow bypass	on-line, internal high flow bypass	on-line	off-line, partial inflow from Halswell-Huritini River during flood flows	off-line, external high flow bypass
main flowpaths intercepted	subsurface & surface drainage + groundwater	surface runoff + groundwater	surface drainage	groundwater + drain floods	river floods	surface drainage + groundwater
catchment land-use	dairy	dairy	dairy, kiwifruit	kiwifruit, dairy, maize	peri-urban & mixed agricultural	dry stock, cropping

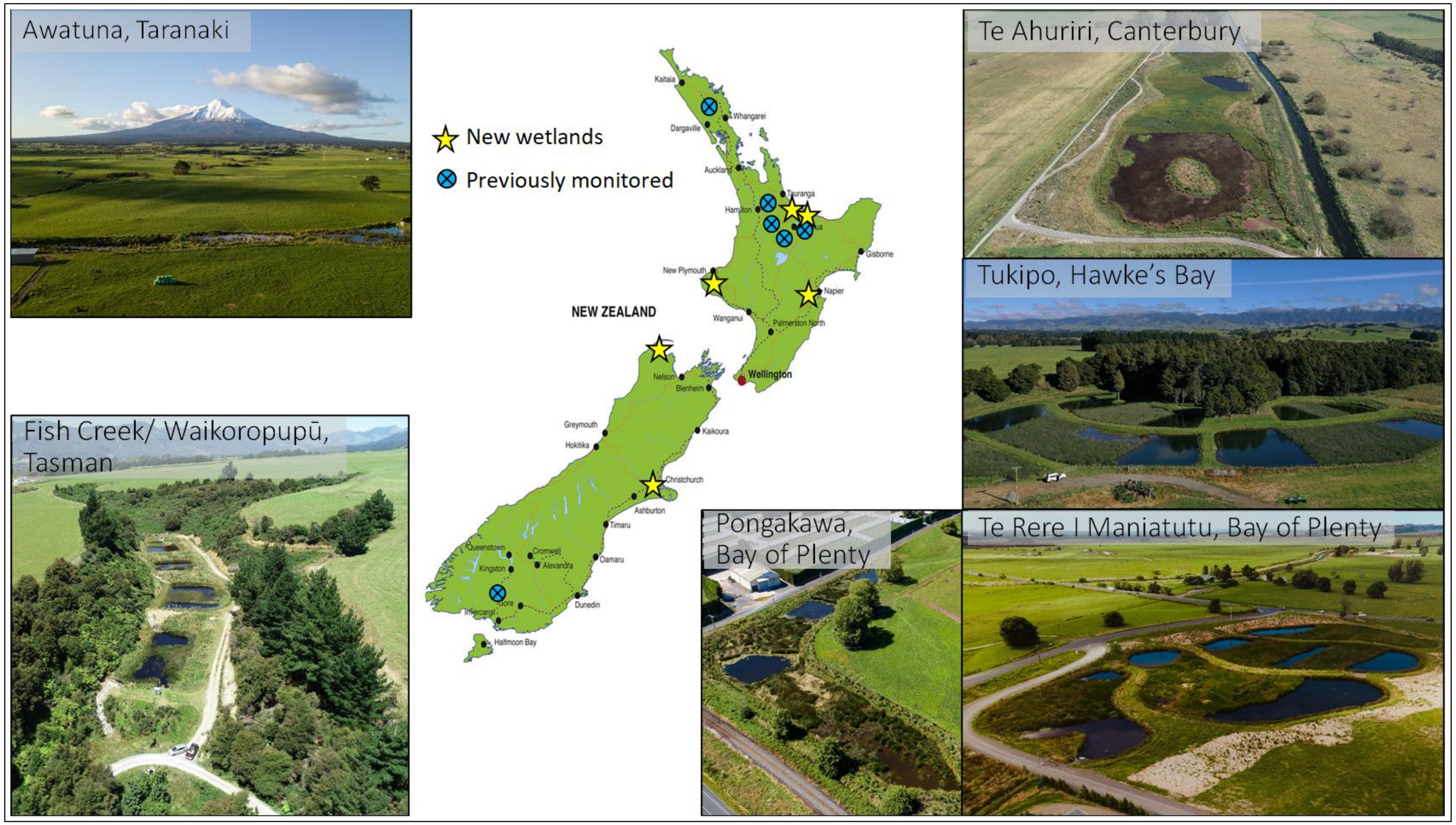

Figure 2-1: Locations and arial photos of the six SLMACC CW.

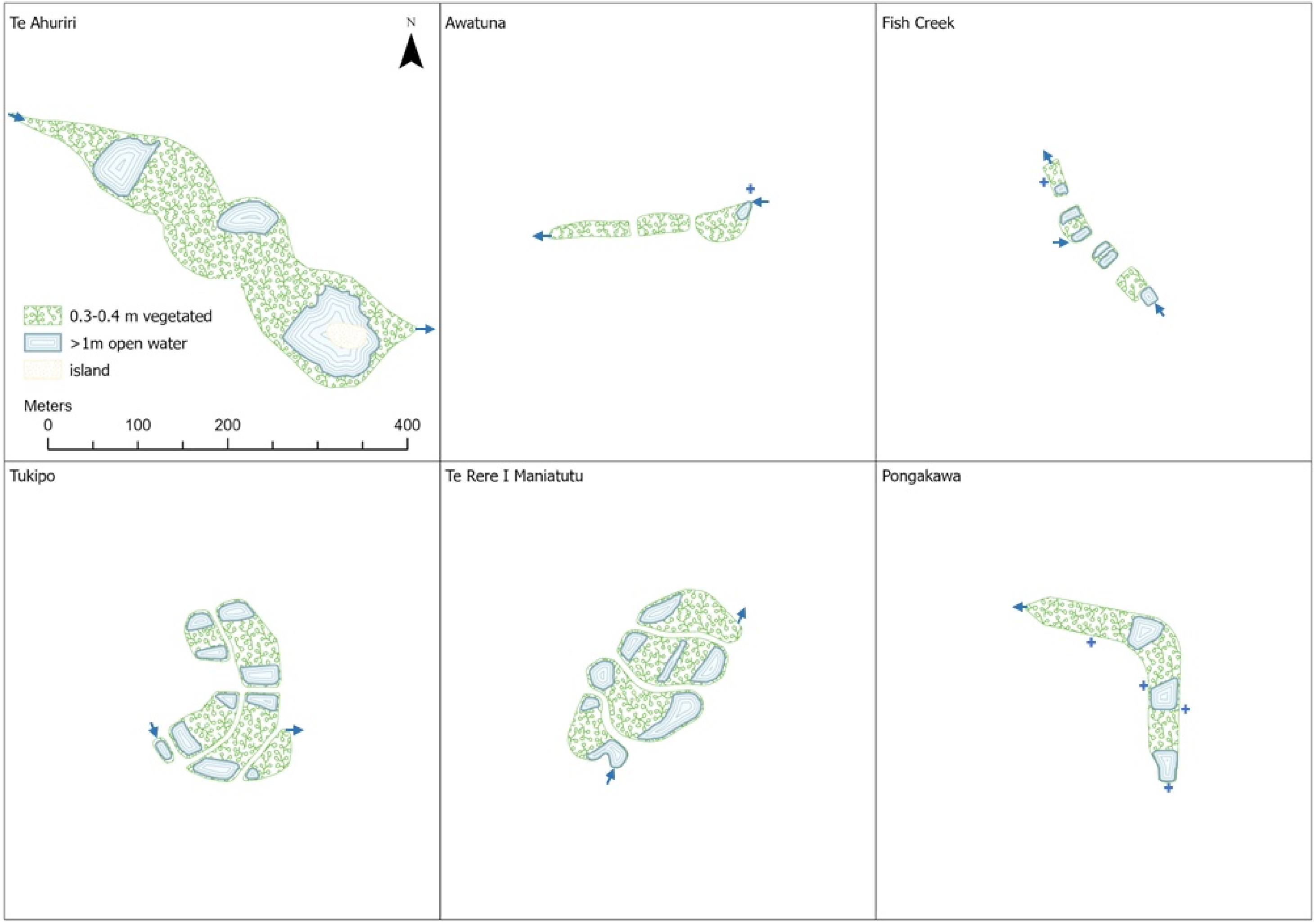

Figure 2-2: As-built SLMACC constructed wetlands shown in 1:5000 scale. Surface water quality monitoring locations are shown with blue arrows, which also indicate flow direction through the wetlands. Locations where groundwater is monitored are shown with blue crosses.

2.2 Wetland monitoring

The high inter- and intra-annual variability of diffuse runoff-flows and contaminant loads makes quantitative evaluation of their reduction in wetland systems complex (Howard-Williams et al. 1985). This means that mass loads of contaminants (the product of concentration and flow integrated through time) in and out of the wetland need to be assessed over several years to get an accurate measure of attenuation rates. Detailed flow and water quality monitoring data are technically challenging and expensive to collect, hence such datasets are rare and extremely valuable.

We developed a standardised CW sampling and analysis plan that was implemented by council and NIWA staff. Wetland diffuse pollution attenuation performance was monitored through a combination of high frequency and discrete sampling of wetland surface inflows and outflows. High frequency (every 5-15 minutes) water level, flow, precipitation, nitrate-N, and turbidity data were measured by in-situ instruments. Figure 2-2 shows locations of surface water and groundwater sampling locations for each wetland. Discrete sampling of the wetland surface inflows and outflows occurred monthly or fortnightly during wet seasons, or monthly during dry/baseflow conditions. At locations or times when groundwater inputs made up a substantial proportion of the wetland inflow, discrete samples of groundwater were also collected (e.g., collected monthly or only a few times a year). Additionally, ISCO automatic water samplers were triggered to take samples every few hours during significant flow events (storms), with the goal of monitoring 3-5 significant flow events at each wetland annually. Further details of the flow and water quality monitoring are provided in Appendix B: Summary of wetland monitoring, flow and water quality data assurance, and load estimation methods.

2.3 Wetland performance assessment

Annual mass loads of SS, TN, and TP for the CW inflow and outflows were estimated using a range of modelling tools. Contaminant export and CW attenuation performance were therefore able to be determined. Groundwater mass loading to CW was determined based on approximately monthly grab sample data and water volumes estimated with annual mass balances (e.g., groundwater flow volume = surface outflow volume – surface inflow volume– net rainfall volume). Measured and flow-proportional concentrations and percentage reductions, mass removal (g m^{-2} CW yr^{-1}), and percentage mass removal were used to assess CW treatment efficacy of TN, TP, and SS on an annual basis. To provide better comparison with diffuse pollution losses from farming and demonstrate CW removal per unit catchment area, the surface and groundwater (combined) catchment inflow loading rates and annual CW load removal rates were also calculated as specific yields in kg ha^{-1} yr^{-1}. Specific yields normalise the load to account for area differences among catchments.

The main findings presented in this report are the annual performance (% load reduction) of TN, TP, and suspended sediment for the four 'on-farm' CWs in Tasman, Taranaki, and Bay of Plenty, where a minimum of one site-year of performance monitoring data have been compiled as of May 2024. There are not yet any diffuse pollution attenuation data for the on-farm CW in Hawke's Bay to report due to widespread damage from Severe Tropical Cyclone Gabrielle[1] in February 2023, and subsequent competing priorities in the region. Study findings for Ahuriri, an off-line, floodplain CW in

[1] Severe Tropical Cyclone Gabrielle was a destructive tropical cyclone that devastated parts of the North Island (particularly Hawke's Bay and Gisborne) in February 2023. It caused widespread flooding, erosion, deposition of debris and sediment, and damage to communities, farms and orchards, and transportation, energy and telecommunications infrastructure. It is the costliest tropical cyclone on record in New Zealand, with total damages estimated to be at least NZ$13.5 billion (US$8.4 billion). https://www.bbc.com/news/world-asia-64940342

Canterbury, have been reported separately (Goeller et al. 2024). Off-line CW receive only a proportion of flow diverted from a stream or river.

Further details of the data analysis methods are provided in Appendix B: Summary of wetland monitoring, flow and water quality data assurance, and load estimation methods.

3 Annual wetland performance results

3.1 Wetland water balances and flow paths intercepted

Given the unique physiographic conditions at each of the study CWs, each is a valuable case study of CW design and performance. Overall, the amount of rainfall, surface inflow, and groundwater received by the wetlands differed markedly across years and across the wetlands (Table 3-1).

Key hydrologic differences among the CW and site years can be summarised as follows:

- Annual periods with higher rainfall resulted in higher inflows to the CWs. Rainfall totals were greatest at Fish Creek and Awatuna and lowest at the Bay of Plenty CW.
- In terms of surface water inflows, the Fish Creek CW had the highest overall hydraulic loading rates (a measure of total annual inflow normalised per basal area of the wetland), characterised by intense storm-driven surface runoff inflows.
- In contrast, Pongakawa CW had the lowest HLR with more than 90% of its inflow entering as groundwater, except during extreme rain events that generate surface flooding into the wetland (<5% of annual outflow volume). Groundwater inflows are more attenuated than surface flows providing more buffered loading spread over longer periods.
- The 2022 – 2023 year was influenced by La Niña climate patterns, resulting in wetter conditions with higher HLR.
- The 2023 – 2024 year was influenced by El Niño climate patterns, resulting in drier conditions with lower HLR across all the CW.
- In terms of the flowpaths intercepted and their temporal differences, seasonal catchment runoff yields, and hence CW inflows and outflows were greatest from May to October each year. This consistent with other studies of CWs in New Zealand. The main hydrological behaviour of each of the CW can be described as follows:
  - Awatuna: Outflows are sustained by baseflow from mixed surface inflows and groundwater seepage year-round, except for dry years when there is net seepage loss from the wetland. Groundwater accounted for <10% of inflow on average across the three years monitored (range 7-15%).
  - Fish Creek: Surface inflows accounted for >94% of outflow in both years. Surface inflows are extremely flashy and rainfall-driven, particularly from May to October. Due to differences in antecedent conditions, higher accumulated rainfall triggers surface runoff between October and May. For most of the time during those months, the wetland outflows are sustained by groundwater seepage between surface run-off events. Groundwater exchange was dynamic, with net gains (4%) and losses (-5%) in wet and dry years, respectively.
  - Maniatutu: Inflows and outflows are driven by seasonal changes in baseflow and storm events. In the dry year, surface inlet and outlet are sporadic, only occurring during major rainfall and runoff events, but there is likely dynamic groundwater exchange with the wetland through a highly permeable layer of pumice soil that

that the wetland intersects. Overall, there was net seepage loss from the wetland on an annual basis from May 2023 – 2024.

- Pongakawa: Groundwater is the predominant inflow (>90% of surface outflow), apart from extreme rain events that cause surface flooding into the wetland (<5% of annual outflow volume). Given the similar soils to Maniatutu, there is likely dynamic groundwater exchange within the deeper zones of the wetland through a highly permeable layer of pumice soil.

Annual water yields for each of the (mm flow per catchment area intercepted per year) are presented in Appendix C, Table C-1 to illustrate the differences in the main sources of flow standardised across the different catchments.

Table 3-1: Annual wetland water balances. Hydraulic loading rate (HLR) is inflow divided by the internal (wetted) area of the CW.

Parameter	Awatuna			Fish Creek		Maniatutu	Pongakawa
	May 2021-2022	May 2022-2023	May 2023-2024	May 2022-2023	May 2023-2024	May 2023-2024	May 2023-2024
precipitation (mm y^{-1})$^{+}$	1820	2061	1350	3332	1909	1201	1197
evapotranspiration (mm y^{-1})$^{++}$	725	660	658	772	828	748	748
surface inflow HLR (m y^{-1})	48	61	33	129	54	11	0.4
extra surface inflow HLR (m y^{-1})				13	9		
surface outflow HLR (m y^{-1})	58	72	36	151	60	10	11
net groundwater HLR (m y^{-1})	10	12	3	9	-2	-1	11
total surface inflow (m^3 y^{-1})	213,225	269,835	147,199	451,151	197,480	203,545	3,454
total surface outflow (m^3 y^{-1})	257,940	321,242	161,715	478,546	191,311	194,822*	113,550
net groundwater inflow (m^3 y^{-1})	39,853	45,187	11,443	27,394	-6,169	-17,446**	105,513
% groundwater inflow (+/-)	15%	14%	7%	4%	-5%	-23%**	93%

$^{+}$precipitation was measured locally at each wetland
$^{++}$daily Priestley Taylor evapotranspiration estimates were used from the closest weather station
*Maniatutu total surface outflow volume: due to issues with unmeasured bypass flow at the outlet weir, outflow volumes were estimated by mass balance using the volumes of water from surface inflow and net precipitation volume, assuming zero groundwater inputs.
**Maniatutu net groundwater and % groundwater inflow: net groundwater exchange was estimated by mass balance using the estimated total outflow volume, total surface inflow volume, and net precipitation volume

3.2 Nutrient and sediment load attenuation performance

Monitoring at the SLMACC wetlands provides comprehensive records of the near-source nutrient and sediment concentrations and loads generated from rural land-use, as well as the water quality improvements achieved by constructed wetlands. Table 3-2 presents the measured annual sub-catchment specific yields of TN, TP, and SS, percent load reductions, and annual removal rates standardised by wetland catchment area (e.g., g TN ha^{-1}). This allows for comparison with farm and wider catchment-scale information on diffuse losses of nutrients and sediments. In contrast, Table 3-3 summarises the annual combined inflow rates and removal rates for TN, TP, and SS standardised by wetland area (e.g., g TN m^{-2}), which allows for comparison across wetlands of different sizes and with other interceptive, diffuse pollution mitigation eco-technologies.

Table 3-2: Annual summary of catchment specific yields and wetland performance standardised by catchment area for TN, TP, and SS. Combined catchment inflow loading rates are from all surface and groundwater inflows.

Parameter	Awatuna			Fish Creek		Maniatutu	Pongakawa		
	May 2021-2022	May 2022-2023	May 2023-2024	May 2022-2023	May 2023-2024	May 2023-2024	May 2023-2024 *low**	*med***	*high****
Total Nitrogen									
combined catchment TN yield (kg ha^{-1} y^{-1})	37.6	38.1	16.4	94.4	25.7	75.2	10.4	13.7	29.7
TN load removal efficiency (%)	47%	34%	28%	30%	27%	75%	13%	34%	70%
annual TN mass removal rate per ha of catchment (kg ha^{-1})	17.7	13.0	4.6	28.3	6.9	56.4	1.4	4.7	20.8
Total Phosphorus									
combined catchment TP yield (kg ha^{-1} y^{-1})	1.3	0.6	0.5	14.9	40.5	8.1	0.8	3.5	13.7
TP load removal efficiency (%)	62%	9%	52%	12%	19%	86%	77%	95%	99%
annual TP mass removal rate per ha of catchment (kg ha^{-1})	0.8	0.06	0.2	1.8	7.7	5.7	0.6	3.3	13.6
Suspended sediment									
combined catchment SS yield (kg ha^{-1} y^{-1})	224.9	247.2	140.5	1476.8	470.3	418.1	26.9	26.9	26.9
SS load removal efficiency load (%)	15%	4%	18%	53%	13%	3%	1%	1%	1%
annual SS mass removal rate per ha of catchment (kg ha^{-1})	33.7	9.9	25.3	782.7	61.1	12.5	0.3	0.3	0.3

*low: inflowing groundwater concentrations weighted flow-proportionally from all piezometers
**medium: inflowing groundwater concentrations averaged from all piezometers
***high: inflowing groundwater concentrations weighted 100% flow-proportional from piezometer 2 for dissolved TN and from piezometer 4 for dissolved TP, which had the highest measured concentrations

Table 3-3: Annual summary of wetland mass and wetland performance standardised for wetland area for TN, TP, and SS. Combined inflow loading rates incorporate surface and groundwater loading for each contaminant.

Parameter	Awatuna			Fish Creek		Maniatutu	Pongakawa		
	May 2021-2022	May 2022-2023	May 2023-2024	May 2022-2023	May 2023-2024	May 2023-2024	May 2023-2024 *low**	*med***	*high****
Total Nitrogen									
combined inflow TN loading rate (g m^{-2} y^{-1})	148.5	150.9	64.7	279.9	71.5	21.4	49.6	65.6	142.1
annual TN removal rate (g m^{-2} y^{-1})	69.7	50.7	18.3	83.0	19.4	16.0	6.3	22.3	98.8
TN load removal efficiency (%)	47%	34%	28%	30%	27%	75%	13%	34%	70%
Total Phosphorus									
combined inflow T loading rate (g m^{-2} y^{-1})	5.1	2.4	1.8	46.5	29.6	2.3	4.0	16.7	65.5
annual TP removal rate (g m^{-2} y^{-1})	3.1	0.2	0.9	5.4	5.6	2.0	3.1	15.8	64.6
TP load removal efficiency (%)	62%	9%	52%	12%	19%	86%	77%	95%	99%
Suspended sediment									
combined inflow SS loading rate (g m^{-2} y^{-1})	891.5	980.4	553.2	6343.1	1499.0	119.1	128.3	128.3	128.3
annual SS removal rate (g m^{-2} y^{-1})	132.5	37.2	100.8	3377.0	196.6	3.5	1.1	1.1	1.1
SS load removal efficiency load (%)	15%	4%	18%	53%	13%	3%	1%	1%	1%

*low: inflowing groundwater concentrations weighted flow-proportionally from all piezometers
**medium: inflowing groundwater concentrations averaged from all piezometers
***high: inflowing groundwater concentrations weighted 100% flow-proportional from piezometer 2 for dissolved TN and from piezometer 4 for dissolved TP, which had the highest measured concentrations

Quantifying CW contaminant loading rates and load reductions in the present study substantially adds to the CW performance knowledge base. These new data span a much broader scope of catchments, and farming systems over a range of annually and seasonally varying flows compared to the existing New Zealand case studies. Generally, as the hydraulic loading rate to a wetland increases, so does the contaminant loading rate.

The CW are sized differently relative to their catchment areas, and the catchment sizes and their diffuse pollutant loads differ. Therefore, it is not possible to discern simple and consistent patterns when comparing the combined inflow contaminant yields versus the combined inflow contaminant loading rates for the wetlands.

Total Nitrogen

- Combined annual catchment TN yields at the point of wetland interception averaged ~38 kg TN ha^{-1} catchment and ranged from 10.4 kg TN ha^{-1} (lowest estimate for Pongakawa) to 94.4 kg TN ha^{-1} at Fish Creek.
  - The combined inflow TN loading rate for the wetlands averaged ~110 g TN m^{-2} and ranged from 21.4 g TN m^{-2} at Maniatutu to 280 g TN m^{-2} at Fish Creek.

- Average annual wetland TN % load removal efficiency was ~40% and ranged from 13% (lowest estimate for Pongakawa) to 75% at Maniatutu.
- Average annual TN removal rate per ha of catchment was ~17 kg TN ha^{-1} and ranged from 1.4 kg TN ha^{-1} (lowest estimate at Pongakawa) to 56.4 kg TN ha^{-1} at Maniatutu.
  - The combined inflow TN removal rate per m^2 of wetland area averaged ~43 g TN m^{-2} and ranged from 6.3 g TN m^{-2} (lowest estimate at Pongakawa) to 98.8 g TN m^{-2} (highest estimate at Pongakawa).

<u>Total Phosphorus</u>

- Combined annual catchment TP yields at the point of wetland interception averaged ~9.3 kg TP ha^{-1} and ranged from 0.46 kg ha^{-1} at Awatuna to 40.5 kg ha^{-1} at Fish Creek.
  - The combined inflow TP loading rate for the wetlands averaged ~19 g TP m^{-2} wetland and ranged from 1.8 g TP m^{-2} at Awatuna to 65.5 g TP m^{-2} (highest estimate at Pongakawa).
- Average annual wetland TP % load removal efficiency was ~57% and ranged from 9% at Awatuna to 99% (highest estimate at Pongakawa).
- Average annual TP removal rate per ha of catchment was ~3.8 kg TP ha^{-1} and ranged from 0.06 kg TP ha^{-1} at Awatuna to 13.6 kg TP ha^{-1} (highest estimate at Pongakawa).
  - The combined inflow TP removal rate per m^2 of wetland area averaged ~11 g TP m^{-2} wetland and ranged from 0.2 g TP m^{-2} at Awatuna to 64.6 g TP m^{-2} (highest estimate at Pongakawa).

<u>Suspended Sediment</u>

- Combined annual catchment SS yields at the point of wetland interception averaged ~340 kg SS ha^{-1} and ranged from 27 kg SS ha^{-1} at Pongakawa to 1477 kg SS ha^{-1} at Fish Creek.
  - The combined inflow SS loading rate for the wetlands averaged ~1,197 g SS m^{-2} wetland and ranged from 119 g SS m^{-2} at Maniatutu to 6,343 g SS m^{-2} at Fish Creek.
- Average annual wetland SS % load removal efficiency was 12.11% and ranged from 1% at Pongakawa to 53% at Fish Creek.
- Average annual SS removal rate per ha of catchment was ~103 kg SS ha^{-1} and ranged from 0.3 kg SS ha^{-1} at Pongakawa to 783 kg SS ha^{-1} at Fish Creek.
  - The combined inflow SS removal rate per m^2 of wetland area averaged 428 g SS m^{-2} wetland and ranged from 1.1 g SS m^{-2} at Pongakawa to 3,377 g SS m^{-2} at Fish Creek.

Further overall CW performance information presented in Table D-1, with more detailed monitoring results presented for each wetland in Appendix E, F, G, and H.

4 Discussion

The annual CW performance (annual % load reductions) for TN, TP, and SS are consistent with the provisional estimates for contaminant removal performance of surface flow CW that intercept diffuse pollution from pastoral land-use in New Zealand (Tanner et al. 2022) (Table 4-1). These new data, along with results from recently published CW case studies in New Zealand, add to the evidence base and provide confidence in CW diffuse pollution attenuation performance (Burbery et al. 2023, Hoang et al. 2023, Sukias et al. 2023).

Table 4-1: Comparison of SLMACC CW annual load reduction performance against predictions from Tanner et al., (2022) based on wetland:catchment area. Wetlands are ordered according to increasing size relative to their catchments (CW:catchment area, %). Tanner et al. (2022) predictions for the corresponding CW:catchment area annual load reduction efficiencies are shown in parentheses. Model predictions for TN are from the warm zone, and model predictions are for TSS not SSC. TSS is measured from a subsample, whereas SSC is measured from a whole sample volume and is therefore considered more accurate.

Parameter		Fish Creek CW:catchment ratio 1.2%		Pongakawa CW:catchment ratio 2.1%		Awatuna CW:catchment Ratio 2.3%		Maniatutu CW:catchment ratio 2.7%	
TN	Avg %	29	(26)	39	(36)	35	(38)	75	(42
	Range %	27-33	(22-34)	13-70	(30-44)	28-47	(32-46)	75	(42)
TP	Avg %	16	(28)	90	(36)	41	(38)	86	(40)
	Range %	12-19	(20-36)	77-99	(25-46)	9-62	(26-48)	86	(27-52)
SS	Avg %	33	(52)	(35-80)	(66)	12	(66)	3**	(73)
	Range %	13-55	(35-80)	1*	(45-93)	4-18	(48-95)	3**	(51-99)

Pongakawa SS*: the main inflow is groundwater with sediment concentrations ~laboratory limit of detection, so cannot directly compare to the guidelines which are for surface inflow wetlands
Maniatutu SS**: storm sample SSC data were missing for this period, so the estimate is very conservative and reflects baseflow with low sediment inputs (hence low removal)

4.1 Comparison against provisional estimates from CW guidelines

The performance estimates in Tanner et al. (2022) were drawn from national and international field-scale monitoring and modelling studies (Woodward et al. 2020). The review data were then integrated with expert opinion to derive contaminant reduction estimates for CW in the New Zealand pastoral context. Those estimates were further refined to derive conservative, long-term performance estimates of TN, TP, and suspended solids load reductions. Importantly, the estimates include an average value and a range. The range represents the high variability in year-on-year performance within CW.

Currently, our best knowledge of the performance of CWs in New Zealand pastoral catchments with mean annual rainfall rates of between 800 and 1600 mmy^{-1} is presented in Tanner et al. (2020). Tanner et al. (2020) demonstrates that as the relative size of the wetland increases from 1 to 5% of the catchment area, median annual removal rates increase from:

- ~25-53% in for TN in warm regions (average temperatures > 12 °C).
- ~17-38% for TN in cool regions (average temperatures 8-12 °C).
- ~26-48% for TP.

  - Note: TP estimates pertain to wetlands not receiving subsurface drainage where dissolved P is the predominant form of TP.

- ~50-90% for SS.
  - Note: TP and SS estimates pertain to wetlands receiving surface runoff and drainage from catchments not dominated by clay soils (<35% clay content), and SS from Tanner et al. (2022) was based on measurements of TSS rather than SSC. TSS is measured from a subsample, whereas SSC is measured from a whole sample volume and is therefore considered more accurate. Also, the difference between the measured SSC and the measured TSS increases as the particle size increases, since sand-size material settles faster than silt and clay-sized materials.

As summarised in Table 4-1, the range of TN and TP attenuation across the SLMACC wetlands are consistent with what is expected for an appropriately designed, and maintained CW. Performance estimates for TN were consistently at or above predictions based on the provisional guideline values in Tanner et al. (2022). The estimates of SS and TP varied substantially across the CW and interannually. In comparison to the previous work byt Tanner et al. (2022), a few features of the SLMACC performance case studies stand out:

- The Awatuna, Fish Creek, and Maniatutu CWs all receive mixed inflows via surface drains and direct seepage. The Awatuna inflows include a substantial component from tile drains. Performance data for such mixed flowpaths are rare in the New Zealand context, despite being common across many farmed catchments.
- The measured annual rainfall for Awatuna (years 1 and 2) and Fish Creek (both years) are above the 1600 mm reference value associated with the performance predictions in Tanner et al. (2022), which usefully extends the range of reliable measurements available for modelling and prediction.
- Catchment land-use at Maniatutu and Pongakawa wetlands is >40% kiwifruit, but the contaminant yields and wetland annual load reductions are consistent with specific yields and the attenuation of pollutant loads by wetlands in dairy-dominated catchments.
- All SLMACC CW fit within the warm-zone for estimating TN reductions where average annual air temperature is > 12 °C. The SLMACC CW performed at, or well above, the TN performance estimates, but with high year-to-year variability.
- Soil catchment clay content was <35% for the SLMACC CWs, but performance estimates of SS and TP varied substantially across the CW and interannually. SS concentrations and yields generated in these catchments were comparatively low (10-fold lower than the average long-term loads expected for intensively grazed dairy pastures in NZ (Monaghan et al. 2021). This resulted in relatively small amounts of sediment being intercepted by the wetlands, especially in dry years. Measured rates of sediment delivery from hillslopes in NZ catchments are rare. Monaghan et al. (2021) reported that SS losses from hillslopes can vary markedly in different landscapes.

4.2 Recommendations for further work to refine and demonstrate CW performance

Preliminary results and progress from this work have been communicated to stakeholders throughout the duration of the project (Appendix I). Overall, the wetland performance monitoring information from this project provide an impressive evidence base. The new CW performance information demonstrates the benefits that might be achieved by appropriately designed and maintained CWs at appropriate locations in New Zealand agricultural catchments.

Recommendations for further work to evaluate CW performance from the SLMACC case study wetlands includes:

- Compile, verify, and analyse new, additional months and years of monitoring data collected after May 2024 to complete the annual periods of data available, and provide additional annual data records.
- Calculate diffuse pollutant loading and attenuation with dynamic modelling that expands on the hydrological process-based models used to date.
- Investigate the mass balance transformations of different forms of nitrogen and phosphorus.
- Estimate *E.coli* attenuation. Note that it is more difficult to calculate *E.coli* attenuation due to fewer data (particularly no continuous data) and the uncertainty of the dynamics of *E.coli* within the wetland (e.g., Stott et al. 2023).
- Quantify any seasonality in pollutant attenuation, or differences between pollutant attenuation in base flow and storm flows.
- Investigate any trends in pollutant attenuation over years since the wetland was established.

Recommendations for further engagement and use of the SLMACC CW performance case studies include:

- Communicate the final results at farmer-oriented field day to demonstrate the water quality improvements and other benefits (e.g., cost-benefit for contaminant reductions) to end-users and stakeholders.
- Incorporate performance data from the current study and other recently published CW case studies into updated practical constructed wetland design and performance guidelines.
- Use performance data from the current study to calibrate and improve national-and catchment-scale yield and mitigation systems modelling.
- Publish the results of the current study in peer-reviewed scientific journals to provide a robust evidence base for supporting implementation of CW in action plans and limit-setting processes.

- Evaluate hydraulic flow paths and the influence of different components within constructed wetland systems (e.g., vegetated shallow vs open-water deep zones) on treatment performance, greenhouse gas emissions, and biodiversity outcomes.
- Evaluate the high-frequency flow and water quality sampling and analysis methods implemented for the SLMACC CW performance monitoring to determine the minimum sampling requirements recommended for estimating diffuse contaminant attenuation.

5 Acknowledgements

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Awatuna CW

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- Landowners: Phillip and Donna Cram.
- NIWA field staff: Gareth van Assema, Angus Kellick, Brent Caldwell.
- Drone mapping: Ben Plumer, Drone Tech NZ.

Fish Creek CW

- TDC staff: Trevor James, Steph Bowis, James Townshend, Claire Webster, Emma Woods.
- Landowner: Brent Page.
- NIWA field staff: Kieran Scott, Ralph Dickson, Pete Pattinson.
- Drone mapping: Jonathan Lopardo, DroneMate.
- Planting: Craig Allen, Freshwater Environmental.

Te Ahuriri CW

- ECAN staff: Tim Davie, Shirley Hayward, David Murphy, Rachel Herbert, Hamish Carrad.
- NIWA field staff: Patrick Butler, Hamish Sutton, Jochen Bind.

Pongakawa and Maniatutu CWs

- BOPRC staff: Pim De Monchy, Jackson Efford, Claire McCorkindale, Thomas Grant, Lisa Bevan, Darryn Hitchcock.
- Landowners: Paul Hickson (Pongakawa), Baygold (Maniatutu).
- Baygold: Olivia Manusauloa.

- NIWA field staff: Liam Wright, Amy Neylon, Graham Timpany, Edd Greenwood.
- Planting: Les Anderson, Naturally Native.
- Drone mapping: Thomas Grant, Les Anderson, and Andy Belcher, Legendary Photography.

Tukipo CW

- HBRC staff: Thomas Petrie, Andy Hicks.
- Landowner: Willie White.
- NIWA field staff: Matt Parker.
- NZ Landcare Trust: Nathan Burkpile.

Laboratory sample analysis

- Hill's Laboratory (Hamilton and Christchurch offices).
- BOPRC Water Quality Lab.

NIWA

- Hydrometric data QA/QC (Evan Baddock, Martin Bylsma, Jas Robb, Mark Corkery, Ryan Evison, Thanh Dang).
- Instrument Systems (Brent Williams, Steve de Lima, Stuart Escott, Rod Mckay, Brendon Smith).
- Data telemetry and database support (Kevin Manson, Kathy Walter, Tony Hill, Hue Tran, Andrew Harper, Evgeny Fardman).
- NIWA project management support (Neale Hudson, Sam Etzel, Annabelle Watson).

6 Glossary of abbreviations and terms

AICc	small-sample corrected Akaike information criterion
GIS	geographic information systems
BOPRC	Bay of Plenty Regional Council
CW	constructed wetland
DEM	digital elevation model
DRP	dissolved reactive phosphorus
ECAN	Environment Canterbury
HBRC	Hawke's Bay Regional Council
HLR	hydraulic loading rate
LiDAR	light detection and ranging data
LOADEST	LOADEST Load Estimator: a program for estimating constituent loads and concentrations in streams and rivers
LSTM	Long-Short Term Memory model
NEMS	National Environmental Monitoring Standards
PET	potential evapotranspiration
SLMACC	Sustainable Land Management and Climate Change fund
SS	suspended sediment
SSC	suspended sediment concentration
SOP	standard operating procedure
TDC	Tasman District Council
TN	total nitrogen
TP	total phosphorus
TRC	Taranaki Regional Council
TSS	total suspended solids

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Appendix A Descriptions of the on-farm constructed wetlands and their catchments

The five on-farm CW designs and vegetation planting guidance were produced by NIWA and provided to Councils as part of the process of refining the New Zealand guidelines for constructed wetlands (Tanner et al. 2022). Since the aim was to maximise denitrification, multiple cells were used in series with open water (deep sedimentation pond) areas to disperse flows, and planting of a mix of native rushes and sedges to provide 60-70% canopy cover in the shallow vegetated zone (Tanner et al. 2022). The use of multiple cells in series with open water areas, to allow for a relatively open canopy cover in parts of the wetland, also promotes ultra-violet light disinfection of faecal microbes, which was an aim at several of the CW. Overall, the basic designs and construction timelines followed the recommendations provided by Tanner et al. (2022) for managing pastoral farm drainage and runoff. The on-farm CW were designed and constructed as follows:

- sized to be between 1-5% of the contributing catchment area, based on surface catchments delineated from 1-m or 2-m LiDAR DEM data,
- shaped as elongated or multi-wetland cell systems with inlet and outlet at opposite ends,
- shaped with overall length:width ratios between 5:1 and 10,
- incorporated initial deep sedimentation pond >1.5 m depth at the wetland inlet sized to be up to 20% of the wetland's internal area,
- used deep (>0.5 m) open water dispersion zones at the inlet of each vegetated wetland zone to distribute flows across the widths of the wetlands and promote even flow along their length,
- planted with shallow (average 0.3 m depth), densely spaced native wetland sedges covering 60-70 % of the internal wetland area, including the final 20% of the wetland area closest to the outlet,
- planted with the main canopy-forming species within the shallow wetland area, with diversity provided by self-establishment of species brought in by birds and wind dispersion,
- planted embankments with hardy riparian plants,
- fenced to exclude livestock, and
- on-going maintenance and protection of wetland embankments and wetland vegetation by weed and pest control, with in-fill planting completed during the initial 18 months of establishment.

To aid in the design of each CW, elevation data were acquired using unmanned aerial vehicle (drone) mapping to delineate the surface catchments and predominant surface runoff and drainage flow paths intercepted by CW. Once the wetlands were constructed and planted, drone mapping of vegetation from altitudes 50-80 m above the pond surfaces using true-colour cameras completed was conducted and repeated annually during summer to coincide with peak plant growth and to provide a baseline of established plant coverage for each year of monitoring. The annual hydrophyte/aquatic plant coverage within the wetland was estimated as a percentage of the overall internal wetland area using geographic information systems (GIS) ArcGIS Pro 3.1 (ESRI, USA). Annual drone photos were also used to guide any required wetland in-fill planting or maintenance. All drone flights were conducted with landowner permission by pilots operating with a current NZ CAA Part 102 Unmanned Aircraft Operator Certification and in compliance with standard NZ CAA Part 101 rules and NIWA health and safety requirements.

Awatuna Wetland, Awatuna, South Taranaki

Awatuna CW was one of the first field-scale, on-farm diffuse pollution treatment wetland in the Taranaki Region. TRC's 'Wetland Consent Fund', which is derived from financial contributions made by holders of piping and drainage consents, was used for the first time in the Region to support creation of Awatuna CW to mitigate the effects of piping by intercepting contaminants after they exit subsurface drainage. The CW was established on Donna and Philip Cram's dairy farm in South Taranaki in summer 2019/20. NIWA designed the wetland and provided flow and water quality monitoring instrumentation, with funding provided by DairyNZ to support its installation. The Cram family retired some marginally productive pasture, fenced the wetland, and is managing weeds and trapping mammalian pests at the site.

The catchment mean annual rainfall is 1993 mm and the mean air temperature is 12.1 °C (data from Cliflo Stratford EWS; 1991-2020). The main inflows to the wetland are from a surface drain fed by subsurface drainage, groundwater, and storm runoff, as well as groundwater seepage within the wetland. The catchment soils are gley allophanic soils perched over an iron pan. A herd of ~270 predominantly Friesian cows are milked on the 117-ha farm (~2.3 cows per ha). The dairy farm is operated with a System 3 regime, feeding Palm Kernel Expeller and a mineral blend in the milking shed and growing their own turnips and fodder beet, as well as harvesting silage and hay. Dairy effluent is held in a single pond with two to three weeks of storage from their two oxidation ponds, and effluent is spread over 24 ha of the farm[2].

Awatuna wetland is an in-line, multi-celled, surface flow CW with an initial 1.5m deep sediment pond followed by three elongated, shallow (0.3-0.6m deep), densely vegetated cells in series (Figure A-1). The wetland footprint sits within a modified agricultural drainage ditch with an internal wetted area of 0.44 ha. This is equivalent to 2.3% of the 18-ha, dairy catchment that flows to the wetland. The outflow of the CW is to an unnamed tributary of Oeo Stream. Prior to construction, TRC consulted with the local iwi Ngāruahine on wetland design aspects, potential impacts on fish and kōura, monitoring, and inclusion of plant species of cultural value for weaving (e.g., kūta, *Eleocharis sphacelata* and, kāpūngāwhā, *Schoenoplectus tabernaemontani*). The planning process, construction methodology, and costs were documented by TRC for reference on future projects.

The wetland planting aimed to achieve 70% coverage of plants within the shallow parts of the wetland, predominantly *Schoenoplectus tabernaemontani* and *Machaerina articulata*. Sophie Arnoux led the selection and planting of riparian and wetland plants on the Cram farm. Hardy plant species suitable for a coastal, high-altitude environment near Egmont National Park that could cope with the cold, flood-prone conditions were selected. Approximately 3,300 wetland and 200 riparian plants were planted at the wetland. A mixture of *Carex secta* and *Carex virgata* was planted in summer 2020 along the wetland shallow margins and in ~50% of the main shallow area of the wetland, since sufficient quantities of *Machaerina articulata* and *Schoenoplectus tabernaemontani* could not be

[2] Farm operation information from https://www.stuff.co.nz/business/farming/86221346/philip-and-donna-cram-receive-taranaki-regional-council-environment-award and pertain to the farm as a whole, not just the wetland subcatchment.

sourced. Due to poor survival of the *Carex* species in areas that were too deep, subsequent infill planting with *Machaerina articulata*, *Schoenoplectus tabernaemontani*, and *Eleocharis acuta* was done in Summer 2021. The average plant coverage of the shallow vegetated zones increased from 50% in 2020, 63% in 2021, 51% in 2022, 66% in 2023, and 68% in 2024. *Juncus effusus* and *Juncus pallidus* have grown in areas of the wetland where the *Carex* species could not establish well due to deeper water levels (400 – 600 mm at baseflow).

The wetland flow and water quality monitoring equipment were commissioned by NIWA in June 2020. From June 2020-2024, NIWA and TRC monitored the performance of Awatuna CW to remove diffuse pollution from the mixed subsurface drainage and groundwater inflows. Groundwater inflow sampling from a tile drain upstream of the wetland commenced in summer of 2022, after noting that the water mass balance from the previous year indicated groundwater seepage inflows. Also, TRC have conducted three semi-annual biodiversity surveys of the flora and fauna in Awatuna CW in summer 2020, 2022, and 2024. The wetland continues to be used as a demonstration site for rural landowners across Taranaki and the catchment community group.

Figure A-1: Awatuna wetland as viewed from upstream and downstream. Drone images taken by Stuart Mackay, NIWA (October 2022) and Ben Plummer, DroneTech (February 2024).

Fish Creek Wetland, Takaka, Tasman

The Fish Creek CW was one of the first subcatchment-scale, surface flow treatment CW in the Tasman region and was funded through TDC's Freshwater Improvement Fund project 'Tasman Wetlands for Water Quality and Freshwater Ecosystems' which runs from April 2021 to June 2026 and is funded by the Ministry for the Environment. The broader Tasman Wetlands project is an integrated partnership with iwi and collaboration with landowners, the Department of Conservation, NIWA, and community organisations such as NZ Landcare Trust.

To address issues with diffuse surface runoff transporting nutrients and faecal bacteria in the Fish Creek catchment, the Fish Creek wetland was designed by NIWA and constructed on Long Bush Farm, located just outside of Takaka, Golden Bay, in Summer/Autumn 2020. The wetland intercepts surface runoff and groundwater from about 26 hectares of intensive dairy farmland and flows into Fish Creek which passes through the Te Waikoropūpū Springs Reserve. The CW was designed to enhance solar disinfection of faecal microbes and attenuation of nutrients to protect water quality of Te Waikoropūpū Springs during storm flows. Due to the cultural significance and ecological sensitivity of these springs, re-instating wetlands in the catchment is regarded as a favourable water quality mitigation tool by the public, farmers, and iwi (Ngati Tama, Ngati Rārua and Te Ātiawa as represented by Manawhenua ki mohua).

NIWA designed the wetland and provided flow and water quality monitoring instrumentation, with funding provided by DairyNZ to support its installation. CW design and construction were funded by Tasman District Council (TDC) in partnership with NIWA. The Page family provided the land in an unproductive gully and agreed to fence the wetland and maintain long-term weed control.

The catchment mean annual rainfall is 2015 mm and the mean air temperature is 12.7 °C (data from Cliflo Takaka EWS; 1991-2020). Soils in the catchment are perch-gley podzol soils with moderate/slow permeability and near surface water logging. The CW has two separate surface inflows from ephemeral flowpaths fed by storm runoff, and the CW also receives groundwater seepage. Due to the high rainfall (>2,000 mm annually) and poorly drained soils, the catchment's hydrology is extremely flashy, with intense, episodic surface runoff produced during storm events. Fresian cows are pasture fed on a 24-30 day grazing rotation at a stocking rate of ~2.4 cows per ha. No effluent is applied within the CW catchment area. Only a small portion of the CW catchment is irrigated, using sprinkler pod irrigation, but irrigation has been rare/non-occurring in the last few years. There was no subsurface drainage or forage cropping within the catchment during the monitoring period, and only a small portion of the catchment retains stock over winter, which are fed out hay grown elsewhere on the farm. Grass silage is grown on the farm and maize silage is occasionally fed-out to stock in spring in a small portion of the wetland's catchment. Fertilizer (urea and ammonium sulphate) is applied in autumn and spring at rates varying between 100-160 kg/ha.

Fish Creek CW is an in-line, multi-celled, surface flow CW with an initial sedimentation pond (>1.5m deep) followed by four interconnected cells (Figure A-2). The wetland was established in June 2020. The shallow planted zone 0.3-0.6m deep occupies 60% of the overall internal wetland's area, with deep open-water zones at the inlets and outlets of each cell to disperse inflows (except for the final cell). An in-line high-flow bypass armoured with boulders and cobble is constructed between each cell to convey high storm flows through the wetland. In Autumn 2022, the first cell was re-configured to decrease the size of the sedimentation pond and increase the shallow area to enable planting with *Schoenoplectus tabernaemontani.*

The wetland planting aimed to achieve 60% coverage of plants within the shallow parts of the wetland, predominantly *Schoenoplectus tabernaemontani* and *Machaerina articulata*. The wetland was planted with ~5,000 aquatic plants and ~1,700 riparian plants in the first year 2020. Infill planting with an additional ~1,000 plants in the wetland completed in April 2022. The average plant coverage of the shallow vegetated zones of the wetland increased from 30% in 2021, 40% in 2022, 46% in 2023, and 56% in 2024.

Flow and water quality monitoring equipment were commissioned in July 2021 and surface inflow and outflow sampling commenced in September 2021. Groundwater inflow sampling via a novaflow pipe intercepting lateral seepage into the wetland commenced in summer of 2022, after noting that the water mass balance from the previous year indicated groundwater seepage inflows, especially during the summer months when there is no surface inflow to the wetland. From September 2021 to December 2024, NIWA and TDC monitored the performance of Fish Creek CW to remove diffuse pollution from surface runoff and groundwater inflows, thanks in part to additional funding from TDC and the MfE Access to Experts Programme from July 2024.

Figure A-2: Fish Creek wetland and its catchment as viewed from different angles... Drone images taken by Jonathan Lopardo, DroneMate (February 2024)..

Pongakawa Wetland, Pongakawa, Bay of Plenty

The Waihī Estuary Catchment of the Bay of Plenty sits between Maketū and Pukehina and is around 35,000 hectares in size. The catchment supports a diverse range of highly productive land-uses, including kiwifruit, dairy, dry-stock, and pine forest. The estuary itself is a significant site, and it is highly valued by iwi and the community for recreation and mahinga kai. But, the Waihī Estuary is suffering from significant water quality issues due to the cumulative and diffuse impacts of land use. Furthermore, over 98% of historic wetlands have been lost in the catchment, with wetland drainage contributing significantly to water quality issues.

The Waihī Estuary is one of the highest NPS-FM priorities in the region, therefore requiring a suite of water quality interventions to achieve change for the community. Under the National Objectives Framework of the NPS-FM, it is predicted that contaminants like sediment, nitrogen, phosphorus, and bacteria will need to be reduced by 30-66%, which poses a significant challenge. As part of the diffuse pollution mitigation toolbox, two constructed treatment wetlands (Pongakawa and Te Rere I Maniatutu) were built in the Waihī Estuary catchment in summer/autumn 2022.

The Pongakawa wetland is located on a low-lying, flood prone retired pasture that intercepts in an ephemeral flowpath and groundwater from an unnamed tributary subcatchment of Puanene Stream near Pongakawa, Bay of Plenty. The Hickson family provided the land and agreed to fence the wetland and maintain long-term weed control. The area occupied by the CW is ~1 ha or ~2.2% of the 45-ha surface catchment it intercepts. Pongakawa CW is a single-celled, surface flow CW with an initial 1.5 m deep sediment pond followed by alternating sections of shallow (0.3-0.4m deep), densely vegetated zones interspersed with 1.2 m deep open water areas to collect and redistribute flows evenly along the wetland (Figure 3). Wetland construction completed in April 2022.

The primary inflow to the wetland is from seepage flow through a shallow layer of sand and volcanic ash, although extreme rainfall events that flood the surrounding surface drains also spill into the wetland, accounting for <5% of the annual CW surface outflow during the monitored period. The catchment mean annual rainfall is 1644 mm and the mean air temperature is 14.3 °C (data from Cliflo Te Puke EWS; 1991-2020). Soils in the catchment are predominantly pumice loam soils, which have clay content <10% and are well drained, and some poorly drained, gley soils. The CW was excavated into an area that was likely historically a wetland, as evidenced by a strongly weathered peat soil above the sandy ash soil layer and a raw, high organic peat layer below the sandy ash layer. Land use in the catchment is predominantly kiwifruit (41%) and dairy (34%), with some maize and chicory cropping (23% and 2%, respectively).

The wetland planting aimed to achieve 70% coverage of plants within the shallow parts of the wetland, predominantly *Machaerina articulata* and *Schoenoplectus tabernaemontani*. The wetland was planted with ~17,000 aquatic plants and ~2,500 riparian plants in autumn 2022. The embankments and wetland surrounds were planted with a diversity of native tree and shrub species planted to enhance site aesthetics, and the wetland is viewable from SH2. Owing to the warm climate and a wet La Niña year following the planting, the plants grew very quickly. The average plant coverage of the shallow vegetated zones of the wetland increased from 42% in 2022, 77% in 2023, and 80% in 2024.

Flow and water quality monitoring equipment were commissioned, and outflow sampling commenced in September 2022. In January 2023, four groundwater sampling piezometers were installed at different locations around the wetland to capture spatial differences in groundwater seepage entering the wetland. Monitoring the performance of Pongakawa CW to attenuate diffuse pollution is underway until June 2025, due to additional funding from BOPRC and the MfE Access to Experts Programme from July 2024. Pongakawa and Maniatutu CW are both active demonstration sites used to promote CW to the catchment community group, rural professionals, and landowners in the Bay of Plenty.

Figure A-3 Pongakawa wetland as viewed from upstream and downstream. Drone images taken by Andy Belcher, Legendary Photography (February 2024).

Te Rere I Maniatutu Wetland, Pongakawa, Bay of Plenty

Bay Gold Limited own a series of kiwifruit orchards in the Waihī Estuary catchment and are continuing to expand their operations throughout the catchment. As an organisation, Bay Gold have become increasingly focused on sustainability and improving environmental outcomes in how they approach orchard management, which has included engaging with BOPRC and NIWA to construct a CW on a recently purchased property High Whey farms. High Whey farms is located on the corner of Maniatutu Road and State Highway 2 and was previously operated as a dairy farm. In summer 2022, the Te Rere I Maniatutu (Maniatutu) CW was constructed on High Whey farm in an area of low-lying, flood-prone paddock that is drained by a surface ditch that floods during heavy weather events.

Maniatutu CW intercepts a farm drain from a larger-catchment outside of the High Whey farm property before it flows into the Kaikokopu Canal and ultimately the Waihī Estuary. Bay Gold provided the land and agreed maintain long-term weed control. The CW area ~1.9 ha or ~2.5% of the 73-ha surface catchment. Maniatutu CW was built as a multi-celled, surface flow CW with an initial 1.5 m deep sediment pond followed by alternating sections of shallow (0.3-0.4m deep), densely vegetated zones planted with emergent rushes, punctuated by 1.2 m deep open water areas to collect and redistribute flows as water moves between each of the wetland's four cells in series (Figure A-4). Wetland construction completed in March 2022.

The catchment soils, rainfall, and average air temperature are similar to Pongakawa CW. The primary inflow to the wetland is from surface drainage, storm runoff, and groundwater exchange through a shallow layer of sand and volcanic ash. Similarly to Pongakawa, Maniatutu CW was excavated into an area that was likely historically a wetland, as evidenced by a strongly weathered peat soil above the sandy ash soil layer and a raw, high organic peat layer below the sandy ash layer. Land use in the catchment is a mix of dairy and kiwifruit (57% and 43%, respectively).

The wetland planting aimed to achieve 70% coverage of plants within the shallow parts of the wetland, predominantly *Machaerina articulata* and *Schoenoplectus tabernaemontani.* The wetland was planted with ~33,000 aquatic plants and ~5,000 riparian plants in autumn 2022. The embankments and wetland surrounds were planted with a diversity of native tree and shrub species planted to enhance site aesthetics, and the wetland is viewable from SH2 as well as accessible to Bay Gold employees and guests on the property. Owing to the warm climate and a wet La Niña year following the planting, the plants grew very quickly. The average plant coverage of the shallow vegetated zones of the wetland increased from 51% in 2022, to 69% in 2023, and 71% in 2024.

Flow and water quality monitoring equipment were installed in July 2022 and commissioned by NIWA in September 2022. In December 2023, the v-notch weirs at the inflow and outflow were replaced by rectangular weirs due to accommodate the larger than anticipated inflow from the catchment. Surface inflow and outflow sampling commenced in September 2022 and is underway until June 2025, thanks to additional funding from BOPRC and the MfE Access to Experts Programme from July 2024.

Figure A-4: Maniatutu wetland as viewed from upstream and downstream. Drone images taken by Andy Belcher, Legendary Photography (February 2024).

Tukipo Wetland, Ashley Clinton, Hawke's Bay

The Tukipo catchment is one of the dissolved inorganic nitrogen management priority subcatchments in the Tukituki Catchment of Hawke's Bay. HBRC approached NIWA to design a CW in the Tukipo catchment to remove dissolved nutrients from agricultural runoff and surface drainage water. The wetland location on the White Farm, Ashley-Clinton, Hawke's Bay, was previously identified by Nathan Burkpile, NZ Landcare Trust, through a regional constructed wetland scoping initiative supported by HBRC. A 7.5ha patch of remnant native forest of tōtara and kahikatea is located adjacent to the wetland and was fenced and placed under QEII Trust protection by the landowners. A wetland of this size is expected to provide habitat for bittern, and the adjacent large trees in the forest patch might be suitable for bat roosts.

The Tukipo CW design and construction funded by HBRC and Fonterra in partnership with NIWA. The White family agreed to retire some marginally productive pasture where the wetland was built, fencing the wetland and adjoining native forest block, and maintaining long-term weed control in the wetland. At the request of the landowner, several of the open water areas were built large enough to be attractive for waterfowl hunting.

The CW Intercepts an unnamed tributary subcatchment of Avoca Stream. The catchment mean annual rainfall is 1025 mm and the mean air temperature is 11.7 °C (data from Cliflo Takapau Plains Aws; 1991-2020). Catchment soils are a mixture of wind-deposited loess, alluvial soils with moderate to good soil drainage, and brown soils that are clayey and poorly drained. Land-use is a mixture of dry stock and dairy farming.

The CW area is ~1.6 ha or ~0.9% of the 180-ha surface catchment. The wetland was built off-line, with five interconnected cells, including an initial sedimentation pond that is 1.5m deep (Figure A-5). A high flow bypass channel routes storm flows around the wetland to the main waterway downstream of the wetland outlet. The shallow planted zone (0.3-0.6m) deep occupies 50-60% of wetland area, with deep open-water zones at the inlets and outlets of each cell to disperse inflows and re-collect outflows before passage to the next cell. The shallow zone plants are predominantly *Machaerina articulata* and *Schoenoplectus tabernaemontani.* The final cell was left primarily as a shallow, densely planted area. Wetland construction was completed Between February and April 2021. Planting with ~22,400 shallow aquatic plants and ~4,400 embankment and riparian plants was completed in April 2021. The overall coverage of wetland vegetation across the shallow areas of the wetland was ~40% shallow vegetation 2022 and is estimated to be >50% in 2024.

In June 2021, the Tukipo wetland was damaged by flooding, only a few months after the wetland was established and planted. Due to subsequent wet ground conditions that were not conducive to earthworks, the damaged wetland embankments and leaking weirs at the inlet and outlet were unable to be repaired until the following summer. In December 2022, the inlet's leaking v-notch weir was replaced with a flume that is more conducive to fish passage. In January 2023, the wetland helped to attenuate flood flows caused by Cyclone Gabrielle, but again, wet ground conditions and prioritisation of earthmoving capacity to other remediation tasks in the region prevented the remainder of the embankment and outlet remedial work to be completed. The final wetland embankment repairs were completed, the outlet flume was installed, and surface inflow and outflow flow monitoring stations completed in June 2024. However, with completion of the current project imminent, no formal monitoring programme has been instituted. Additional funding arrangements to support a more limited monitoring programme are currently being explored.

Figure A-5: Tukipo wetland and its catchment as viewed from different angles. Drone images taken by Thomas Petrie, HBRC (April 2021, just after planting, and November 2023).

Appendix B Summary of wetland monitoring, flow and water quality data quality assurance, and load estimation methods

Flow and water quality monitoring and data quality assurance

We developed a standardised CW sampling and analysis plan that was implemented by Council and NIWA staff. Wetland diffuse pollution attenuation performance was monitored through a combination of high frequency and discrete sampling of wetland surface inflows and outflows.

The high frequency monitoring encompassed water level, flow, precipitation, nitrate-N, and turbidity, which were measured every 5-15 minutes via in-situ instruments. Surface inflows and outflows were measured every 5 minutes using v-notch weirs. A stilling well with encoder or a pressure transducer was installed at each weir to measure water level within +/- 1 mm. Theoretical stage discharge relationships were calculated for each weir, and the rating curves were verified by manual flow gauging by Council and NIWA staff. Rainfall was measured at each wetland with a 0.2 mm tipping rain bucket. NIWA Instrument Systems and Environmental Data staff programmed, tested, and installed this instrumentation in partnership with council water quality technicians and provided ongoing support. High frequency turbidity was measured by DTS-12 turbidity sensors (FTS, Victoria, Canada) and high-frequency nitrate-n was measured by a Trios Opus sensors (Trios, Rastede, Germany). Both sensors were installed in perforated PVC pipes and were equipped with mechanical wipers to wipe the lens prior to measurement. Council technicians cleaned and checked the instrumentation on a monthly basis to ensure proper functioning and good data delivery.

Discrete sampling of the wetland surface inflow(s) and outflow was undertaken by Council staff. The discrete sampling occurred fortnightly during the main drainage season (approximately May to October), or monthly during dry/baseflow conditions. Where and/or when groundwater inputs make up a substantial proportion of the wetland inflow, discrete samples of groundwater were also collected (e.g., collected monthly or only a few times a year). The ISCO automatic samplers were triggered to take samples every few hours during significant flow events (storms), with the goal of monitoring 3-5 significant flow events at each wetland annually. Due to the remoteness of some sites, the event samples were collected within 48-72 hours of the event and transported on ice to Hill's or Bay of Plenty Regional Council laboratories. All sample tests were conducted according to standard methods. Bay of Plenty Regional Council Laboratory analysed *E.coli* for the Maniatutu and Pongakawa wetlands.

The telemetered, near-continuous flow, turbidity, and nitrate-N data and regular and event-based water quality data were stored in NIWA's time series manager Aquarius Time Series. The discrete water sample data include concentrations of SSC, TSS, TP, DRP, TN, nitrate-N, ammonium-N, and *E. coli*. All data processing (data editing, verification, and grading) were performed in Aquarius Time Series (Aquatic Informatics ULC, Vancouver, BC. Canada), using National Environmental Monitoring Standards (NEMS) and NIWA SOP guidance. Rainfall measured at each CW was compared to rainfall records from the NIWA or Council Electronic Weather Station closest to each of the wetlands, and these data were used to fill any gaps (missing data) in the wetland rainfall records.

Nutrient and sediment load and attenuation estimation

Small gaps in the surface inflow or outflow records were filled with imputation by Structural Model and Kalman Smoothing using the imputeTS package in R (Moritz et al. 2017). Gaps in the flow record that were longer than several days and spanned non-steady state baseflow or zero flow conditions were present at Awatuna (upstream and downstream), Fish Creek (additional side inflow), and Maniatutu (upstream), due to equipment malfunctions. These missing flow data gaps were filled using a Long-Short Term Memory (LSTM), a deep learning technique. LTSM is a type of deep neural network, excels at handling time-series data (see Ren et al., 2022 for more information). LTSM models were trained using a subset of the upstream and/or downstream data and rainfall data for the corresponding flow sites. We used the Nash-Sutcliffe efficiency coefficient (NSE) to evaluate the accuracy of the predicted flow, and R2 > 0.70 to assess good model performance. The imputed and modelled flow data were fused with the observed flow records to ensure that flow records did not have any missing data. This resulted in 105,120 five-minute observations per year for each surface inflow or outflow monitoring location at each wetland.

Gaps in the discrete nutrient and sediment sample data and in the high-frequency nitrate-N and turbidity data were filled by modelling concentrations using USGS regression models contained in Load Estimator (LOADEST), a program for estimating constituent loads in streams in rivers (Runkel et al. 2004). LOADEST was operated using the rLOADEST package in R. In both cases (high frequency and discrete data), the observed concentration and flow timeseries data were used to train regression models with explanatory variables including various functions of streamflow and decimal time to account for underlying annual and seasonal variability (Runkel et al. 2004). Where appropriate, a flow lag term was added as an explanatory variable to account for differences in concentration or dilution due to antecedent conditions, but the flow lag term was only retained if it improved model predictions. Akaike Information Criteria scores with a correction for small sample sizes (AICc) were used to select the most parsimonious model that fit the flow and concentration timeseries. The model fit was assessed based on evaluation of Adjusted Maximum Likelihood Estimation (AMLE) statistics, R2, NSE, bias, residual variance, and goodness of fit of the observed versus modelled concentration timeseries.

Where the modelled nitrate-N and turbidity concentrations from the high-frequency sensors had consistent relationships with the discrete sample TN and TP or SSC concentrations, respectively, and the modelled concentrations from the high frequency data had better fit to the observed data than did the discrete-sample-based model estimates, these were used as surrogates. This was the case for Awatuna wetland, where nitrate-N was used as a surrogate to estimate TN, and turbidity was used as a surrogate to estimate TP and SSC.

The high-frequency timeseries of flow and modelled TN, TP, and SS concentrations were integrated to calculate CW surface inflow and outflow loads. Groundwater mass loading to CW was determined based on approximately monthly grab sample data and water volumes estimated with annual mass balances (e.g., groundwater flow volume = surface outflow volume – surface inflow volume– net rainfall volume). Net rainfall was calculated as the difference between rainfall measured at each wetland minus estimated Priestley Taylor Potential Evapotranspiration (PET) from the closest weather station. For PET estimates, we assumed a vegetation coefficient of 1, which is similar to that measured in restored marshes in the Sacramento-San Joaquin Delta, California, USA. (Drexler et al. 2008; Eichelmann et al. 2018).

A combined inflow load was calculated for each CW based on the surface inflow and groundwater inflow loads, and mass removal (g m^{-2} CW yr^{-1}), and percentage mass removal were used to assess CW treatment efficacy of TN, TP, and SSC on an annual basis. To provide better comparison with diffuse pollution losses from farming and demonstrate CW removal per catchment area, the surface and groundwater (combined) catchment inflow loading rates and annual CW load removal rates were also calculated in kg ha^{-1} yr^{-1}.

Appendix C Annual catchment water yields and wetland water balances

Table C-1: Annual wetland water yields standardised by catchment area (e.g., yield (mm) per catchment area per year). Catchment precipitation and PET (potential evapotranspiration) are measured totals for each annual period. Groundwater flow yield was calculated as the difference between outlet and inlet surface flow yields and does not include net catchment precipitation.

Parameter	Awatuna			Fish Creek		Maniatutu	Pongakawa
	May 2021-2022	May 2022-2023	May 2023-2024	May 2022-2023	May 2023-2024	May 2023-2024	May 2023-2024
catchment precipitation (mm y^{-1})[+]	1820	2061	1350	3332	1909	1201	1197
catchment PET (mm y^{-1})[++]	725	660	658	772	828	748	748
inlet surface flow yield (mm y^{-1})	1226	1551	846	3876	2075	302	7
groundwater flow yield (mm y^{-1})	108	110	-10	-2053	-1346	-29	226
outlet surface flow yield (mm y^{-1})	1334	1661	836	1823	729	273[*]	233

[+]precipitation was measured locally at each wetland
[++]daily Priestley Taylor potential evapotranspiration estimates were used from the closest weather station

Appendix D Annual wetland performance data summary

Table D-1: Annual summary of wetland performance derived from the continuously measured hydrometric parameters at the wetland inlet(s) and/or outlet plus discrete sampling of nutrients and sediment from inlet(s), groundwater wells (where applicable), and outlets. TN, TP, and SS concentrations are flow proportional averages (g m^3 y^{-1}). Aerial loading rates (g m^{-2} y^{-1}) were calculated by dividing loads by the wetland basal area. Combined inflow loading rates are from all surface and groundwater inflows. Removal rates are the difference between the inlet and the outlet.

Parameter	Awatuna			Fish Creek		Maniatutu	Pongakawa		
	May 2021-2022	May 2022-2023	May 2023-2024	May 2022-2023	May 2023-2024	May 2023-2024	May 2023-2024		
							*low**	*med***	*high****
surface inflow TN flow-avg concentration (g m^{-3})	2.83	2.21	1.85	1.95	1.15	2.03	3.89	3.89	3.89
average groundwater inflow TN concentration (g m^{-3})	1.42	1.62	1.35	0.43	0.45		4.66	6.21	13.60
outflow TN flow-avg concentration (g m^{-3})	1.36	1.39	1.28	1.30	0.91	0.54	3.89	3.89	3.89
combined inflow TN loading rate (g m^{-2} y^{-1})	149	151	65	280	72	21	50	66	142
outflow TN loading rate (g m^{-2} y^{-1})	79	100	46	197	52	5	43	43	43
annual TN removal rate (g m^{-2} y^{-1})	70	51	18	83	19	16	6.	22	99
% removal efficiency TN load	47%	34%	28%	30%	27%	75%	13%	34%	70%
surface inflow TP flow-avg concentration (g m^{-3} y^{-1})	0.10	0.039	0.054	0.32	0.48	0.22	0.081	0.081	0.081
groundwater inflow TP concentration (g m^{-3} y^{-1})	0.029	0.007	0.008	0.04	0.007		0.38	1.61	6.32
outflow TP flow-avg concentration (g m^{-3} y^{-1})	0.033	0.031	0.024	0.27	0.42	0.033	0.081	0.081	0.081
combined inflow TP loading rate (g m^{-2} y^{-1})	5	2	2	46	30	2	4	17	65
outflow TP loading rate (g m^{-2} y^{-1})	2	2	1	41	24	0.3	1	1	1
annual TP removal rate (g m^{-2} y^{-1})	3	0.2	1	5	6	2	3	16	64
% removal efficiency TP load	62%	9%	52%	12%	19%	86%	77%	95%	99%
surface inflow flow-avg SSC concentration (g m^{-3} y^{-1})	16	14	16	44	24	11	12	12	12
groundwater inflow SSC concentration (g m^{-3} y^{-1})	12	12	12	12	12		12	12	12
outflow SSC flow-avg concentration (g m^{-3} y^{-1})	13	13	12	20	23	11	11	11	11
combined inflow SSC loading rate (g m^{-2} y^{-1})	891	980	553	6343	1499	119	128	128	128
outflow SSC loading rate (g m^{-2} y^{-1})	756	943	452	2966	1302	116	127	127	127
annual SSC removal rate (g m^{-2} y^{-1})	133	37	101	3377	197	3	1	1	1
% removal efficiency SS load	15%	4%	18%	53%	13%	3%	1%	1%	1%

Pongakawa: surface inflow concentrations from a single flood event were estimated to be same as the annual flow-proportional concentration measured out the outflow (a conservative estimate)
*low: inflowing groundwater concentrations are weighted flow-proportionally from all piezometers
**medium: inflowing groundwater concentrations are averaged from all piezometers
***high: inflowing groundwater concentrations are weighted 100% flow-proportional from piezometer 2 for dissolved DN and from piezometer 4 for dissolved TP

Appendix E Awatuna wetland monitoring data summary

Table E-1: Awatuna wetland summary of sediment, nutrient, and *E.coli* concentrations at the wetland inlet, groundwater, and outlet as characterised by discrete sampling from 1 May 2021 to 30 April 2024. 'N' is the number of samples collected in the monitoring period, 'Avg' is the average value, 'SD' is the standard deviation, a measure of how dispersed the data are relative to the mean value, 'Min' is the minimum, 'Max' is the maximum, and 'Per (10^{th}-90^{th})' is the percentile where a certain percentage of measurements falls below that number. Blank values indicate no monitoring data collected.

Parameter	N	Avg	SD	Min	Max	$10\%^{ile}$	$25\%^{ile}$	Median	$75\%^{ile}$	$90\%^{ile}$
surface inflow NO_3-N (g m^{-3})	96	1.48	0.72	0.36	4.1	0.64	1.01	1.32	1.79	2.4
groundwater inflow NO_3-N (g m^{-3})	22	1.25	0.49	0.64	2.5	0.83	0.9	1.13	1.36	1.95
outflow NO_3-N (g m^{-3})	87	0.82	0.7	0.002	4.2	0.031	0.17	0.76	1.26	1.65
surface inflow NH_4-N (g m^{-3})	96	0.14	0.27	0.01	1.75	0.029	0.056	0.076	0.10	0.25
groundwater inflow NH_4-N (g m^{-3})	22	0.11	0.025	0.068	0.18	0.082	0.097	0.11	0.13	0.14
outflow NH_4-N (g m^{-3})	87	0.08	0.054	0.01	0.23	0.01	0.039	0.077	0.10	0.16
surface inflow TN (g m^{-3})	95	2.14	1.04	0.61	6.3	1.19	1.47	1.83	2.6	3.6
groundwater inflow TN (g m^{-3})	22	1.48	0.47	0.86	2.6	1.05	1.16	1.37	1.57	2.2
outflow TN (g m^{-3})	90	1.38	0.71	0.38	4.5	0.53	0.71	1.42	1.89	2.25
surface inflow DRP (g m^{-3})	96	0.008	0.009	0.004	0.054	0.004	0.004	0.004	0.005	0.02
groundwater inflow DRP (g m^{-3})	22	0.004	0	0.004	0.004	0.004	0.004	0.004	0.004	0.004
outflow DRP (g m^{-3})	87	0.005	0.001	0.004	0.011	0.004	0.004	0.004	0.004	0.007
surface inflow TP (g m^{-3})	95	0.069	0.13	0.002	0.75	0.003	0.005	0.014	0.072	0.2
groundwater inflow TP (g m^{-3})	22	0.008	0.008	0.002	0.029	0.002	0.004	0.005	0.009	0.019
outflow TP (g m^{-3})	88	0.041	0.03	0.004	0.14	0.008	0.018	0.035	0.05	0.086
surface inflow SSC (g m^{-3})	91	15.57	13.24	10	79	10	10	11	14	25
groundwater inflow SSC (g m^{-3})	22	11.36	2.92	10	24	10	10	11	11	12
outflow SSC (g m^{-3})	82	11.12	2.51	10	25	10	10	10	11	13
surface inflow *E.coli* (cfu 100 mL^{-1})	96	5042	11505	5	53000	20	90	240	1300	26000
groundwater inflow *E.coli* (cfu 100 mL^{-1})	22	49	149	1	700	1	2	6	18	120
outflow *E.coli* (cfu 100 mL^{-1})	88	2365	4646	12	28000	120	320	950	2350	6000
surface inflow DOC (g m^{-3})	82	2.80	2.21	0.5	9.6	0.7	1.3	2	3.8	6.1
groundwater inflow DOC (g m^{-3})	22	1.11	0.63	0.5	2.4	0.5	0.5	1.1	1.4	2.1
outflow DOC (g m^{-3})	73	3.72	1.74	0.6	8.2	1.6	2.3	3.6	5	6

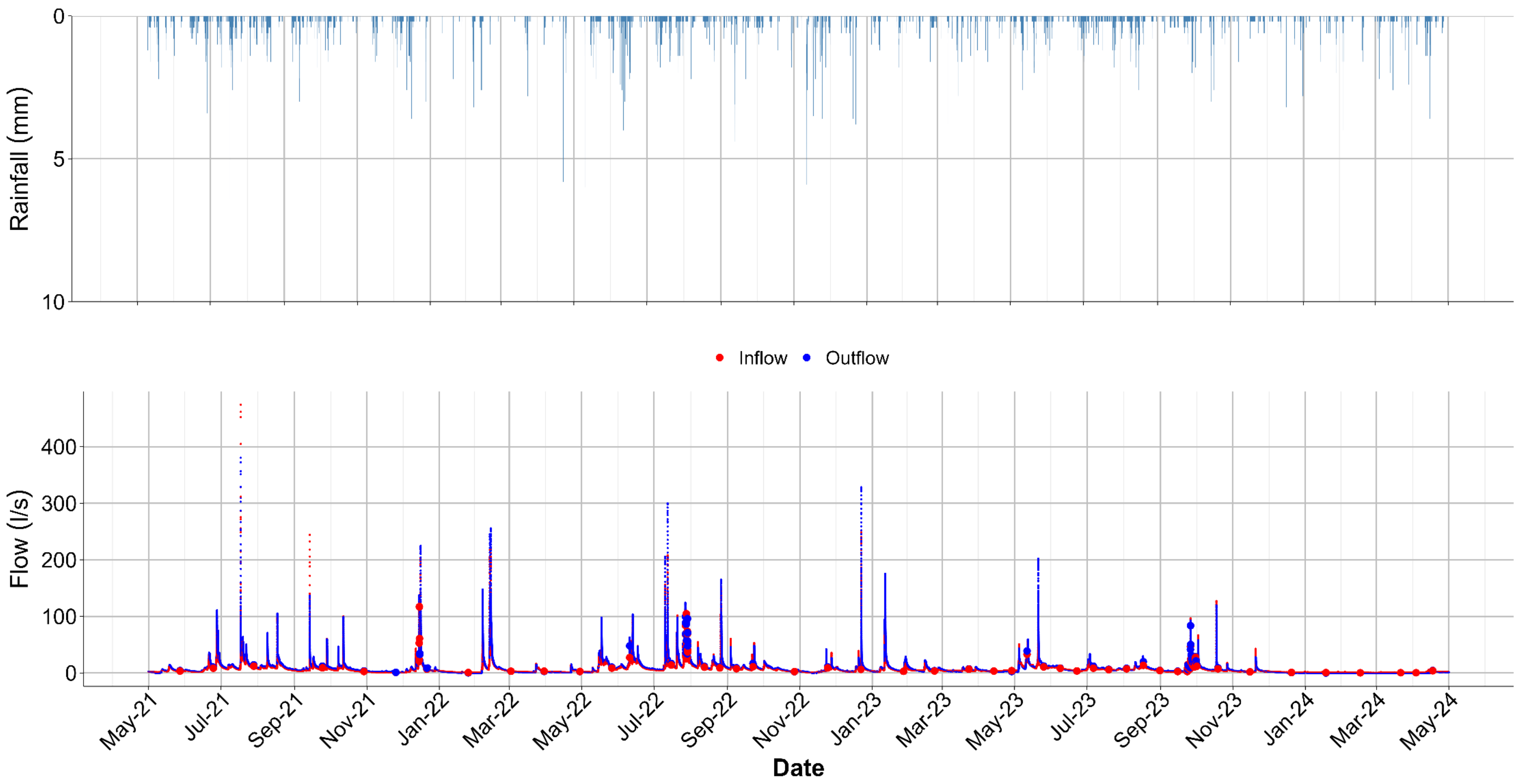

Figure E-1: Awatuna wetland timeseries of rainfall and surface inflow and outflow. Coloured points indicate when discrete samples were collected.

Appendix F Fish Creek wetland monitoring data summary

Table F-1: Fish Creek wetland summary of sediment, nutrient, and *E.coli* concentrations at the wetland inlet, side inlet (extra surface inflow), groundwater, and outlet as characterised by discrete sampling from 1 May 2022 to 30 April 2024. 'N' is the number of samples collected in the monitoring period, 'Avg' is the average value, 'SD' is the standard deviation, a measure of how dispersed the data are relative to the mean value, 'Min' is the minimum, 'Max' is the maximum, and 'Per (10th-90th)' is the percentile where a certain percentage of measurements falls below that number. Blank values indicate no monitoring data collected.

Parameter	N	Avg	SD	Min	Max	10%ile	25%ile	Median	75%ile	90%ile
surface inflow NO_3-N (g m^{-3})	71	0.55	0.85	0.001	3.8	0.01	0.13	0.27	0.6	1.46
extra surface inflow NO_3-N (g m^{-3})	10	0.28	0.22	0.049	0.58	0.056	0.11	0.17	0.5	0.57
groundwater inflow NO_3-N (g m^{-3})	12	0.42	0.20	0.17	0.66	0.18	0.24	0.42	0.61	0.66
outflow NO_3-N (g m^{-3})	112	0.26	0.27	0.001	1.99	0.002	0.098	0.21	0.3	0.58
surface inflow NH_4-N (g m^{-3})	71	0.063	0.079	0.005	0.3	0.007	0.015	0.022	0.087	0.16
extra surface inflow NH_4-N (g m^{-3})	10	0.23	0.66	0.005	2.1	0.005	0.008	0.023	0.046	1.08
groundwater inflow NH_4-N (g m^{-3})	12	0.005	0.003	0.001	0.013	0.005	0.005	0.005	0.005	0.005
outflow NH_4-N (g m^{-3})	112	0.077	0.1	0.005	0.68	0.006	0.018	0.042	0.103	0.19
surface inflow TN (g m^{-3})	70	1.68	1.19	0.49	6.4	0.59	0.96	1.37	1.88	2.8
extra surface inflow TN (g m^{-3})	10	1.9	1.66	0.39	6	0.45	0.65	1.47	2.5	4.35
groundwater inflow TN (g m^{-3})	12	0.46	0.21	0.21	0.73	0.23	0.25	0.52	0.65	0.7
outflow TN (g m^{-3})	109	1.37	0.70	0.29	4.1	0.55	0.8	1.33	1.74	2.1
surface inflow DRP (g m^{-3})	71	0.26	0.18	0.024	1.08	0.086	0.15	0.21	0.31	0.51
extra surface inflow DRP (g m^{-3})	10	0.31	0.29	0.001	0.81	0.017	0.092	0.24	0.5	0.78
groundwater inflow DRP (g m^{-3})	12	0.003	0.006	0	0.021	0.001	0.001	0.001	0.001	0.002
outflow DRP (g m^{-3})	112	0.19	0.16	0.005	0.58	0.033	0.065	0.15	0.26	0.45
surface inflow TP (g m^{-3})	71	0.34	0.21	0.057	1.33	0.14	0.23	0.3	0.38	0.61
extra surface inflow TP (g m^{-3})	10	0.40	0.33	0.021	1.01	0.042	0.14	0.36	0.66	0.92
groundwater inflow TP (g m^{-3})	12	0.021	0.033	0.001	0.11	0.002	0.002	0.005	0.02	0.069
outflow TP (g m^{-3})	112	0.36	0.32	0.054	1.98	0.11	0.15	0.25	0.52	0.62
surface inflow SSC (g m^{-3})	71	15.85	9.57	4.37	49	10	10	11	23	30
extra surface inflow SSC (g m^{-3})	10	30	46.97	11	162	11	11	11.5	27	96.5
groundwater inflow SSC (g m^{-3})	12	23.2	31.54	6.4	118	10	11	11.5	15	46
outflow SSC (g m^{-3})	100	15.45	10.57	4.74	70	10	10	11	17	26.5
surface inflow *E.coli* (cfu 100 mL^{-1})	28	1575	3995	7	21000	20	80	370	1100	3700
extra surface inflow *E.coli* (cfu 100 mL^{-1})	7	8300	11952	400	33000	400	600	1600	14000	33000
groundwater inflow *E.coli* (cfu 100 mL^{-1})	12	3	7	1	27	1	1	1	2	2

Parameter	N	Avg	SD	Min	Max	10%ile	25%ile	Median	75%ile	90%ile
outflow *E.coli* (cfu 100 mL^{-1})	60	2831	5416	1	30000	11	102	705	3400	5200
surface inflow DOC (g m^{-3})	71	13.09	5.64	4.2	34	6.2	9.3	12.6	16	19.2
extra surface inflow DOC (g m^{-3})	10	15.7	11.35	0.5	31	2.15	4.9	14.35	29	31
groundwater inflow DOC (g m^{-3})	12	1.46	1.83	0.5	5.9	0.5	0.5	0.5	1.45	4.6
outflow DOC (g m^{-3})	99	11.5	5.35	2.3	27	4.2	6.8	11.4	15.4	18

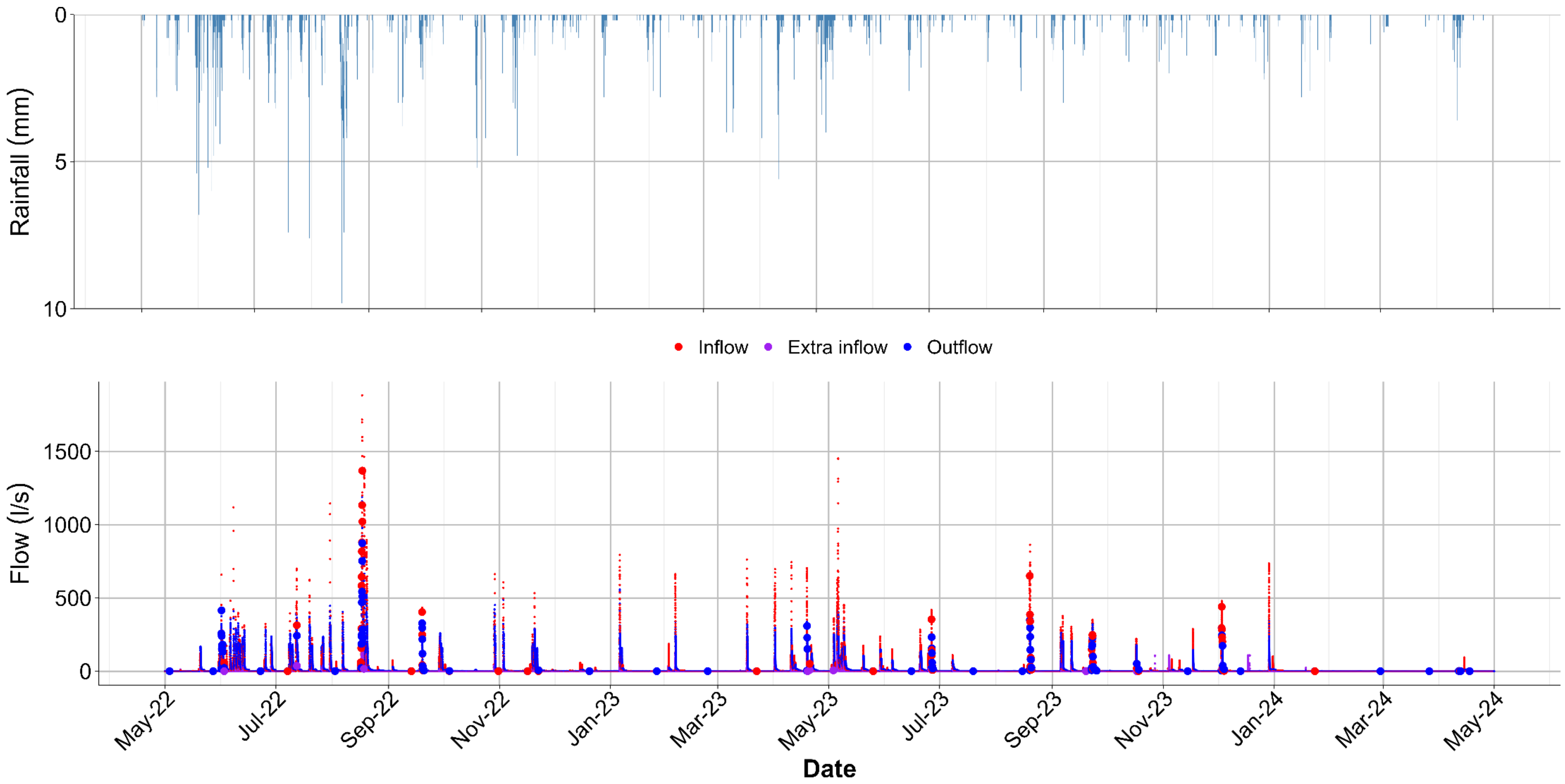

Figure F-1: Fish Creek wetland timeseries of rainfall and surface inflow and outflow. Coloured points indicate when discrete samples were collected.

Appendix G Pongakawa wetland monitoring data summary

Table G-1: Pongakawa wetland summary of sediment, nutrient, and *E.coli* concentrations at the wetland surface inlet, groundwater piezometers (x4), and surface outlet as characterised by discrete sampling from 1 May 2023 to 30 April 2024. 'N' is the number of samples collected in the monitoring period, 'Avg' is the average value, 'SD' is the standard deviation, a measure of how dispersed the data are relative to the mean value, 'Min' is the minimum, 'Max' is the maximum, and 'Per (10th-90th)' is the percentile where a certain percentage of measurements falls below that number. Blank values indicate no monitoring data collected.

Parameter	N	Avg	SD	Min	Max	10%ile	25%ile	Median	75%ile	90%ile
surface inflow NO_3-N (g m^{-3})										
groundwater inflow NO_3-N (g m^{-3})	69	3.50	6.13	0.002	20	0.015	0.02	0.098	3.3	14.4
outflow NO_3-N (g m^{-3})	34	2.56	1.83	0.002	5.7	0.002	1.64	2.4	3.8	5.6
surface inflow NH_4-N (g m^{-3})										
groundwater inflow NH_4-N (g m^{-3})	65	1.86	2.55	0.01	8.6	0.01	0.064	0.55	4.3	6.2
outflow NH_4-N (g m^{-3})	28	0.14	0.58	0.01	3.1	0.01	0.012	0.024	0.047	0.064
surface inflow TN (g m^{-3})										
groundwater inflow dissolved TN (g m^{-3})	69	6.15	5.81	0.22	20.85	0.39	1.4	3.6	9.6	14.15
outflow TN (g m^{-3})	28	3.28	1.84	0.46	6.5	0.59	2.4	3.15	4.65	6
surface inflow DRP (g m^{-3})										
groundwater inflow DRP (g m^{-3})	67	1.49	2.90	0.004	10.8	0.004	0.007	0.04	1.03	7
outflow DRP (g m^{-3})	28	0.008	0.02	0.004	0.11	0.004	0.004	0.004	0.004	0.006
surface inflow TP (g m^{-3})										
groundwater inflow TDP (g m^{-3})	68	1.61	3.16	0.002	11.7	0.002	0.005	0.018	0.71	7.2
outflow TP (g m^{-3})	28	0.05	0.031	0.021	0.18	0.027	0.029	0.042	0.064	0.076
surface inflow SSC (g m^{-3})										
groundwater inflow SSC (g m^{-3})										
outflow SSC (g m^{-3})	17	10.94	1.44	10	16	10	10	11	11	12
surface inflow *E.coli* (cfu 100 mL^{-1})										
groundwater inflow *E.coli* (cfu 100 mL^{-1})	66	103	328	0	2100	0	2	10	50	200
outflow *E.coli* (cfu 100 mL^{-1})	22	383	805	7	3900	30	80	170	350	590
surface inflow DOC (g m^{-3})										
groundwater inflow DOC (g m^{-3})										
outflow DOC (g m^{-3})	27	4.37	6.98	0.5	38	0.6	1.4	3	4.1	6.2

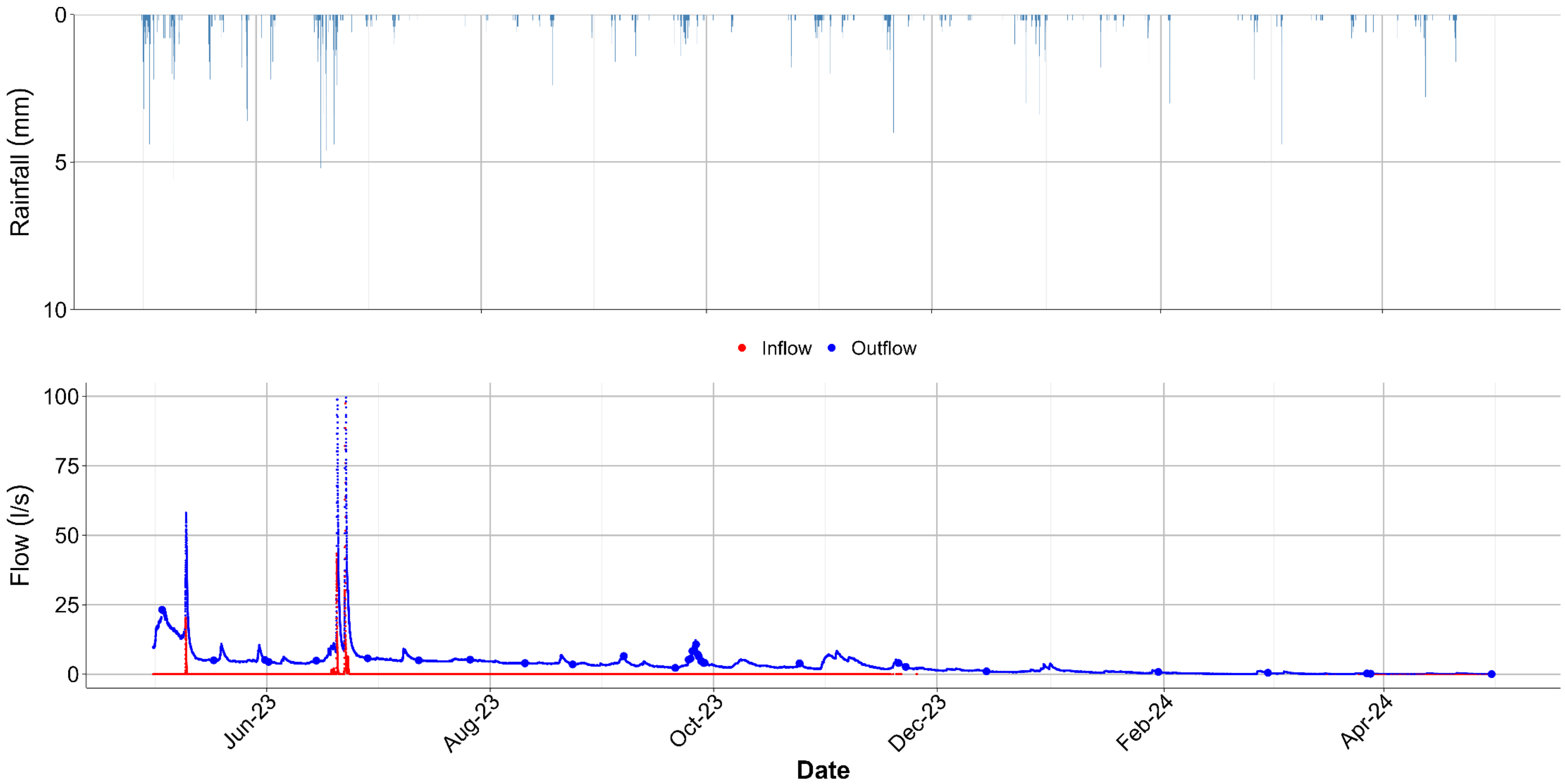

Figure G-1: **Pongakawa.** Estimated flows in the large storm event in June 2023 were >250 l/s surface inflow and >3,000 l/s surface outflow (data not shown).

Appendix H Te Rere I Maniatutu monitoring data summary

Table H-1: Maniatutu wetland summary of sediment, nutrient, and *E.coli* concentrations at the wetland inlet and outlet as characterised by discrete sampling from 1 May 2023 to 30 April 2024. 'N' is the number of samples collected in the monitoring period, 'Avg' is the average value, 'SD' is the standard deviation, a measure of how dispersed the data are relative to the mean value, 'Min' is the minimum, 'Max' is the maximum, and 'Per (10^{th}-90^{th})' is the percentile where a certain percentage of measurements falls below that number. Blank values indicate no monitoring data collected.

Parameter	N	Avg	SD	Min	Max	$10\%^{ile}$	$25\%^{ile}$	Median	$75\%^{ile}$	$90\%^{ile}$
surface inflow NO_3-N (g m^{-3})	26	0.93	0.48	0.035	1.54	0.33	0.57	0.98	1.41	1.47
groundwater inflow NO_3-N (g m^{-3})										
outflow NO_3-N (g m^{-3})	24	0.02	0.051	0.002	0.24	0.002	0.002	0.002	0.007	0.066
surface inflow NH_4-N (g m^{-3})	19	0.12	0.12	0.01	0.34	0.015	0.033	0.076	0.22	0.34
groundwater inflow NH_4-N (g m^{-3})										
outflow NH_4-N (g m^{-3})	20	0.01	0	0.01	0.01	0.01	0.01	0.01	0.01	0.01
surface inflow TN (g m^{-3})	20	1.80	0.38	0.75	2.5	1.34	1.59	1.88	2.00	2.15
groundwater inflow TN (g m^{-3})										
outflow TN (g m^{-3})	20	0.60	0.13	0.39	0.96	0.42	0.54	0.61	0.68	0.73
surface inflow DRP (g m^{-3})	19	0.044	0.045	0.014	0.21	0.015	0.023	0.031	0.042	0.11
groundwater inflow DRP (g m^{-3})										
outflow DRP (g m^{-3})	20	0.008	0.006	0.004	0.024	0.004	0.004	0.004	0.012	0.017
surface inflow TP (g m^{-3})	19	0.14	0.14	0.034	0.6	0.037	0.053	0.071	0.2	0.37
groundwater inflow TP (mg L^{-3})										
outflow TP (mg L^{-3})	20	0.044	0.02	0.015	0.111	0.022	0.032	0.043	0.052	0.058
surface inflow SSC (g m^{-3})	12	10.5	0.52	10	11	10	10	10.5	11	11
groundwater inflow SSC (g m^{-3})										
outflow SSC (g m^{-3})	10	10.5	0.53	10	11	10	10	10.5	11	11
surface inflow *E.coli* (cfu 100 mL^{-1})	15	1942	2658	2	8000	40	160	260	4200	6300
groundwater inflow *E.coli* (cfu 100 mL^{-1})										
outflow *E.coli* (cfu 100 mL^{-1})	14	523	1325	3	5100	4	22	215	310	440
surface inflow DOC (g m^{-3})	20	6.51	2.51	2.9	12.3	3.3	4.25	6.35	8.3	9.15
groundwater inflow DOC (g m^{-3})										
outflow DOC (g m^{-3})	19	7.28	1.52	4.9	11	5.6	6.2	6.8	8.2	9.8

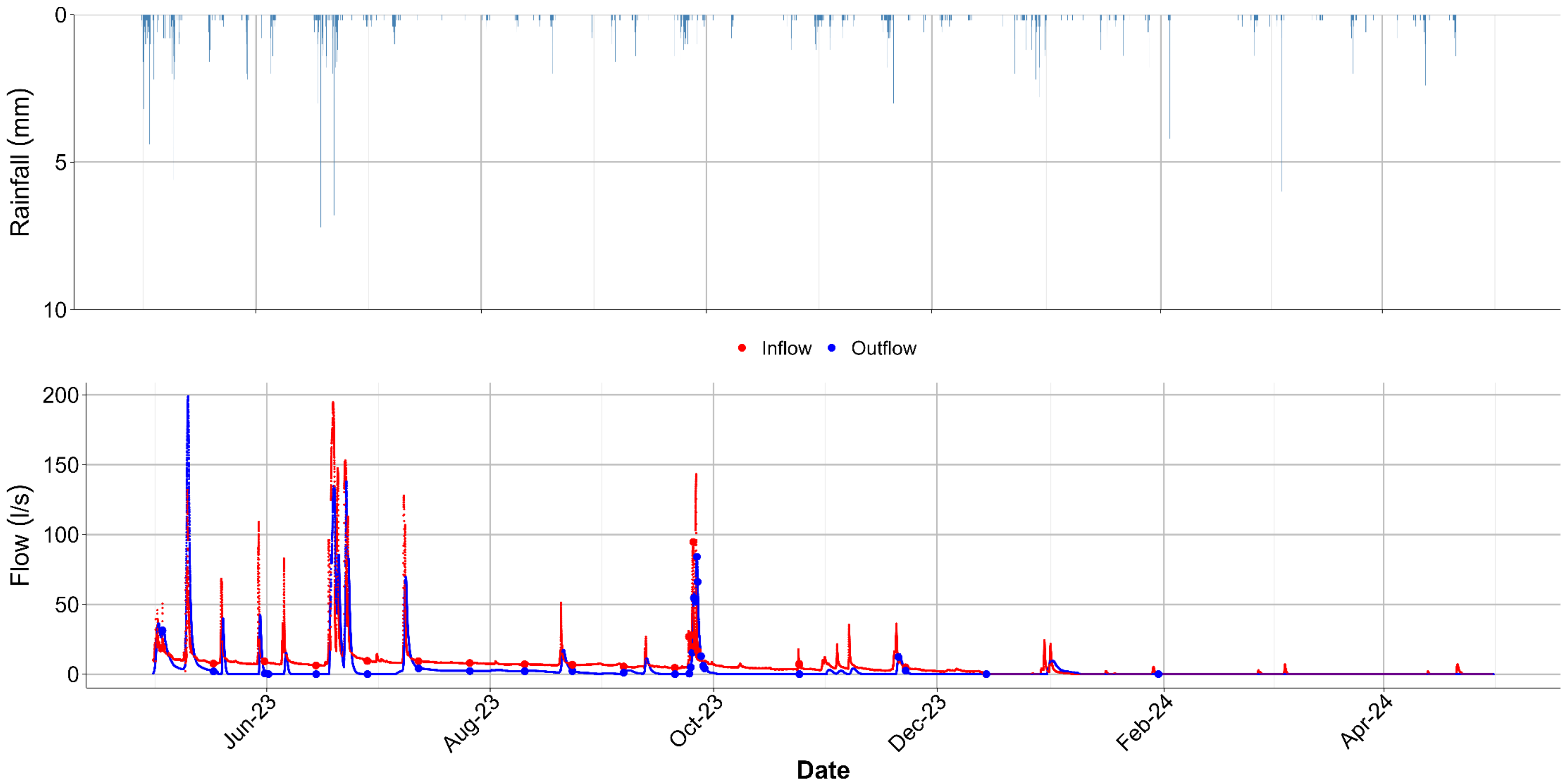

Figure H-1: Maniatutu wetland timeseries of rainfall and surface inflow and outflow. Coloured points indicate when discrete samples were collected.

Appendix I Annotated list of constructed wetland next-user and stakeholder communication outputs July 2020 to October 2024

This appendix provides a narrative summary of the SLMACC constructed wetland project presentations and communication updates to the rural community, next-users, and stakeholders over the life of the four-year project. The communication outputs listed below are presented in the style of an annotated bibliography, starting with the introduction of the broader project at international and national science conferences in 2021. On-going media updates and related communications outputs demonstrating and promoting the constructed wetland sites are included, as well as targeted workshops and field demonstration days. Within each category, outputs are listed in ascending chronological order. Not included in these lists are online meetings or online presentations of wetland performance monitoring or operational matters to the collaborating Councils or MPI, MPI milestone reports or technical evidence of completion, NIWA internal One.Niwa online communications, or social media posts (e.g., World Wetlands Day). Also, although not quantified here, the frequent communication among NIWA, MPI, Councils, and industry partners involved in the SLMACC wetlands contributed massively to the success of the project.

The overall SLMACC constructed wetland science and media communication list includes over 50 different outputs:

- 3 International conferences, 1 international invited seminar,3 domestic conference presentations and 2 conference papers promoting the SLMACC constructed wetlands;
- 1 constructed wetland technical guideline and 1 promotional video;
- 2 masterclasses, 2 webinars, and 1 domestic conference presentation on constructed wetland design;
- 2 webinar and 3 presentations to government officials and local government science and land management staff;
- 24 on-line media outputs to rural professionals and/or the general public on the use of constructed wetlands to improve rural water quality;
- 5 meetings and correspondence with Overseer on improving the Overseer constructed wetland module; and
- 3 field demonstration days and 3 presentations for rural professionals, farmers, and community members.

3 International conferences, 1 international invited seminar, 3 domestic conference presentations, and 2 conference papers promoting the SLMACC constructed wetlands

In 2021, the project was introduced in two virtual presentations delivered at two international conferences.

Tanner, C., Sukias, J., Woodward, B., Goeller, B., Matheson, F. McKergow, L., Wright-Stow, A., Kalaugher, E., Depree, C. (2021). Quantifying field-scale performance and developing practical guidelines to accelerate uptake of constructed wetlands for on-farm nutrient management. Virtual audio-visual presentation, Symposium on Constructing and Rehabilitating Wetlands for Diffuse Pollution and Biodiversity Management in

Agroecosystems, INTECOL International Wetlands Conference. Christchurch, NZ. 11-14 October.

Tanner, C., Sukias, J., Woodward, B., Goeller, B., Matheson, F. McKergow, L., Kalaugher, E., Depree, C., Wright-Stow, A. (2021). New Zealand guidelines for constructed wetland treatment of diffuse run-off from pastoral farms. Virtual audio-visual presentation, 9th WETPOL International Conference on Wetland Pollution Control and Dynamics. Vienna, Austria. 13-17 September 2021.

In April 2024, NIWA presented an overview and key wetland performance findings at an invited seminar at the Institute of Hydrobiology and Aquatic Ecosystem Management, University of Natural Resources and Life Sciences (BOKU), in Vienna, Austria. The seminar delivered in-person, recorded, and streamed to ~20 researchers. In Augus 2024, the SLMACC case study sites were introduced at the 10th International Phosphorus Workshop held at Dundee University, Scotland.

Goeller, B. (2024). Rehabilitating agricultural streams with constructed wetlands: Lessons learned in New Zealand. Invited seminar at the Institute of Hydrobiology and Aquatic Ecosystem Management, University of Natural Resources and Life Sciences (BOKU), Vienna, Austria. 25 April 2024.

Goeller, B., Woodward, B, Tanner, C. (2024). Constructed wetlands for agricultural phosphorus retention: New Zealand and international experiences. 10th International Phosphorus Workshop (IPW10): Phosphorus processes in catchments. University of Dundee, Dundee, Scotland.26-30 August 2024.

In February 2022 and February 2024, NIWA introduced the project and presented preliminary results at the Massey University Farmed Landscapes Research Centre Conference (FLRC). FLRC hosts an annual workshop which is conducted on a topic of importance to the New Zealand land-based industries. FLRC has hosted these workshops at Massey University since 1987, which are of relevance to scientists, researchers, fertiliser industry representatives, producer boards, agricultural and horticultural consultants, progressive farmers, Government policy analysts and local and regional authorities who are concerned with primary production in New Zealand. Written conference proceedings papers are published and freely available on the FLRC website.

Goeller, B., Tanner, C., McKergow, L., Vincent, A. Hicks, A., James, T., de Monchy, P., Murphy, D., Phipps, R. (2022). Quantifying and demonstrating constructed wetland contaminant attenuation from mixed agricultural runoff. Oral presentation at Farmed Landscape Conference on Adaptive Strategies for Future Farming. Massey University, Palmerston North, NZ. 9-11 February.

Goeller, B., Tanner, C., McKergow, L., Vincent, A., Hicks, A., James, T., de Monchy, P., Murphy, D. Phipps, R. (2022). Quantifying and demonstrating constructed wetland contaminant attenuation from mixed agricultural runoff. In: Adaptive Strategies for Future Farming. (Eds C.L. Christensen, D.J. Horne and R. Singh). http://flrc.massey.ac.nz/publications.html. Occasional Report No. 34. Farmed Landscapes Research Centre, Massey University, Palmerston North, New Zealand. 4 pages.

Goeller, B., Tanner, C., McKergow, L., Vincent, A., Phipps, R., Arnoux, S., Pickford, C., Xu, J. (2024). Performance of a constructed wetland treating tile drain and groundwater flows from a Taranaki dairy farm. Oral presentation at Farmed Landscape Conference on Opportunities for Improved Farm and Catchment Outcomes, Massey University, Palmerston North, NZ. 13-15 February.

Goeller, B., Tanner, C., McKergow, L., Vincent, A., Phipps, R., Arnoux, S., Pickford, C., Xu, J. (2024). Performance of a constructed wetland treating tile drain and groundwater flows from a Taranaki dairy farm. In: Opportunities for Improved Farm and Catchment Outcomes. (Eds. C.L. Christensen, D.J. Horne and R. Singh). http://flrc.massey.ac.nz/publications.html. Occasional Report No. 36. Farmed Landscapes Research Centre, Massey University, Palmerston North, New Zealand. 4 pages.

Tanner, C., Goeller, B., McKergow, L., Vincent, A., Sukias, J., James, T., Efford, J., Pickford, C. (2024). Quantifying diffuse agricultural contaminant attenuation by constructed wetlands across diverse agricultural landscapes. New Zealand Freshwater Sciences Annual Conference, Rotorua Energy Events Centre, Rotorua, NZ. 21 November.

1 constructed wetland technical guideline and 1 promotional video

Three of the SLMACC wetlands (Awatuna, Fish Creek, and Tukipo) are featured as case study examples in NIWA and DairyNZ's "Constructed wetland practitioner guide". NIWA has also produced a constructed wetland demonstration video that prominently features the designs and examples from the Maniatutu and Awatuna wetlands, but also includes drone footage from the Fish Creek and Tukipo wetlands. The wetland guidelines and video are freely available on NIWA's website.

Tanner, C., Depree, C., Sukias, J., Wright-Stow, A., Burger, D., Goeller, B. (2022). Constructed Wetland Practitioners Guide: Wetland Design and Performance Estimates. DairyNZ/NIWA, Hamilton, New Zealand.

McKay, S., Goeller, B., Tanner, C. (2022). Constructed wetlands. NIWA Video.https://niwa.co.nz/freshwater-and-estuaries/management-tools/restoration-tools/constructed-wetland-guidelines.

2 masterclasses, 2 webinars, and 1 domestic conference presentation on constructed wetland design

The SLMACC CW demonstration sites are illustrative examples of how to design constructed wetlands, and they have been featured in hands-on training as well as virtual webinars.

Tanner, C., Sukias, J., Woodward, B., Goeller, B., Matheson, F., McKergow, L., Wright-Stow, A., Kalaugher, E., Depree, C. (2020). New guidelines for constructed wetland treatment of pastoral farm run-off. Presentation to New Zealand Freshwater Science Society/Hydrological Society/Rivers Group Conference, Invercargill, Dec 2020.

Tanner, C., Wright-Stow, A. (2022). New guidelines for managing farm contaminant losses using constructed wetlands. New Zealand Land Treatment Collective Webinar. 29 July 2022.

Matheson, F., Tanner, C., Woodward, B. (2022). Masterclass on edge of field mitigations to treat runoff water. Presented at the NZARM conference, The Beehive, Wellington. 18 October 2022.

Tanner, C., Tomer, M., Goeller, B., Matheson, F. (2023). Which mitigation goes where for what? Invited on-line presentation to the Ministry of Primary Industries On-farm Support Team, 21 Nov 2023.

Tanner, C., Goeller, B. (2024). Surface flow constructed wetlands: A proven nature-based solution to reduce on-farm nutrient and sediment losses. Masterclass for the Catchment Solutions Project, Ministry for the Environment. Massey University, 7-8 November 2024.

2 webinars and 3 presentations to government officials and local government science and land management staff

As part of a wrap-up of NIWA's five-year, MBIE Endeavor-funded Programme on Doubling Diffuse Pollution Attenuation, a recorded webinar-style presentation of the SLMACC constructed wetland demonstration network and key results was shared with over 50 staff from Councils and the Department of Conservation. A similar presentation was given to ~20 Council staff members of the Land Management SIG. A further invited webinar was run in collaboration with BOPRC for NZARM, with ~60 online attendees. These webinars and other presentations to Government officials, Council science and land management staff, and rural professionals have provided a forum for discussing applied science approaches to mitigate rural water quality issues, which is enhancing the capability government agencies, industry and rural professionals to respond to the immense challenges of rehabilitating catchments from source-to-sea at pace and scale across the country.

Tanner, C., Goeller, B. (2024). Constructed wetlands as interceptive mitigations for reducing contaminant losses. Presentation to Minster Andrew Hoggard, BOPRC and community members. Baygold, Maniatutu, Bay of Plenty. 6 June 2024.

Tanner, C., Craggs, R., Goeller, B. (2024). The Interceptor Project- Doubling on-farm diffuse pollution mitigation. 45 min presentation to the Bay of Plenty Regional Council Monitoring and Operations Committee. 10 June 2024.

Tanner, C., Craggs, R., Moghaddam, R., Goeller, B., Thiange, C., Mathews, Y. (2024). Findings from the Interceptor Project- Doubling on-farm diffuse pollution mitigation. Two hour recorded on-line webinar to council land management, monitoring, science, and policy staff. Over 50 people in attendance. 12 June 2024.

Goeller, B., Tanner, C. (2024). Quantifying and demonstrating constructed wetland contaminant removal performance. On-line presentation to the Land Management SIG Meeting, Environment Canterbury, Christchurch. 18 September 2024.

Efford, J., Goeller, B. (2024). Treatment wetland construction and performance in the Bay of Plenty. On-line webinar for NZARM via Microsoft Teams. 28 September 2024.

24 on-line media outputs to rural professionals and/or the general public

The SLMACC wetland project (including the wetland case study sites in the practical guidelines) has been featured in numerous online media articles over the last few years, with more publications planned as the project continues.

DairyNZ. (2020). Wetland aims for water quality rise. NZ Herald, The Vision is Clear. 3 August 2020. https://www.nzherald.co.nz/the-vision-is-clear/news/wetland-aims-for-water-quality-rise/SAO4QBBK47QO3X2NVB4PXGENMM/.

DairyNZ. (2022). Guidance to help new farm wetlands flourish. 25 May 2022. https://www.dairynz.co.nz/news/guidance-to-help-new-farm-wetlands-flourish/.

RadioNZ. (2022). Farmers encouraged to make the most of wetlands. 27 May 2022. https://www.rnz.co.nz/news/country/467980/farmers-encouraged-to-make-the-most-of-wetlands.

Piddock, G. (2022). Wetland guidelines released following four-year project. Farmers Weekly. 30 May 2022. https://www.farmersweekly.co.nz/news/wetland-guidelines-released-following-four-year-project/.

The Country. (2022). DairyNZ's new guide to help farmers get the most out of wetlands. NZ Herald. 2 June 2022. https://www.nzherald.co.nz/the-country/listen/dairynzs-new-guide-to-help-farmers-get-the-most-out-of-wetlands/5E66GMF66YY37HS5HYCGNCNNJM/.

Uys, G. (2022). Build your own wetland and clean up the farm's environmental footprint. Stuff News. 03 June 2022. https://www.stuff.co.nz/business/farming/128758678/build-your-own-wetland-and-clean-up-the-farms-environmental-footprint.

Bay of Plenty Regional Council. (2022). Baygold Wetland Project – YouTube. June 2022. https://www.youtube.com/watch?v=C-a446kcN3U.

MacDuff, C. (2022). Wasteland to wetland FedsNews, 19 July 2022. https://www.fedsnews.co.nz/wasteland-to-wetland/.

Edwards, S. 2022. Guidance to help new farm wetlands flourish. FEDSNEWS. June 19, 2022. https://www.fedsnews.co.nz/guidance-to-help-new-farm-wetlands-flourish/.

Bay of Plenty Regional Council. (2022). Waihī Estuary health under the microscope. 28 July 2022. https://www.boprc.govt.nz/your-council/news/news-and-media-releases/media-releases-2022/july-2022/waihi-estuary-health-under-the-microscope.

Gullery, L., Goeller, B., Tanner, C. (2022). Better outcomes for downstream water quality. Freshwater update, October 2022. https://niwa.co.nz/freshwater/freshwater-and-estuaries-update/freshwater-update-88-september-2022/better-outcomes-for-downstream-water-quality.

Gullery, L., Matheson, F. (2022). Effective mitigation systems to manage contaminant losses. Irrigation NZ magazine. Spring 2022.

IrrigationNZ News. (2022). Better outcomes for downstream water quality. News Spring 2022, September 2022, page 36-37.

Tanner, C. (2023). New guide available for constructed wetland treatment of diffuse farm run-off and drainage. Posted to the IWA Connect Plus Diffuse Pollution and Eutrophication Specialist Group Webpage. February 2023 IWA - Community Portal - Group (iwaconnectplus.org)

Gullery, L., Matheson, F. (2023). Effective mitigation systems to manage contaminant losses. NZ Local Government Magazine.

Cram, P., Cram, L. (2023). Small Taranaki wetland making a big difference. Water New Zealand Journal, May-June 2023, 62. https://www.waternz.org.nz/Article?Action=View&Article_id=2430

Gullery, L., Goeller, B., Tanner, C. (2023). Small Taranaki wetland making a big difference. DairyNZ press release. https://www.dairynz.co.nz/news/small-taranaki-wetland-making-a-big-difference/#:~:text=Wetlands%20can%20significantly%20reduce%20nutrient,Water%20Day%20on%20March%2022.

Gullery, L. (2023). Building back wetlands. Water & Atmosphere 29, 28-33. June 2023 https://niwa.co.nz/publications/water-and-atmosphere/water-atmosphere-29-june-2023.

Tanner, C. (2023). Government to explore wetlands as carbon sink. Interviewed by Isobel Ewing. https://www.newshub.co.nz/home/politics/2023/08/government-urged-to-explore-potential-of-wetlands-to-absorb-carbon.html. 27 August 2023.

Fear, A., Tanner C. (2023). Building back our wetlands. Science for a resilient future: NIWA year in review 2023, p. 36. National Institute of Water and Atmospheric Research. December 2023. https://niwa.co.nz/sites/niwa.co.nz/files/NIWA14298_Year-in-Review-2023_10FA-Single-Pages_web.pdf

Rush, A., Tanner, C., Goeller, B. (2024). Wetland Wonders. Forest and Bird 391:32-34 Autumn 2024.

Rush, A. Tanner, C., Goeller, B. (2024). Is your wetland working? Article for Water Magazine. May-June 2024. 46-48.

Troughton, J. (2024). Leading the charge: Industry exemplars showing how to grow sustainably. NZ Kiwifruit Journal June / July 224. 67-70.

Troughton, J. (2024). Pongakawa wetland: Extension work starts. Te Puke Times. https://www.nzherald.co.nz/bay-of-plenty-times/te-puke-times/pongakawa-wetland-extension-work-starts/LZD2Z2CRMREMZPOMTIXVHZ4IKI/. 18 June 2024.

5 meetings and correspondence with Overseer on improving the Overseer constructed wetland module

We have also met and corresponded with Overseer at least five times during the project to keep them abreast of our progress and help determine how best we can provide information to them. NIWA held an initial scoping discussion with Overseer to introduce and discuss NIWA's MPI SLMACC constructed wetlands project in August 2021. In August 2022, we re-engaged with Overseer to discuss Overseer's requirements for NIWA to provide annual performance data summaries from constructed wetlands, including previously collected data from NZ field trials as well as from the SLMACC sites. We have shared historical constructed wetland performance datasets (e.g., annual summaries of inlet vs outlet mass load reductions) with Overseer in November 2022. In April 2024, NIWA and Overseer had a scoping discussion around future inclusion of interceptive mitigations in the Overseer farm nutrient budgeting tool.

Hudson, N., Tanner, C., Hughes, A., Goeller, B. (2021). Meeting with Dr Jackie Harper, Chief Scientist at Overseer Ltd to discuss future inclusion of constructed wetland and detention bund data in the Overseer farm nutrient budgeting tool. 28 May 2021.

Hudson, N., Tanner, C, Goeller, B., Matheson, F. (2022). Meeting with Dr Jackie Harper and/or Alexander Hunt-Painter, Overseer Ltd to discuss future inclusion of constructed wetland and detention bund data in the Overseer farm nutrient budgeting tool. 4 August 2022, November 2022, February 2023.

Hudson, N., Tanner, C, Goeller, B., Matheson, F. (2024). Meeting with Dr Mark-John Bruwer and Alexander Hunt-Painter, Overseer Ltd to discuss future inclusion of interceptive mitigations in the Overseer farm nutrient budgeting tool. 4 April 2024.

3 field demonstration days and 3 presentations for rural professionals, farmers, and community members

NIWA was invited by HBRC and the Tukipo Catchment Care Group to present the SLMACC wetland monitoring project and introduce the Tukipo wetland design at a catchment community meeting. The day included presentations and discussions from other rural professionals (e.g., Beef + Lamb, Fonterra, DairyNZ, NZ Landcare Trust), as well as a site visit to help farmers and community members envision the constructed wetland, before construction started. In summer/autumn 2024, NIWA presented a brief overview of the SLMACC wetland demonstration network, including the completed Tukipo wetland, to the Tukituki Landcare Group, Fonterra, MPI, and HBRC, as part of a related project to identify suitable sites for constructed wetlands to reduce dissolved inorganic nitrogen in the Tukituki priority subcatchments.

Goeller, B., Tanner, C. (2020). Constructing wetlands to treat agricultural runoff. Invited presentation to the Tukipo Catchment Care Group, Ashley-Clinton, Hawke's Bay. 17 November 2020.

Goeller, B., Wadwha, S., Tanner, C. (2024). Desktop-Based Mapping Potential Constructed Wetland Sites in the Tukituki Catchment. On-line presentation to the Tukituki Landcare Group, Fonterra, MPI, and HBRC via Microsoft Teams. Ca. 10 attendees. 12 June 2024.

NIWA with collaborators from BOPRC presented performance data for the Maniatutu and the Pongakawa wetlands at 2 field days and a community event organised by 1) Baygold and 2) the Waikokopu Catchment Group to engage rural professionals and farmers from across the Bay of Plenty. A visit to this site and subsequent video conference meetings have also been held with the Danish Agricultural Innovation Organisation, SEGES, who are looking to set up similar trials in Denmark based on our constructed wetland design guidelines. Maniatutu wetland was also the centrepiece of a feature article in NIWA's June 2023 Water & Atmosphere publication and was featured during a field trip at the 2024 NZFSS conference.

Tanner, C., Goeller, B., Sukias, J. (2023). The Maniatutu constructed wetlands: How they work and preliminary treatment performance. Presentation at field-day for the 2023 Ballance Farm Environment Awards, Baygold Ltd (Supreme Winners), Maketu, Bay of Plenty. 18 April 2023.

De Monchy, P., Efford, J., Tanner, C.C., Goeller, B. (2024). Pongakawa & Maniatutu Constructed Treatment Wetlands, Waihī Estuary Catchment, Bay of Plenty. Joint

presentation at the Wai Kokopu Catchment Group Landowner and Community Event "Discover the wealth of wetlands". BOPRC and NIWA, Pongakawa Hall, 14 October 2024.

The NIWA and ECAN water quality monitoring work is featured within a the "Whakaora Te Ahuriri – A Wetland for Te Waihora" documentary, available on YouTube. ECAN organised a broader hui in September 2023 that pulled together results of the water quality, ecological, and cultural monitoring that has taken place at the wetland over the last two years. NIWA presented the Te Ahuriri performance monitoring results at a science-Mātauranga workshop held with ECAN, Iwi, and researchers to assimilate the monitoring information into future management plans for the wetland.

Environment Canterbury. (2021). Whakaora Te Ahuriri – A Wetland for Te Waihora. https://www.youtube.com/watch?v=UVr-gVr9jms.

Goeller, B. Tanner, C., Butler, P., McKergow, L., Vincent, A. (2023). Te Ahuriri constructed wetland: complexity of inflows and associated water quality. Ahuriri Science Hui, Whakaora Te Waihora, Tai Tapu Community Centre, Canterbury. Presented by Chris Tanner to ~40 attendees. 12 September 2023.

Taranaki Regional Council

AGENDA
Policy & Planning

Whakataka te hau

Karakia to open and close meetings

Whakataka te hau ki te uru
Whakataka te hau ki te tonga
Kia mākinakina ki uta
Kia mātaratara ki tai
Kia hī ake ana te atakura
He tio, he huka, he hauhu
Tūturu o whiti whakamaua kia tina.
Tina!
Hui ē! Tāiki ē!

Cease the winds from the west
Cease the winds from the south
Let the breeze blow over the land
Let the breeze blow over the ocean
Let the red-tipped dawn come with a sharpened air
A touch of frost, a promise of glorious day
Let there be certainty
Secure it!
Draw together! Affirm!

Nau mai e ngā hua

Karakia for kai

Nau mai e ngā hua
o te wao
o te ngakina
o te wai tai
o te wai Māori
Nā Tāne
Nā Rongo
Nā Tangaroa
Nā Maru
Ko Ranginui e tū iho nei
Ko Papatūānuku e takoto ake nei
Tūturu o whiti whakamaua kia tina
Tina! Hui e! Taiki e!

Welcome the gifts of food
from the sacred forests
from the cultivated gardens
from the sea
from the fresh waters
The food of Tāne
of Rongo
of Tangaroa
of Maru
I acknowledge Ranginui above and Papatūānuku below
Let there be certainty
Secure it!
Draw together! Affirm!

AGENDA AUTHORISATION

Agenda for the Policy and Planning Committee meeting held on Tuesday 4 February 2025.

Confirmed:

24 Jan, 2025 11:43:31 AM GMT+13

A D McLay

Director Resource Management

Approved:

24 Jan, 2025 8:52:30 AM GMT+13

S J Ruru

Chief Executive