HEKEAO / HINDS

WATER ENHANCEMENT TRUST

Hekeao/Hinds Environmental Enhancement Projects

Year 9 Annual Report

(June 2024 – May 2025)

Dr Brett Painter (HHWET Executive Director)

	Name	**Date**
Prepared by:	*Dr Brett Painter (HHWET Executive Director)*	*03/10/2025*
Reviewed by:	*Peter Lowe (HHWET Chair)*	*07/10/2025*
External review by:	*Dr Helen Rutter (Lincoln Agritech ltd)*	*17/10/2025*
Approved by:	*Peter Lowe (HHWET Chair)*	*01/11/2025*

Hekeao/Hinds River mouth, winter 2025 (Source: Brad McDonald, MCCC)

Chairman's Foreword

It is again a privilege to present this Chairmans Foreword for the operational year 2024/25 (year 9).The work of HHWET has continued to have the support of the wider Ashburton community and businesses, including the Hekeao/Hinds Plains landowners who are funding these Environmental Enhancement projects. Ashburton District Council are valued partners giving access to water and land. Ongoing support from MHV Water and RDRML is also critical to HHWET operations.

This year, the technical workstream was dominated by preparing for and appearing at a publicly notified hearing to advance this project to catchment scale operations. The support from local farmers and businesses to HHWET at the hearing was outstanding. Readers of this annual report will be in no doubt that HHWET's aims and proven actions are improved ecosystem health, which includes water quantity, water quality and ecological/biodiversity components. I question why this project was subjected to the cost and significant time delay that a publicly notified hearing involved, given that the potential effects are environmental gains (not degradation). All consents were granted in April 2025 with no change to conditions as sought. HHWET now faces further delays and costs as a result of a submitter to the hearing appealing the decision to the Environment Court.

The year 9 operations have been successful and include:

- Total recharge volume of 7,344,000 m^3 despite having only two consented sites running.
- The second best year to date for MAR01-influenced groundwater nitrate-N.
- The best year to date for NRR1 recharge volume (4.9 million m^3).
- The second best year to date for lower Hekeao/Hinds River annual median nitrate-NN (5.3 mg/l).
- The best year to date for Windermere Drain annual median (7.8 mg/l) and 95%ile nitrate-NN (9.5 mg/l), which achieves the 2035 PC2 target (9.8 mg/l) for the first time.
- An increase in Windermere Drain fish species from 6 to 9.

Of value this year has been the input of a Mid Canterbury Catchment Collective (MCCC) observer to HHWET meetings. We also look forward to working with a CSIF&G observer to replace the now-retired Mark Webb around our board table soon.

Brett Painter in the role of HHWET Executive Director and Murray Neutze (from MHV Water) as MAR Operations Manager are both working hard for the district and HHWET. On behalf of HHWET Trustees I sincerely thank them for their expertise and dedication to our area and projects.

I would like to again acknowledge the Hekeao/Hinds farmers that are working hard to achieve the required on-farm nutrient leaching reductions required in Canterbury's LWRP PC2 rules.

Finaly, my sincere thanks to Brett and HHWET Trustees; thank you for keeping focused and working for the benefit of our community during what has been a difficult year.

Peter Lowe
Chairperson
Hekeao/Hinds Water Enhancement Trust

Acknowledgements

The author wishes to thank the Hekeao/Hinds Water Enhancement Trust (HHWET) for governance support, Ashburton District Council for access to land and water, Pattle Delamore Partners for technical support, Ben Williams for legal support, MHV Water, Rangitata Diversion Race Management Ltd (RDRML), and Hydrometrics field staff for monitoring information, Eiffelton Community Group Irrigation Scheme (ECGIS) for collaboration on the Windermere Drain Enhanced TSA project, local contractors, and all report reviewers.

Executive summary

Background:

New Zealanders want clean rivers, streams, and waterways. We want to be able to swim in, fish, gather kai, enjoy and most importantly drink from our freshwater sources. We also want our future generations to enjoy that same opportunity.

The Hekeao/Hinds catchment is within the borders of Mid Canterbury. The Pacific Ocean forms the eastern coastline, and the Southern Alps form the western boundary. The area is bordered to the north by the Hakatere/Ashburton River and to the south by the Rakitata/Rangitata River. This farming area is among the most productive irrigated agricultural districts in New Zealand.

Hekeao/Hinds Water Enhancement Trust (HHWET) is a community-led charitable trust established in 2019, currently governed by 11 Trustees representing Ashburton District Council (ADC), Canterbury Regional Council (CRC), Ashburton community, Hinds Drains Working Party, Mid Canterbury Federated Farmers, Rangitata Diversion Race Management Ltd, MHV Water, and Ashburton District irrigation companies other than MHV Water. Mid Canterbury Catchment Collective representatives also attend monthly meetings. HHWET employ an Executive Director and contract out other services.

The Challenge:

Increased farming intensity, climate cycles, climate change and other demands on our water resource have resulted in adverse environmental effects – namely reduced water quantity during dry periods and reduced quality due to increased nitrate concentrations (and microbial contamination in some places). The Hekeao/Hinds community have recognised this and are addressing these catchment scale environmental issues, both through on-farm changes and catchment-scale nature-based enhancements. These efforts are focussed on achieving the following 2035 targets as detailed in Plan Change 2 to Canterbury's Land and Water Regional Plan (LWRP PC2, 2018):

- Reducing on-farm nitrogen losses by 36%;
- Reducing median annual shallow groundwater concentrations of nitrate-N to less than 6.9 mg/l;
- Reducing median annual hill-fed lowland waterway concentrations of nitrate-N to less than 3.8 mg/l; and
- Reducing median annual spring-fed plains waterway concentrations of nitrate-N to less than 6.9 mg/l.

The primary aim of PC2 can be summarised as improved ecosystem health, which includes water quantity, water quality and ecological/biodiversity components. HHWET's goals are to assist ecosystem health improvements by:

- Targeting and protecting drinking water supplies;
- Enhancing groundwater quality;
- Improving baseflows to spring-fed streams and rivers for ecological, cultural, and social values; and
- Improving and sustainably managing groundwater storage (levels).

To achieve these goals, HHWET are contributing to an Integrated Catchment Management (ICM) approach for developing a Hekeao/Hinds Environmental Enhancement Scheme via four complementary focus areas (as presented in Figure ES 1-1). These are:

- On-farm improvements via the Hekeao/Hinds Science Collaboration Group, including leading the Irrigation Nutrient Recycling workstream and contributing to the development of a Vadose zone Monitoring System (VMS) project during 2024/25.
- Managed Aquifer Recharge (MAR) and Near River Recharge (NRR) for groundwater and river ecosystem health improvements. Additional ecological/biodiversity gains occur in the vicinity of MAR and NRR sites due to waterway fencing, land retirement, native plantings, lizard, bird, and fish habitat.
- Supporting the trialling and implementation of Targeted Stream Augmentation (TSA), bioreactors and constructed wetlands for spring-fed ecosystems.
- Managing allocation to support sustainable water allocation, and ensure that MAR, NRR and TSA activities are not covering for overuse or overallocation situations. For example, HHWET will not support any future surface water take consent applications from the Hekeao/Hinds River (thus maximising the benefits of NRR) and have confirmed that no surface water takes from the Hekeao/Hinds River mainstem have occurred for >10 years. HHWET have also committed to only applying for supplementary/shadow take and/or use consents rather than applying for new consents.

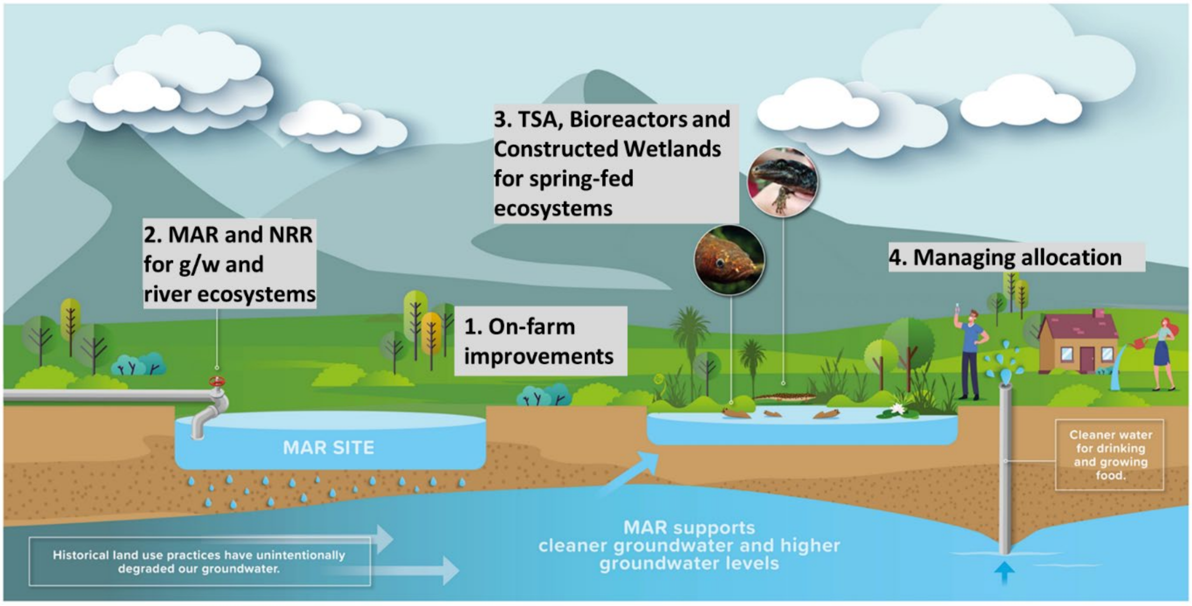

Figure ES 1-1: Hekeao/Hinds Integrated Catchment Management (ICM) approach.

2024/25 progress:

During Year 9 (2024/25), HHWET continued the project phase that began in 2021, which comprises a ten-year catchment-scale implementation plan funded by a targeted rate to Hekeao/Hinds Plains landowners through Environment Canterbury's Long-Term Plan. Arrangements continued with project partners Ashburton District Council (ADC), Rangitata Diversion Race Management Ltd (RDRML), and MHV Water. HHWET Trustees remained the same as 2023/24. HHWET met monthly except for January, with meetings focussed on agreements, arrangements, operations, health and safety, permissions and policies, financial accountability, analysis of evidence, external reporting, and progress monitoring toward 2024/25 objectives.

The primary technical focus for 2024/25 has been consenting processes and construction planning for the next stage of the Hekeao/Hinds Environmental Enhancement Scheme, which includes new MAR and NRR sites, and trials of bioreactor, constructed wetland and TSA concepts (Figure ES 1-2). Development of this process has relied on the extensive monitoring and analysis to date. Target areas for MAR, NRR, TSA, bioreactors and constructed wetlands (BW) have been defined and consent processes supported for the new MAR/NRR sites (lodged December 2022). The public hearing for MAR/NRR consents was held in December 2024, with independent commissioner hearing panel decisions in HHWET's favour for a NRR1 continuance decline objection (released on 31 March 2025) and the granting of all consents confirmed on 30 April 2025. Unfortunately, the consent granting decisions were appealed to the Environment Court by Te Rūnanga o Arowhenua on 21 April 2025. A hearing is anticipated early in 2026. With Environment Canterbury's discretionary decline of continuance for existing MAR sites 2-18 (Figure ES 1-2), only MAR01 and NRR1 could operate during 2024/25.

HHWET also supported the conclusion of the eClean bioreactor consenting process (lodged May 2023 and granted June 2024) and subsequent installation and commissioning processes. The Windermere Drain Enhanced TSA project has continued in collaboration with Eiffelton Community Group Irrigation Scheme (ECGIS) and an extension to a pilot scale constructed wetland (led by the Lowlands Catchment Group) successfully met all criteria for progression. Unfortunately, two other nearby potential constructed wetland sites did not meet benefit:cost expectations. However, two new potential constructed wetland sites have been identified, with assessments scheduled to begin in Spring 2025.

HHWET supported three post graduate students in 2024/25:

- Sidinei Teixeira, whose Master of Water Resource Management thesis (producing a new method to determine source contributions to a groundwater sample) was awarded First Class Honours;
- Madeline Inglis, whose Master of Science thesis (assessing the transport and removal rate of *E. coli* through groundwater near an HHWET MAR site) was lodged; and
- Justin Legg, whose PhD research into Hekeao/Hinds Plains nitrate mitigation options yielded two published papers.

Operationally it was a very successful year, with minimal site shutdowns due to maintenance or monitoring triggers (e.g., high Rangitata River turbidity, high Hekeao/Hinds River flows, high *E. coli* counts in MAR source water, high rainfall events or high groundwater). Operational highlights include:

- The second best year to date for MAR01-influenced groundwater nitrate-N (an average of 1.8 mg/l at monitoring well BY20/0152, only slightly higher than the 1.7 mg/l achieved in 2022/23).
- The best year to date for NRR1 recharge volume (4.9 million m^3).
- The second best year to date for lower Hekeao/Hinds River annual median nitrate-NN (5.3 mg/l).
- The best year to date for Windermere Drain annual median (7.8 mg/l) and 95%ile nitrate-NN (9.5 mg/l), which achieves the 2035 PC2 target (9.8 mg/l) for the first time.
- An increase in Windermere Drain fish species from 6 to 9, which along with lower Hekeao/Hinds River, is the highest identified in the district.

HHWET's 2024 Business Case Addendum (underpinned by Macfarlane Rural Business Economic Analysis) to support HHWET's on-going community consultations was finalised in July 2024 and communicated via public presentations, HHWET's website and Facebook account, and the HHWET 2023/24 Annual Report. **The HHWET Business Case Addendum demonstrates that continuation of HHWET activities:**

- **Saves Hekeao/Hinds Plains landowners an additional one off decrease in total capital asset value of $2.2 billion.**
- **Saves Hekeao/Hinds Plains farmers an additional annual reduction in farm gate profit of $108 million.**
- **Saves regional businesses an additional annual reduction in spending of $355 million.**

What we learned:

Key learnings from Year 9 (2024/25) include:

- The high volume of regularly monitored sites covering the Hekeao/Hinds Plains continues to provide valuable data for analysis and decision support. The increasing length of this dataset provides increased confidence in the results of monitoring analysis and provides for more rigorous analysis options (e.g., Legg et al., 2025).
- Catchment scale monitoring of groundwater nitrate concentrations continues to show that seasonal and annual rainfall variation is the primary contributor to nitrate concentration variation at the catchment scale (i.e., across many monitored sites). Nitrate concentrations for the 2024 calendar year were generally below average, strongly influenced by 18 months of below average rainfall from mid-2023 to late 2024. The change to well above average rainfall for the first half of 2025 corresponds (with variable lag times) with increases in nitrate concentrations. Ongoing decreases in on-farm nutrient leaching potential are required to reduce the volume of nutrients transported through Hekeao/Hinds water systems during rain-induced leaching events.
- At the local scale, post graduate research and HHWET analysis shows that HHWET activities are contributing to improved ecosystem health in the targeted areas of surface and groundwater systems. Once the catchment-scale MAR/NRR consents can be activated, HHWET are confident that further improvements in ecosystem health (magnitude and area) will follow.
- The Windermere Drain 95%ile nitrate-NN result for 2024/25 is the first PC2-specified 2035 target to be achieved (assisted by the Enhanced TSA project). This project shows that human requirements (e.g., drainage and water distribution) can work with ecosystem requirements, and that challenging ecosystem health targets can be achieved when collaborative efforts are maintained. A second solar array to support Windermere Drain augmentation (for irrigation and TSA) is being installed and further TSA enhancement opportunities are being investigated.
- The pilot scale lower Hekeao/Hinds constructed wetland (on Wairuna Farm) is showing that constructed wetlands are a technically and economically feasible method for converting nitrate to nitrogen gas under local conditions. Additional sites to upscale this contribution to Hekeao/Hinds Plains ecosystem health targets will therefore be progressed.
- The first year of trialling the eClean bioreactor in a rural setting showed that the bioreactor processes were promising, but power supply security and intake design were not robust enough for local conditions. Further assessment following design upgrades is required to determine the benefit:cost of this option for the Hekeao/Hinds Plains.

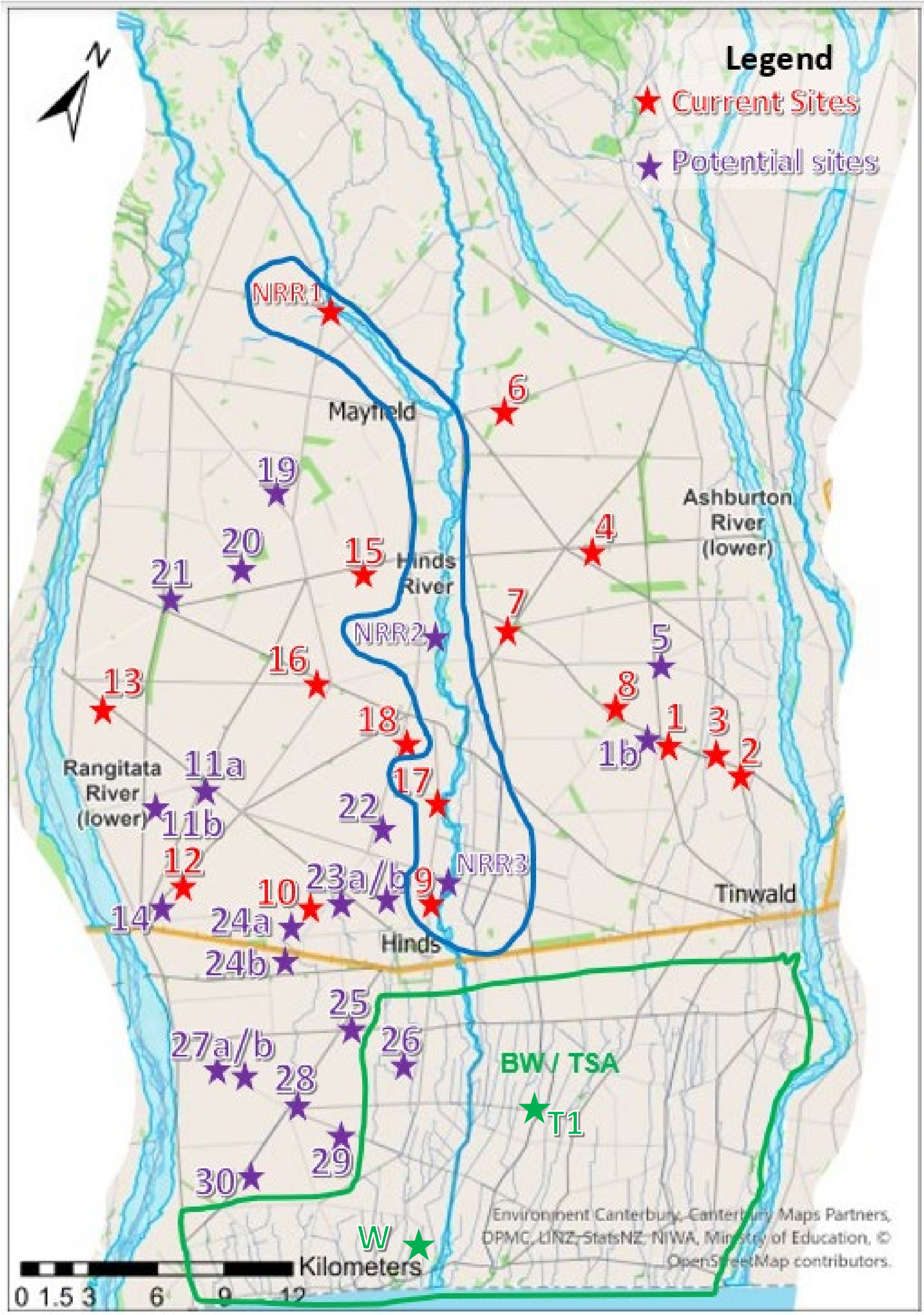

Figure ES 1-2: HHWET Environmental Enhancement Scheme 2024/25

Table of contents

List of Figures

List of Tables

1 Introduction

1.1 Plan Change 2 to Canterbury's Land and Water Regional Plan

Plan Change 2 (PC2) to Canterbury's Land and Water Regional Plan (CLWRP) provides the following introduction to the Hekeao/Hinds Plains and the community-led Solutions Package:

The Hinds/Hekeao Plains Area today is highly modified. Drainage of the wetland area east of State Highway 1 began in the 1850s, allowing the establishment of one of Canterbury's most productive agricultural areas. An artificial channel, cut in the 1860s-1870s, created a permanent outlet for the river to flow to the sea. A small hāpua (lagoon) is present at the river mouth, although this is blocked to the sea most of the time. Many of the artificial drains, stock water races and modified channels which replaced the wetlands and waterways, provide substitute habitats for a variety of fish and invertebrate species.

The Hinds/Hekeao Plains Area was historically, and is currently, an important area for food production. It currently provides significant employment in the area, both on-farm and in processing and servicing industries. The social and economic wellbeing of the community is reliant on the agricultural industry, and it is important that it is retained so that the communities can thrive.

Agricultural development, however, has had a significant impact on the cultural, ecological and recreational values and opportunities of the area. Today, drainage remains a primary function of many of the lowland water bodies, however they continue to be a taonga and source of mahinga kai for Ngāi Tahu and support significant ecological and recreational values.

During 2013 and 2014 the Ashburton Zone Committee engaged with the local community and stakeholders to develop a package of actions (the 'Solutions Package') that was considered the most effective to protect cultural values and opportunities to gather mahinga kai safely, maintain water quality and quantity in the Upper Hinds/Hekeao Plains Area, and improve water quality and quantity in the Lower Hinds/Hekeao Plains Area, while also sustaining a healthy economy and community.

The Committee's Solutions Package consists of four main parts with both regulatory and nonregulatory recommendations:
- *catchment scale actions (e.g. on-farm mitigation measures, managed aquifer recharge);*
- *local scale actions (e.g. riparian fencing, planting, and well-head protection);*
- *investigations, monitoring and review of the Solutions Package; and*
- *community engagement.*

The primary aim of PC2 can be summarised as improved ecosystem health, which includes water quantity, water quality and ecological/biodiversity components. In previous decades, ecosystem health was assisted by a combination of lower intensity farming systems and higher levels of unmanaged aquifer recharge (from leaky water distribution systems, less efficient irrigation systems and direct by-wash discharge from water races and irrigation races into waterways). The more recent reductions in ecosystem health have been influenced by increased land use intensity combined with lower levels of unmanaged aquifer recharge (from less leaky water distribution systems, more efficient irrigation systems and reductions in direct by-wash discharge from water races and irrigation races into waterways). Climatic changes (e.g., increased intensity and regularity of droughts and floods) have also influenced ecosystem health over time. Ecological/biodiversity (e.g., via riparian planting) coverage has remained at low levels compared to the pre-1850s era, though has measurably increased in the last few years.

PC2 water quality targets include requirements to reduce on-farm nitrogen leaching by 36% by 2035 and reduce median annual shallow groundwater concentrations of nitrate-N to a target of <6.9 mg/l by 2035. The PC2 2035 target for the lower Hekeao/Hinds River is a median annual concentration of 3.8 mg/l nitrate-N and for other lowland waterways is 6.9 mg/l nitrate-N. PC2 water quantity actions include new groundwater allocation limits, new minimum flows for waterways, support for groundwater abstractors to move from stream depleting takes to deep groundwater, plus managed aquifer recharge (in contrast to the unmanaged recharge of previous decades) and targeted stream augmentation. The Hinds Drains Working Party (HDWP) was established as part of the PC2 process to support PC2 implementation in the lower catchment via recommendations, monitoring and review. Key HDWP recommendations focussed on the development of management plans for the main lower catchment water bodies. These plans included ecological/biodiversity actions as well as water quantity and quality aspects.

Reports received by HHWET from Hekeao/Hinds irrigation companies and independent irrigators as submissions to HHWET's December 2024 resource consent hearing suggests that on-farm nitrogen leaching reductions are on track to achieving the PC2 targets, including the largest local irrigation company (MHV Water) reporting that they had already achieved the 2030 PC2 nutrient leaching interim target and had 94% of shareholders at Farm Environment Plan (FEP) audit grades of A or better. During 2024, the Ashburton District Council (ADC) released a new Biodiversity Strategy (ADC, 2024). A key relevant action for HHWET in the ADC Biodiversity Strategy is Objective 2.1(c) "*Investigate the use of stormwater swales, MAR (Managed Aquifer Recharge) sites, rivers and stockwater race networks to improve native vegetation cover in the district.*" During 2024/25 ADC also initiated its Stockwater Exit Transition Programme, which is intended to conclude in mid-2027. HHWET are an active party in future water race management discussions.

1.2 HHWET operations and monitoring summary for 2024/25

Table 1-1 shows that the total recharged MAR/NRR volume in 2024/25 via one MAR site and one NRR site was 7.34 million m^3. This is approximately 17% higher than the 2023/24 result, but significantly less than the 13.8 million m^3 recharged in 202/21 when all 17 constructed MAR/NRR sites were consented to operate. Table 1-1 also includes the opening and closing water balance. The water balance is required as sometimes water is ordered but cannot be used (usually due to a site shutdown). This water is 'stored' in the MHV distribution system until it can be used.

Table 1-1: 2024/25 Hekeao/Hinds MAR/NRR recharge

	MAR / NRR Volume (cubic metres)
June 2024 opening balance – taken but not delivered	155,753
2024/25 ordered through RDR	**7,509,461**
HHWET water delivered to NRR1 Site	-4,945,230
MHV water delivered to MAR01 to repay 2023/24 deficit	-145,757
HHWET water delivered to Pilot Site (MAR01)	-2,253,470
Total 2024/25 delivered volume	**-7,344,457**
HHWET ordered water not used due to site shutdowns	-310,761
2024/25 closing balance – taken but not delivered	9,996

MAR and NRR sites are shutdown when a consent condition trigger level is reached. Different MAR and NRR sites can contain different combinations of triggers (e.g., rainfall, river flow, groundwater level, turbidity and/or *E. coli*). HHWET's consent compliance and performance monitoring is undertaken on behalf by MHV Water staff. During 2024/25, source water from the Rangitata River was variable for turbidity (4-3000 NTU), as for previous years. Turbidity spikes in the RDR are caused by Rangitata River freshes which result in NRR1 shutdowns when triggers were reached. Turbidity is highest at the NRR1 offtake from the RDR (resulting in NRR1 site shutdowns ~20% of the time during 2024/25); however, it reduces as sediment settles out as water travels through the distribution system (particularly in water storage ponds). NRR1 also ceased operations twice during 2024/25 when the adjoining South Branch Hekeao/Hinds River exceeded its 5 m^3/s trigger level.

The MAR01 discharge consent contains shutdown triggers for rainfall, groundwater level, and *E. coli*. MAR01 was not required to shut down for groundwater level or *E. coli* trigger breaches during 2024/25, however the rainfall trigger was exceeded five times over 4 rainfall events. After each rainfall event, the site was turned off for at least 48 hours.

1.3 2024/25 HHWET Annual Report structure

The remainder of this report focusses on NRR and MAR operational updates, key monitoring information and analysis. Updates are also provided on the other catchment-scale nature-based enhancements HHWET are involved in, which are at an earlier stage of development. Consent compliance monitoring results are presented in the HHWET Annual Consent Compliance Monitoring Report (HHWET, 2025).

2 Hekeao/Hinds River

Chapter 2 of the Year 5 HHWET (2021) Annual Report introduced the Hekeao/Hinds Plains hydrogeology, and HHWET's nature-based enhancement activities focussed on the Hekeao/Hinds River. These activities are being trialled to understand how they can individually and collectively (including with on-farm enhancements) contribute to improved Hekeao/Hinds River ecosystem health. One of the specific goals is to contribute positively to Canterbury's Land and Water Regional Plan (Plan Change 2) 2035 annual median target of 3.8 mg/l nitrate-N (usually measured as nitrate-nitrite-N) in the lower Hekeao/Hinds River for 90% aquatic species protection.

The key upper catchment enhancement activity is the addition of clean water to the river system via Near River Recharge (NRR). NRR is like MAR in that it involves recharging groundwater via leaky basins, wetlands and/or races. However, NRR sites are close enough to contribute directly (via shallow groundwater) to the river reach immediately adjacent and down-gradient of the discharge site/s. Complementary lower catchment enhancement activities currently involve the trialling of a constructed wetland, a bioreactor and a Targeted Stream Augmentation (TSA) project.

NRR sites are designed to ensure that NRR source water (in this case, Rangitata River water) is always filtered through alluvial material before mixing with natural river system water. This filtering process blocks the transport of algae (e.g., didymo), modifies the temperature (and potentially the chemistry) of NRR water and ensures that there is no risk of ecosystem harm by direct mixing of NRR water with river water. The shallow groundwater table around NRR sites is raised, which supports local wetlands and the establishment of native plants (aquatic and terrestrial). The aquatic life of supported wetlands and river reaches is therefore enhanced. Other biodiversity initiatives, such as protection of valued existing terrestrial plants and/or wildlife, have also been progressed at HHWET's NRR site.

Figure 2-1 shows the location of two current and two potential NRR sites. The first site (NRR1) has been operational since September 2018 (Figure 2-2). MAR17b (classified as a MAR site but close enough to the Hekeao/Hinds River to also provide NRR) began operations in June 2020, but has not been operational since May 2023 due to Environment Canterbury's discretionary decision to decline consent continuance. Assessment and preliminary design processes for NRR2 and NRR3 began in 2021 to support the current suite of consent applications which were lodged in December 2022, with the independent commissioner panel decision to grant consents currently under appeal (see Executive Summary).

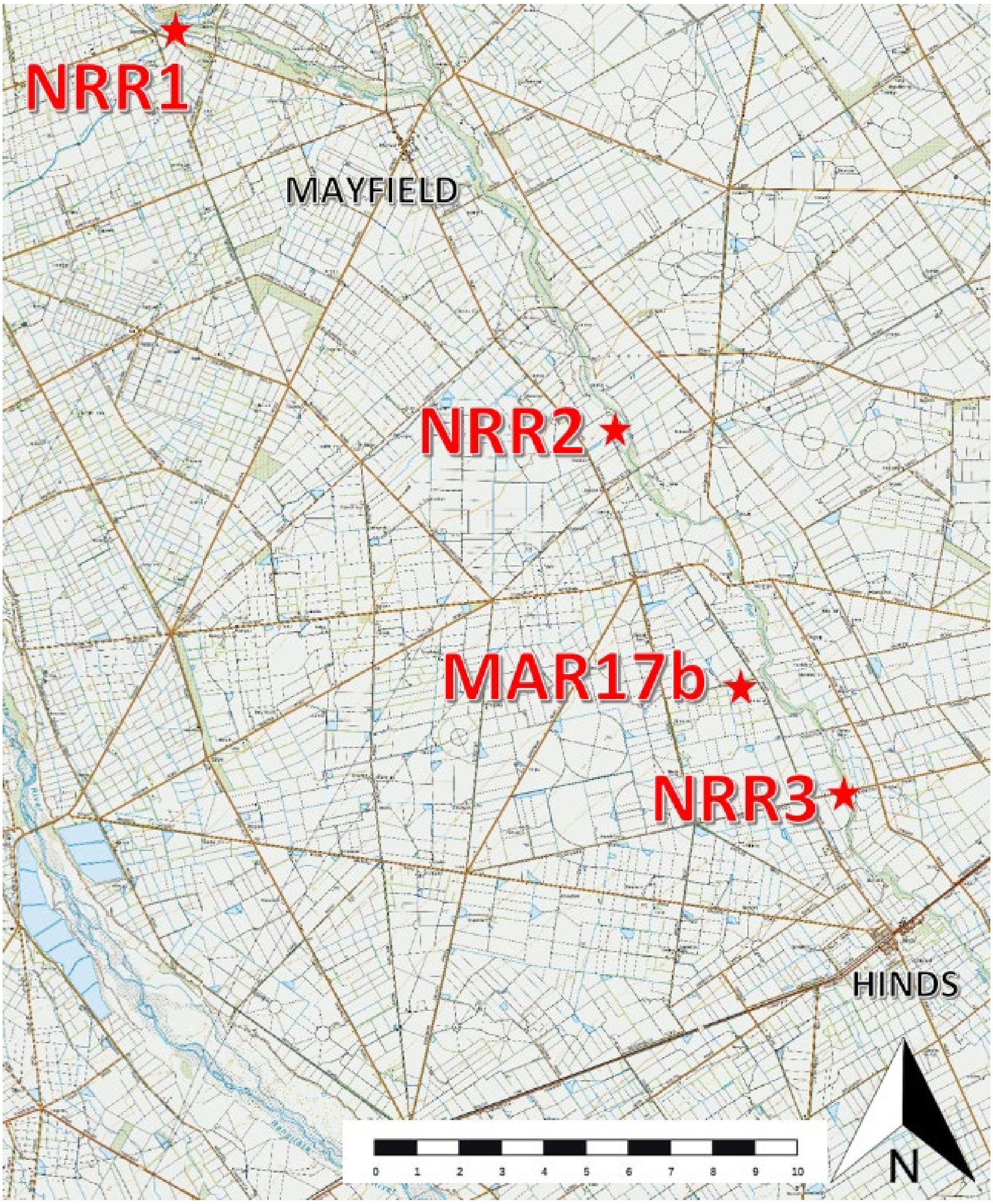

Figure 2-1: Current and potential sites targeting the Hekeao/Hinds River

2.1 NRR1 – South Branch Hekeao/Hinds River

NRR1 (Figure 2-2) receives Rangitata River water, via siphon, directly from the Rangitata Diversion Race (RDR). Current maximum consented supply flow is 210 l/s; however, the construction of additional recharge basins in 2021 has enabled supply flow up to 400 l/s to be trialled (under compliance discretion) as part of assessments for the replacement discharge consent which was lodged in December 2022. HHWET's request for continuance on NRR1 discharge consent CRC210704 was initially declined by Environment Canterbury. HHWET lodged an objection against this decision, with HHWET's objection upheld by an independent commissioner panel.

In addition to the recharge channels and basins, lizard habitat (under DOC Covenant) has been created away from the flood plain, and an historical oxbow wetland has been rehabilitated and extended for native fish habitat. This wetland is supported by the raised local groundwater due to NRR. Since the site began operations in 2018, approximately 25 hectares of farmland in the vicinity of NRR1 has been fenced and retired by the landowners, and approximately 17,000 native plants (wetland and dryland) have been reintroduced, including in two further historic wetlands (Figure 2-3 to Figure 2-7). These plantings are considered to have contributed to increased bird life in the area, with new birds spotted near NRR1 since 2018 including Australasian Bittern, Marsh Crake, Bellbird, Kingfisher, and Kōtuku/White Heron. Air New Zealand have provided funding for the next planting stage in Spring 2025, to be planted by Brailsfords Ltd, HHWET and Mayfield School students.

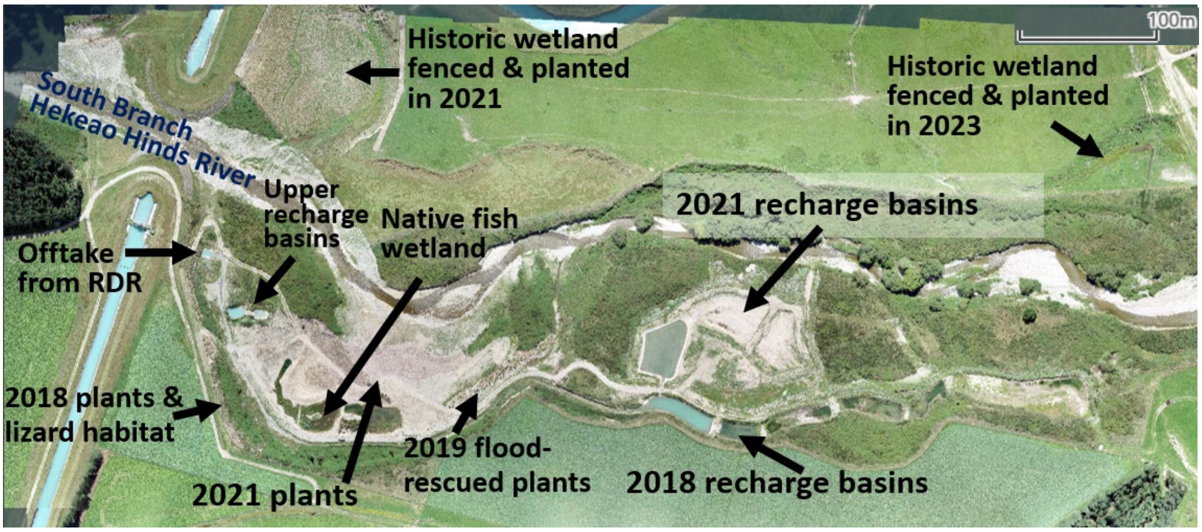

Figure 2-2: NRR1 site overview

Figure 2-3: NRR1 site native fish wetland and Spring 2021 plantings, with recharge race in the foreground (Source: HHWET)

Figure 2-4: Area under DOC Covenant for lizard habitat, with 2018 plantings (Source: HHWET)

Figure 2-5: NRR1 2018 (right) & 2021 (left) recharge basins (Source: HHWET)

Figure 2-6: NRR1 upper tributary wetland, fenced and planted in Spring 2021 (Source: HHWET)

Figure 2-7: NRR1 lower tributary wetland, fenced and planted in Autumn 2023 (Source: HHWET)

Table 2-1 and Figure 2-8 present the monitoring requirements for NRR1 consent CRC210704, with all compliance monitoring results also presented in the annual compliance monitoring report (HHWET, 2025). Recharge source water has remained low in nitrate-N and *E. coli* since 2018, but turbidity varies significantly with Rangitata River flow (Table 2-2). The turbidity trigger for ceasing MAR operations at this site has been set at 100 NTU. This is a higher trigger than at other MAR sites, as deposited sediment is relatively easy to clean from the sediment traps and recharge basins. Table 2-2 and Figure 2-9 present the turbidity and NRR1 flow analysis for 2024/25. Site shutdowns to date for high turbidity in past years have historically occurred up to 33% of the time, but only occurred less than 20% of the time during 2024/25. This was influenced by mild La Niña conditions and rainfall primarily from the east, resulting in fewer Rangitata River freshes than average. During El Niño conditions, the opposite is more likely to occur, with rain from the west and more regular and extended Rangitata River freshes (with associated elevated turbidity). The NRR1 site is also shut down when there are high flows in the adjacent South Branch Hekeao/Hinds River (>5000 l/s), which, since 2018, have occurred ~1.5% of the time (and on two occasions in 2024/25, see Figure 2-10).

The temporary gauge at South Branch Hekeao/Hinds River - Lower Downs Bridge (site #69106 on Figure 2-8) was destroyed in the May 2021 floods and has not been reinstated by Environment Canterbury, thus, flow monitoring was unable to be continued at this site. Reporting prior to May 2021 is presented in sections 2.1.1 and 2.1.2 of the 2020/21 HHWET Annual Report. The results consistently show increased river flows, decreased *E. coli* counts and decreased nitrate-N concentrations between the South Hinds Siphon (site #69101) and Lower Downs Bridge (site #69106). NRR1 recharge provides the primary input to the river systems between these monitoring sites.

Analysis of potential NRR1 influence further down the South Branch Hekeao/Hinds River system (Figure 2-11) was first presented in the 2019/20 HHWET Annual Report, with updates in Section 2.1.1 of the 2023/24 HHWET Annual Report. These assessments concluded that the South Branch Hekeao/Hinds River recharges local groundwater (primarily to the true left) down-gradient from the Lower Downs

Bridge (as per BY20/0222 groundwater level records), which contributes spring-fed flows to the Silverstream tributary of the North Branch Hekeao/Hinds River.

In the same analysis, well K37/0278 was shown to be a useful indicator of water quantity effects down-gradient from NRR1 due to its proximity to the North and South Branches of the Hekeao/Hinds River (150 m away) and depth (16 m deep). Figure 2-12 shows K37/0278 groundwater levels responding quickly (within days) to flow fluctuations in the South Branch Hekeao/Hinds River. Figure 2-13 presents shallow groundwater levels for the full K37/0278 record (back to 1975), showing that maximum depth to groundwater since NRR1 operations began (September 2018) has been about 4.3 m whereas maximum depth to groundwater prior to 2018 regularly exceeded 5 m. A t-test comparing groundwater levels in the ~7 years of NRR1 operation compared to the previous 7 years concluded that the groundwater level records were statistically significantly different (n = 2125, alpha = 0.01 and P(T<=t) one-tail = $6*10^{-21}$).This evidence suggests that K37/0278 groundwater levels are positively influenced by NRR1 recharge, particularly during low rainfall periods.

The Hekeao/Hinds River is a priority for enhancement of ecosystem health and recreation amenity, as part of the Hekeao/Hinds Environmental Enhancement Scheme. To monitor long term changes in fish diversity/population sizes and any potential NRR influence, Central South Island Fish and Game (CSIFG), along with Environment Canterbury, implemented fish monitoring surveys in 2017. Annual surveys include the South Branch Hekeao/Hinds River upstream from the Lower Downs Road Bridge (downstream from the NRR1 site). All sites are 30 m long with upstream and downstream nets used to enable diminishing-return population estimates to be calculated (Carle-Strub method).

At the South Branch Hekeao/Hinds River site only three fish species have been found during the annual surveys: upland bully, Canterbury galaxias, and a single adult long finned eel/tuna. Figure 2-14 shows a step change in upland bully and Canterbury galaxias populations since NNR1 began operations in late 2018. The December 2022 survey showed the highest Canterbury galaxias population to date but a lower number of upland bullies than recent surveys. The low numbers of predators such as eels and trout (noting there were two trout, one with recent eel bite marks, found by a separate electric fishing assessment just upgradient from the survey reach in December 2023), combined with improved low flows due to NRR1, are likely to be key contributors to increased population levels for these native fish species since the scheme started in 2018. CSIFG did not have the capacity to undertake a survey in 2024/25 but have committed to resuming surveys from late 2025.

Additional aquatic ecological monitoring was also undertaken above (RDR Siphon) and below (Lower Downs Bridge) the NRR1 site for the first 18 months following NRR1 commissioning in September 2018. This consisted of monthly invertebrate monitoring, carried out using the Stream Health Monitoring and Assessment Kit (SHMAK) method, and quarterly fish monitoring, using a single pass electric fishing machine (EFM) method, over a 50 m reach, to provide semi-quantitative estimates of fish abundance and species present. The results of this study showed higher populations of Canterbury galaxias and bully species at the Lower Downs Bridge site compared to the RDR Siphon site, plus healthy invertebrate communities at both sites. These are reflective of good water quality and habitat under relatively stable flow conditions (see the 2019/20 HHWET Annual Report). A catchment group has been undertaking further monitoring since 2023 across the area, including the upper South Branch and North Branch Hekeao/Hinds River and their tributaries, and are using this monitoring to guide additional catchment enhancements such as fencing, planting, land management enhancements and land retirement. Ongoing improvements in river ecosystem health can therefore be anticipated.

The NRR1 Wetland Management Plan (McMurtrie, 2020) specifies a range of monitoring requirements to assess habitat suitability for native species such as the upland bully and Canterbury mudfish/Kōwaro. Telemetered equipment to monitor temperature, water level and dissolved oxygen in the primary and downstream wetlands was installed in Autumn 2022. A fish survey undertaken in Autumn 2023 by Environment Canterbury and Central South Island Fish and Game staff identified more than 2100 upland bullies in the three NRR1 wetlands.

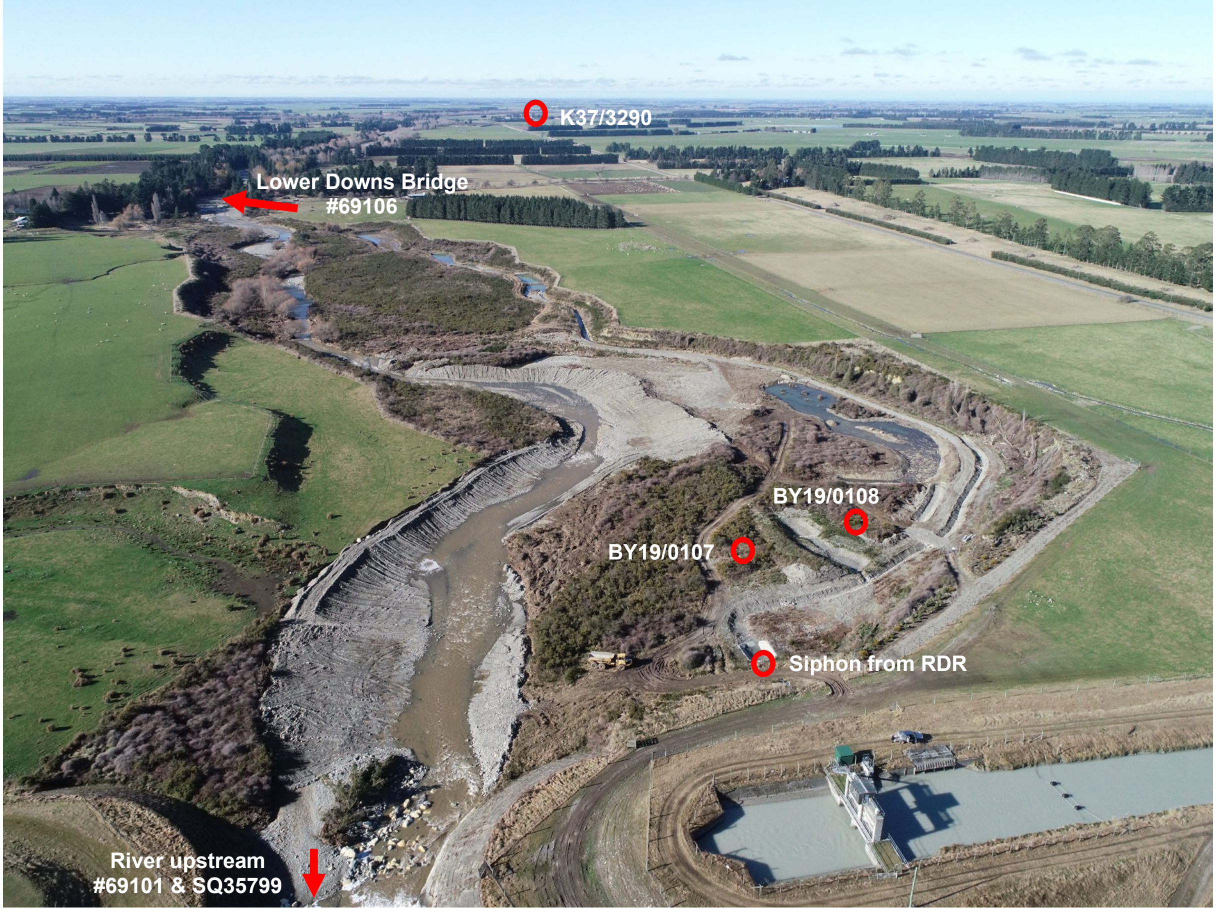

Figure 2-8: NRR1 monitoring points (Source: HHWET, July 2021)

Table 2-1: NRR1 Monitoring - CRC210704 (Source: HHWET)

Monitoring Category	Parameter	Location	Parameters	Minimum Sampling Frequency
Quantity	Recharge source water	Project Siphon from RDR	flow/stage	15-minute
	River upstream (control)	ECan South Branch upstream of project (#69001)	flow/stage	15-minute
	River downstream (effects)	Temporary Gauge on South Branch at Lower Downs Bridge	flow/stage	15-minute
	Site groundwater Levels	BY19/0107	water level	Hourly
	Groundwater Levels	ADC monitoring information from Mayfield Community Supply - K37/3290	water level	Hourly
Quality	Groundwater Quality	ADC monitoring information from Mayfield Community Supply - K37/3290	Nitrate-Nitrogen, *E. coli* bacteria	Monthly sampled by ADC
	Site groundwater quality	BY19/0107	Nitrate-Nitrogen, *E. coli* bacteria	Monthly
	Source (recharge) water	Project Discharge Siphon	Nitrate-Nitrogen, *E. coli* bacteria, Turbidity, TSS	Monthly, except Turbidity which is measured hourly
	River upstream (control)	Site Inflow Source (#SQ35799)	Nitrate-Nitrogen, *E. coli* bacteria, Turbidity, TSS	Monthly
	River downstream (receiving waters)	Temporary Gauge on South Branch at Lower Downs Bridge	Nitrate-Nitrogen, *E. coli* bacteria, Turbidity, TSS, DRP	Monthly
Aquatic Ecology	River downstream (effects)	Recharge Above Temporary Gauge on South Branch at Lower Downs Bridge	Electro-fishing Survey, didymo	Annually (Fish and Game, ECan)

Table 2-2: NRR1 intake turbidity distribution for the period from 1/6/2024 to 31/5/2025 (percent of flow less than prescribed turbidity) (Source: HHWET)

Percentile	Turbidity, 1/6/2024 - 31/5/2025 (NTU)
10	7
20	10
30	19
40	28
50	37
60	44
70	59
80	88
90	155
100	3000

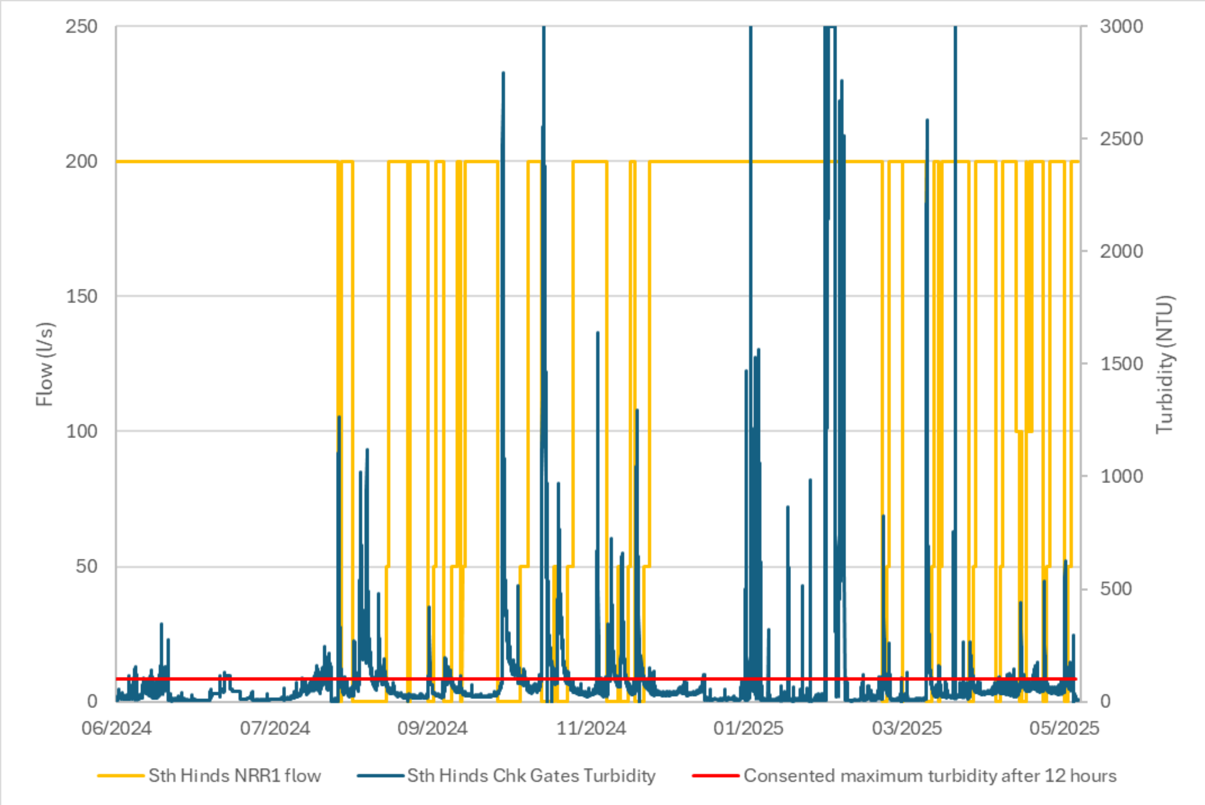

Figure 2-9: 2024/25 NRR1 intake turbidity and flow monitoring (Source: RDRML/HHWET)

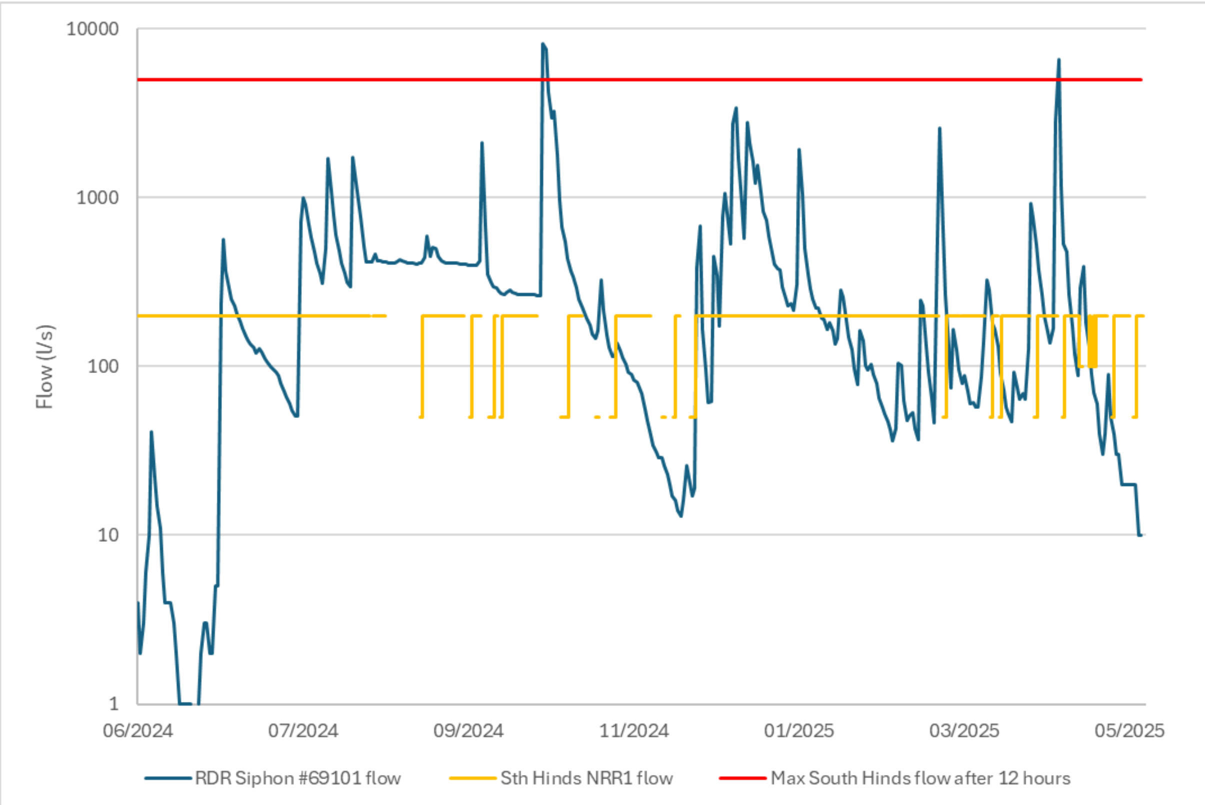

Figure 2-10: 2024/25 NRR1 and Hekeao/Hinds River flow (Source: HHWET, CRC)

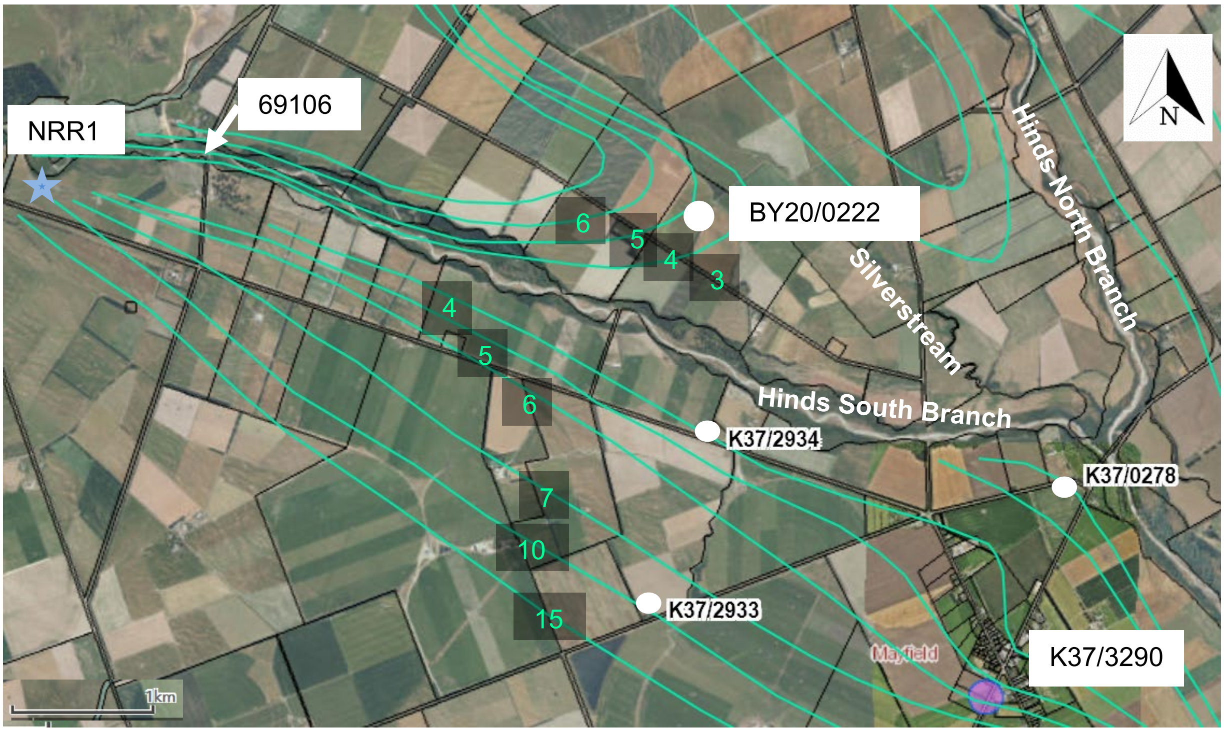

Figure 2-11: NRR1 down-gradient monitoring wells and minimum depth to groundwater contours (in m) (Source: Canterbury Maps)

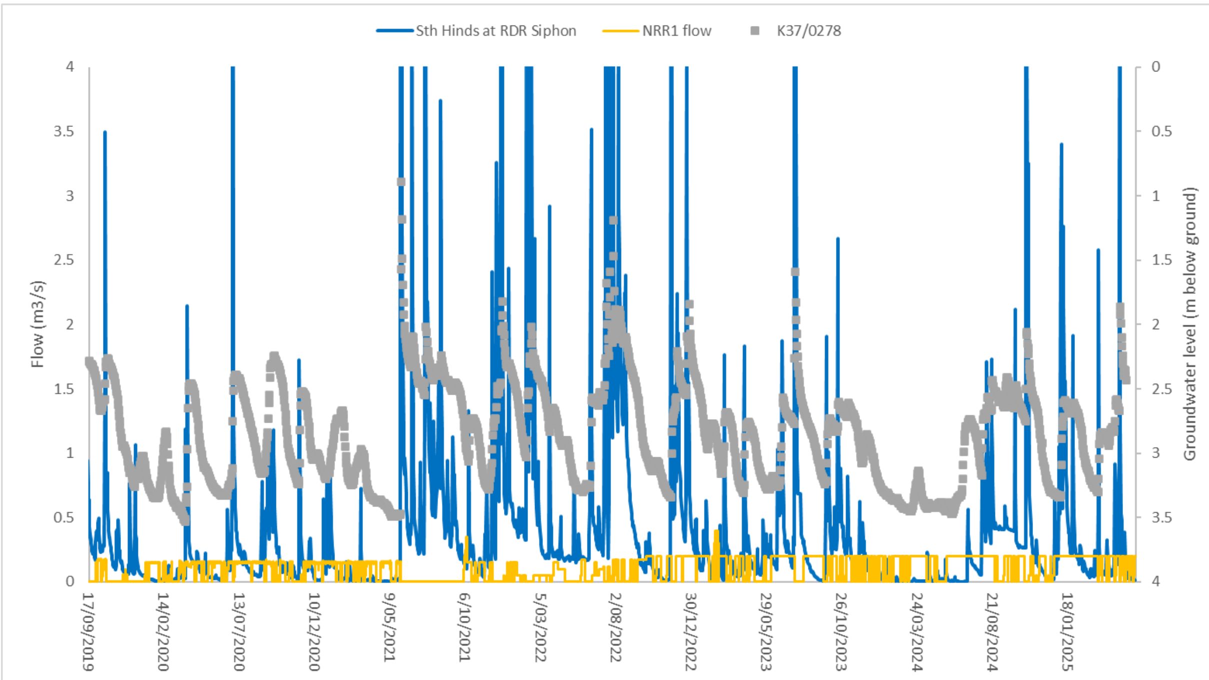

Figure 2-12: South Hinds flow, NRR1 flow and K37/0278 groundwater level comparison (Source: CRC, HHWET)

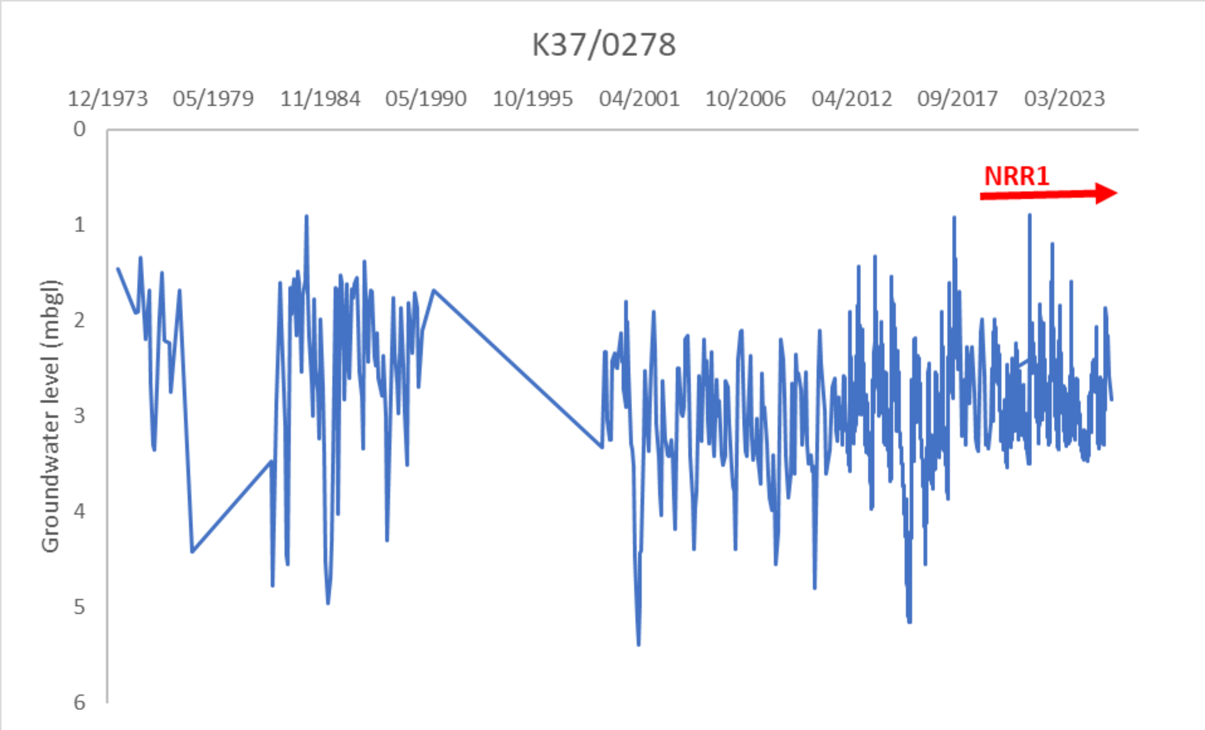

Figure 2-13: Full record of K37/0278 groundwater levels (Source: CRC)

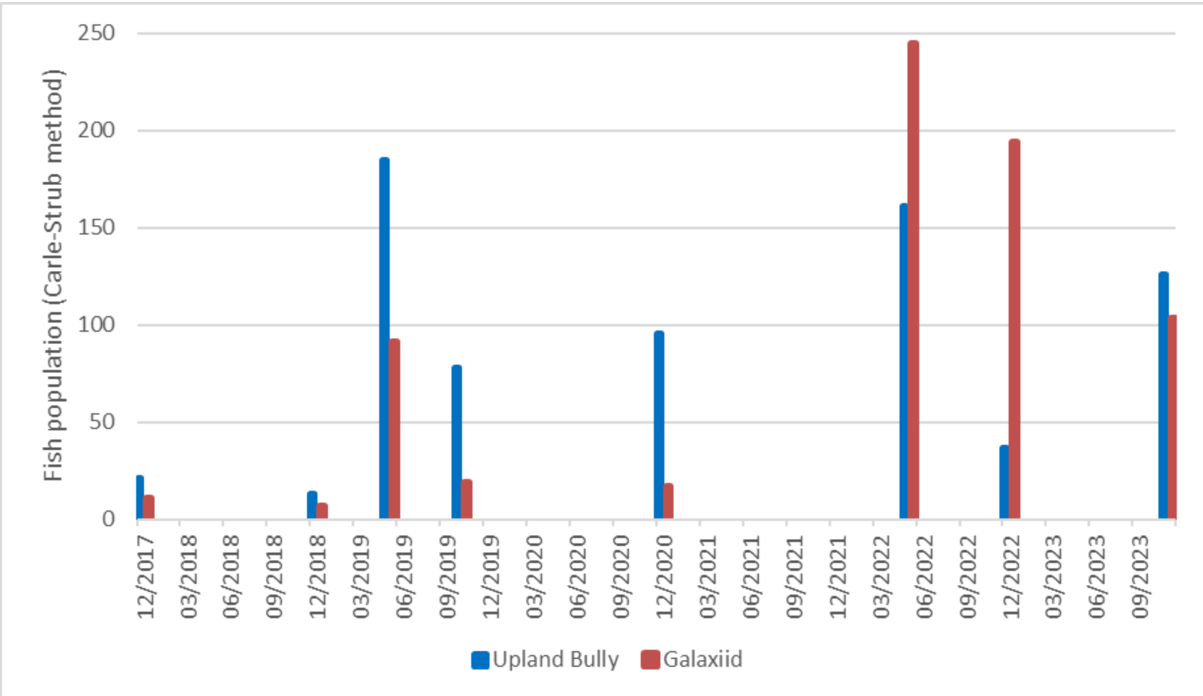

Figure 2-14: Hekeao/South Branch Hinds River at Lower Downs Rd Bridge, annual fish population estimates per 30 lineal metres, 2017 – 2025 (Source: Central South Island Fish and Game)

2.2 Lower Hekeao/Hinds River

The lower Hekeao/Hinds River is a groundwater-fed waterway most of the time, supplied via springs in and near the riverbed as well as by its four groundwater-fed tributaries (Northern, Taylors, O'Shaughnessy's, and Montgomery's Drains – see Figure 2-15). When mid to upper catchment groundwater levels are sufficiently high (usually following above average rainfall recharge), the river mainstem also flows. Water quality and quantity at the Hekeao/Hinds River Lower Beach Road monitoring site is therefore influenced by climate, land management and enhancement activities through the central portion of the Hekeao/Hinds Plains up to the foothills. No other single current monitoring site across the catchment represents a greater proportion of the catchment. This site also has the most challenging 2035 PC2 nitrate-N target of all waterways in the lower catchment (annual median of 3.8 mg/l, compared with 6.9 mg/l for the other waterways).

The lower catchment waterways support valued mahinga kai, native fish, and non-native fish habitat. Due to the complexities of the catchment influences on these waterways and their high ecosystem values, the Ashburton Zone Committee recommended the formation of the Hinds Drains Working Party in 2014 to develop a set of action/management plans (AZC, 2014). The Hinds Drains Working Party Final Recommendations were duly delivered in early 2016 (HDWP, 2016). In mid-2022 a 5-year summary of progress to date was prepared and discussed with the Hinds Drains Working Party (HDWP, 2022). Progress of relevance to HHWET activities is presented in Section 2.4 of the HHWET 2021/22 Annual Report (HHWET, 2022).

To inform actions and progress toward relevant HDWP and LWRP objectives, Environment Canterbury and Fish & Game undertake surface water quality and aquatic ecosystem health monitoring along the Hekeao/Hinds River and some of its lower catchment contributing drains. Additional surface water quality monitoring of O'Shaughnessy's and Montgomery's Drains was also initiated by MHV Water in 2020/21. These waterways are of relevance to lower Hekeao/Hinds River water quality. Key surface water monitoring points in the lower catchment are noted on Figure 2-15, with Hekeao/Hinds River flow (at Poplar Rd), quality and ecosystem health analysis (at Lower Beach Rd) presented on Figure 2-16 and Figure 2-17. Ecosystem health is represented by QMCI (Quantitative Macroinvertebrate Community Index) in Figure 2-17. The QMCI is based on the tolerance or sensitivity of species (taxa) to organic pollution and nutrient enrichment.

Water quality is represented by nitrate-nitrite-nitrogen[1] (NNN), with Figure 2-17 showing that the annual 95 percentiles for the last three years have been the best since 2012. For a general assessment, we compared the most recent 6 year averages with the preceding 6 year averages (before and after PC2 enhancements). Rainfall was 16% higher in the most recent 6 year period, which is unlikely to be sufficiently different to measurably influence results. The 6 year comparison of NNN concentrations shows a statistically significant improvement ($P(T<=t)$ of 0.004 for One-tail Paired Sample for Means t-Test, thus rejecting the hypothesis that the means are equal at the 0.01 level of significance). Mean NNN decreased by 11%, median NNN decreased by 15% and the variance decreased by 29%. The 6 year comparison of 7-day Mean Annual Low Flow (the lowest 7-day average flow for each 5 year period) also shows a 60% improvement (increase). A statistical comparison is not appropriate for QMCI as once-a-year measurements are only representative of the immediately preceding conditions. However, in the most recent 6 year period, the worst QMCI result was 12% below the PC2 target, while in the earlier 6 year period, the worst QMCI result was 48% below the PC2 target.

In winter 2024, MHV Water commissioned 6 eDNA (environmental DNA) sample replicates for the Hekeao/Hinds River at Lower Beach Road and the derived TICI (Taxon-Independent Community Index) from these. TICI is an alternative ecosystem categorisation method to QMCI that can be calculated

[1] Nitrite concentrations are relatively low in Hekeao/Hinds Plains waterways, so the comparison of nitrate-NN monitoring with nitrate-N targets is only slightly conservative.

directly from an eDNA sample. The median TICI score of 109.73 is just below the 'Excellent' ecosystem health category (110.0), and is consistent with recent QMCI results.

A comparison between annual rainfall and NNN in Figure 2-17 shows a correlation between high rainfall years and high NNN statistics (in the same and/or following year) up until 2022. However, this relationship does not continue for the above average rainfall years concluding June 2023 and June 2025. Rainfall induced transport of nutrients through the soil profile, unsaturated zone and groundwater system is a natural phenomenon, and has been assessed for the Hekeao/Hinds Plains (e.g., Legg et al., 2025). As discussed above, the lower Hekeao/Hinds River contains a combination of groundwater influenced by land use recharge and river flow (surface and subsurface) that is less influenced by landuse activities.

Figure 2-18 focuses on the 2024/25 period, with Hekeao/Hinds River at Poplar Road flow and Hekeao/Hinds River at Lower Beach Road nitrate-NN concentrations from Figure 2-16, plus:

- NRR1 flow;
- NRR1+South Branch Hekeao/Hinds River flow above NRR1 (with flow above NRR1 being used as a surrogate for all upper Hekeao/Hinds River flows in the absence of flow recorders on other tributaries); and
- Environment Canterbury's shallow groundwater level monitoring well (K37/2456) beside the upper springs of the Northern Drain tributary to the lower Hekeao/Hinds River, with groundwater levels being used as a surrogate for lower Hekeao/Hinds River tributaries (in the absence of flow recorders). Of these tributaries, Northern Drain usually has the highest flows.

Flows in Figure 2-18 are presented in log scale due to significant flow variations. Figure 2-18 shows that shallow groundwater levels began the year approximately 11 m above the base of the 17 m deep K37/2456 well and finished the year approximately 15 m above the well base. In the context of the full groundwater level record for K37/2456 (2005-2025), this represents a change from near record low groundwater levels (6^{th} percentile) to very high groundwater levels (90^{th} percentile). Groundwater level increases occurred from early August to early October 2024, and then in May 2025. On average, lower Hekeao/Hinds River tributary flows are therefore assumed to also be lowest at the beginning of the hydrologic year and greatest at the end, with flow increases correlating with groundwater level increases.

Comparing lower (Poplar Road) and upper (with NRR1 + South Branch Hekeao/Hinds River flow above NRR1 as a surrogate) catchment Hekeao/Hinds River flows provides some insight into the relative contribution of groundwater to river flow in the lower plains. During the months of July and August 2024, and January 2025, upper catchment flows were similar to or greater than[2] lower catchment flows. In late October 2024, an 11 m^3/s fresh down the river system also resulted in comparable flows. At other times, the flow at Poplar Road tended to be much higher than the upper catchment, indicating significant groundwater contribution to flow along the reach.

Nitrate-NN samples were obtained from the Hekeao/Hinds River at Lower Beach Road during 2024/25. Recorded nitrate-NN concentrations varied from 1.8 – 8 mg/l, with a median of 5.3 mg/l. The 1.8 mg/l recorded in October 2024 was the lowest on record (see Figure 2-16). Nitrate-NN concentrations decreased during the months of July, August and October 2024, and January 2025. During months when nitrate-NN concentrations increased, the lower catchment flow was significantly greater than upper catchment flow, except for brief upper river freshes such as mid-March 2025. In contrast, the lowest concentration was obtained in October 2024 when flows were comparable between the sites.

[2] Considering different lag times for water travelling above and below ground down the Hekeao/Hinds River system, upper river flow that doesn't reach the lower river can be assumed to be transported through the connected groundwater system.

There is some indication, therefore, that for the 2024/25 period, Hekeao/Hinds River at Lower Beach Road nitrate-NN concentrations were highest when the lower plains river flow was dominated by groundwater and lowest when the river flow was dominated by upper catchment river water. NRR assists with this balance, as does rainfall that is greater in the upper plains than the lower plains (as occurred from October to December 2024).

Figure 2-19 compares annual median NNN for the four lower Hekeao/Hinds Drains with their 2035 PC2 target (plus annual rainfall for context). For 2024/25, the drains to the west (true right) of the Hekeao/Hinds River produced similar annual median NNN to 2023/24, while the drains to the east (true left) of the Hekeao/Hinds River produced higher annual median NNN than 2023/24 (potentially influenced by additional cattle wintering noted in their upper catchment). Given the overall increase in drain NNN concentrations for the current year, the decrease in NNN concentrations for the Hekeao/Hinds River at Lower Beach Road is particularly pleasing.

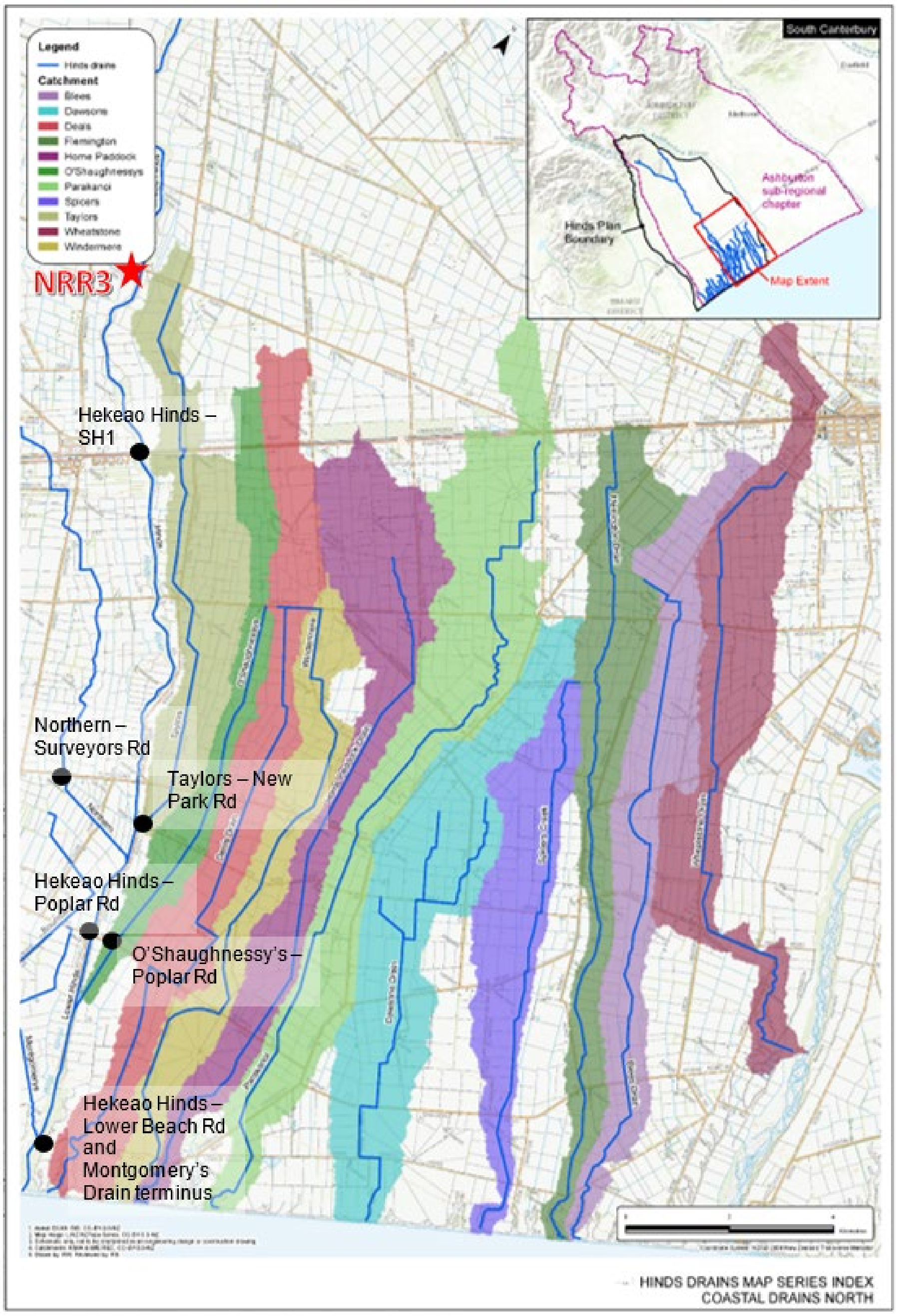

Figure 2-15: Hekeao/Hinds River monitoring sites (Source: HDWP)

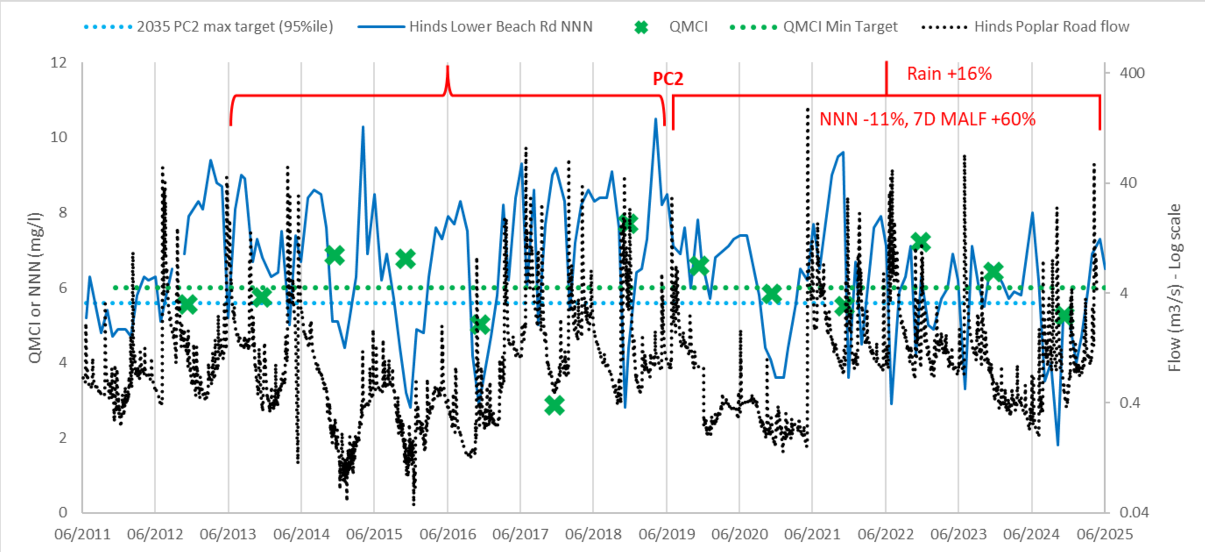

Figure 2-16: Hekeao/Hinds River flow, NNN and QMCI highlighting the 6 year period pre-PC2 and the following 6 year period (Source: CRC[3])

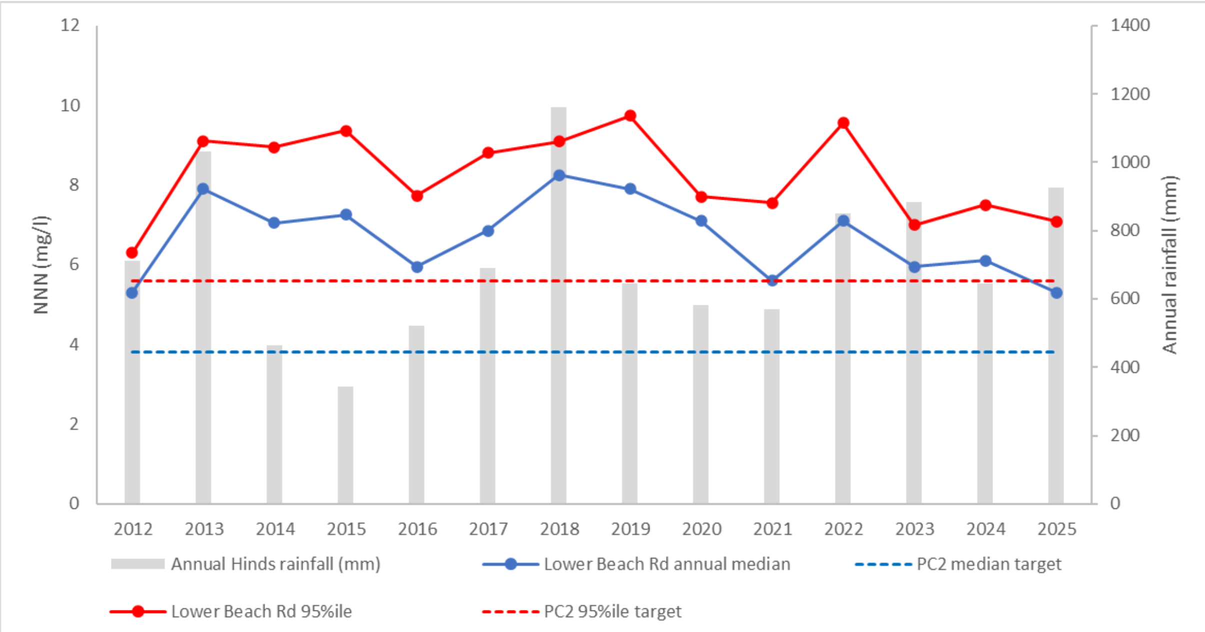

Figure 2-17: Annual (year ending 30 June) Hinds Plains rainfall and annual median Nitrate-Nitrite-Nitrogen concentrations for the Hekeao/Hinds River at Lower Beach Rd (Source: CRC)

[3] This work uses QMCI material sourced from Hilltop Manager database and the SOE streamhealth dataset stored in the Streamhealth MS Access database, which is licensed under a Creative Commons Attribution 4.0 International licence by Environment Canterbury.

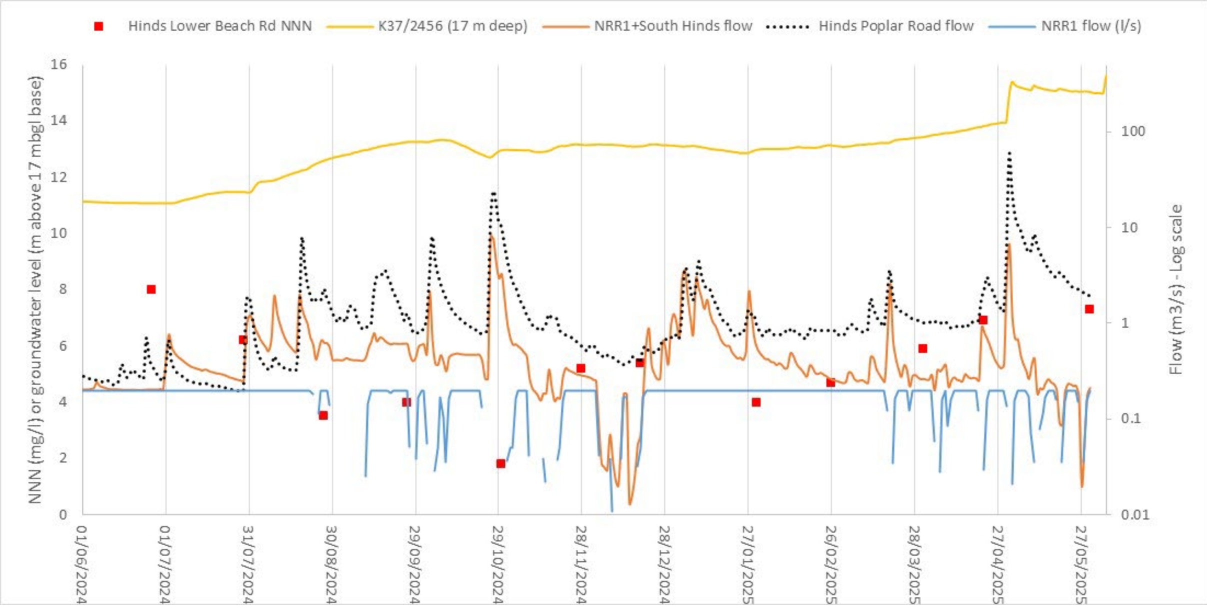

Figure 2-18: Hekeao/Hinds River flow, NNN and nearby shallow groundwater levels for 2024/25 (Source: HHWET, CRC)

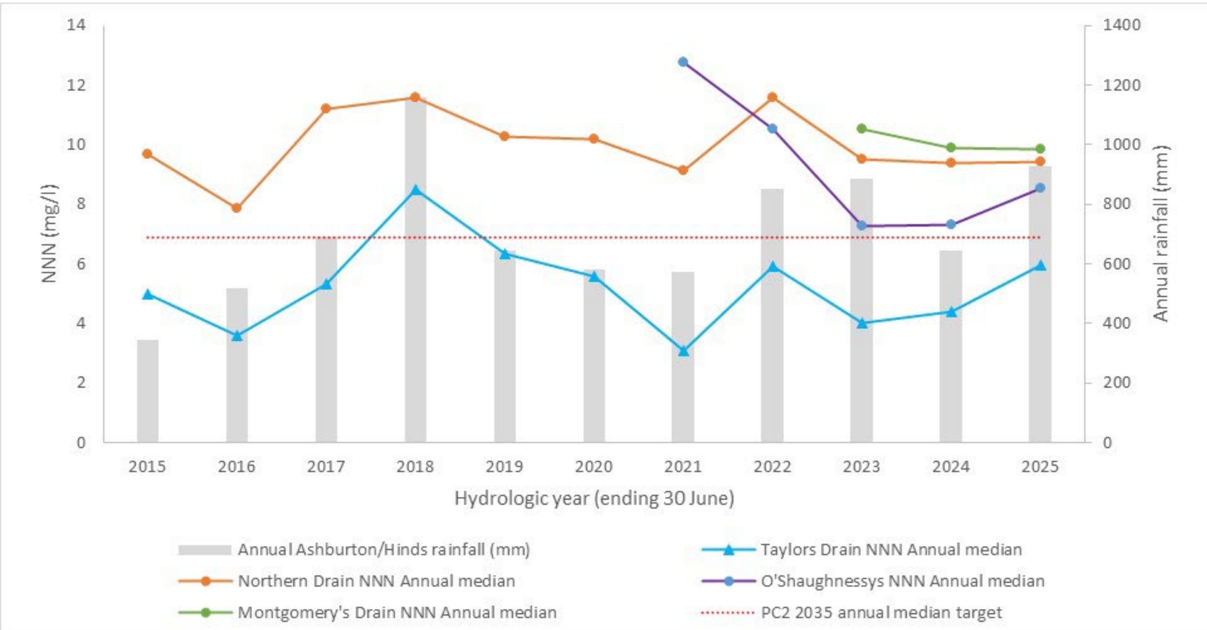

Figure 2-19: Lower Hekeao/Hinds River tributary NNN concentrations (Source: CRC/MHV)

Lower Hekeao/Hinds River fish surveys comprise annual assessment of fish diversity and abundance by electric fishing at two sites in the lower river – one about 0.4 km inland from the coast and the other just above Poplar Rd (about 6 km above the lagoon). Central South Island Fish and Game were unable to conduct a survey during 2024, but have committed to a 2025 survey. Total estimated population size (from three passes) is presented in Figure 2-20. The 2021 "Above Lagoon" population was dominated by 362 bluegilled bully and the 2022 population was dominated by 666 common smelt. Seven of the nine fish species caught in the lower river were migrant species requiring passage to and from the sea to complete their life cycles. Webb (2021) notes that the presence of these migrant species suggests the Hekeao/Hinds River mouth was open frequently enough in these years to enable fish migration. While the NRR contribution of flow support with high quality water can be assumed to be positive for fish populations and macroinvertebrates, direct links between annual NRR volume and estimates of fish populations/QMCI are unlikely to be measurable, given the more significant influence provided by rainfall (and resultant spring flows).

A trail camera was placed at a site overlooking the Hekeao/Hinds River mouth in October 2024 to assist with identifying mouth opening timing and regularity. Some openings have been captured on camera (e.g., Figure 2-21); however, other potential opening periods (due to the presence of birds, which indicates the likely presence of fish) are obscured by the beach head or coastal cliff when the mouth moves (e.g., Figure 2-22). Based on the trail camera photos, the river mouth was expected to be open between 48 and 65% of the time between 9 October 2024 and 31 May 2025. A second trail camera was placed at the Boundary Creek hapua in October 2024 and was moved to face the river mouth in mid-November 2024. Soon after placement, the river mouth moved too far north to be visible, until January 2025 when it moved south and into view. From January to May 2025, trail camera photos suggested that the mouth was open to the sea between 74 and 85% of the time, aided by a high starting point on the beach head and a short steep drop to the sea. Trail cameras will be left at these sites until re-deployed for other assessments.

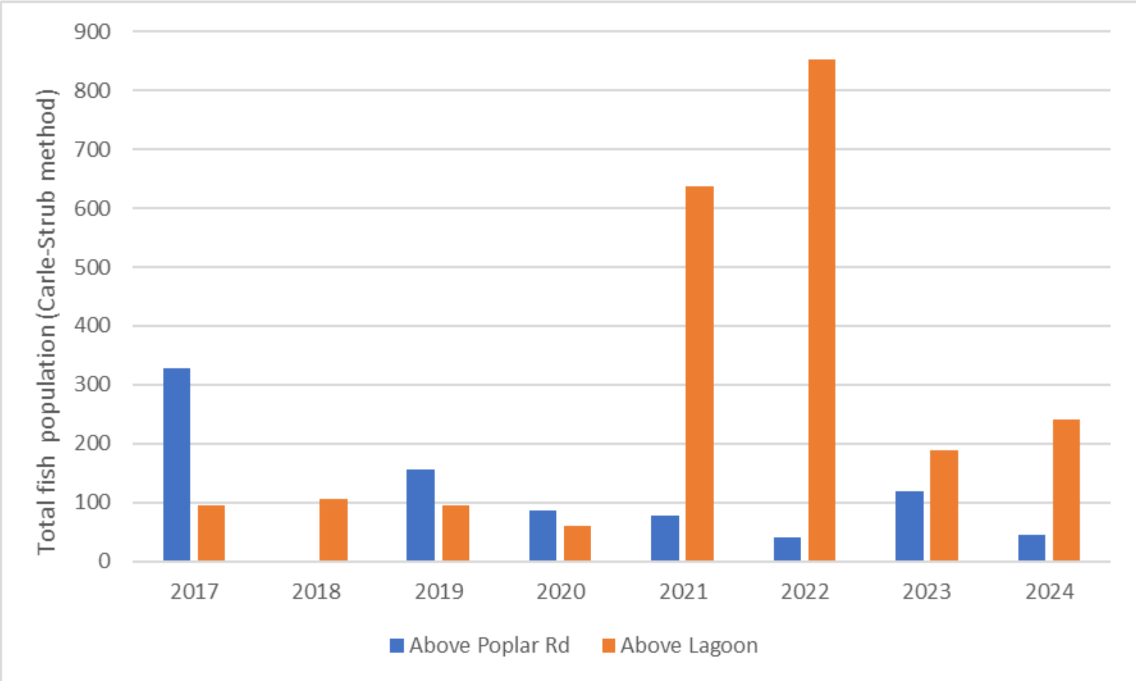

Figure 2-20: Total fish population estimates for two lower Hekeao/Hinds River sites (Source: M. Webb, Central South Island Fish and Game)

Figure 2-21: Trail camera photo of Hekeao/Hinds River mouth on 28 April 2025 (source: HHWET)

Figure 2-22: Trail camera photo of Hekeao/Hinds River mouth on 4 March 2025 (source: HHWET)

3 Hekeao/Hinds MAR Case Studies

An overview of MAR/NRR site operations and monitoring is presented in the introduction, with Table 1-1 showing that the total recharged MAR/NRR volume in 2024/25 via one MAR site and one NRR site was 7.34 million m^3. This is approximately 17% higher than the 2023/24 result, but significantly less than the 13.8 million m^3 recharged in 2020/21 when all 17 constructed MAR/NRR sites were consented to operate. The low annual volume is due to continued operations at the remaining MAR sites declined by Environment Canterbury while HHWET waited for replacement consent applications to be heard. This was a discretionary decision by Environment Canterbury, which has unfortunately resulted in a cessation on the environmental gains made in recent years resulting from operation of the affected MAR sites. For this annual report, a detailed assessment of the only operational MAR site (MAR01) is presented.

3.1 MAR01 - Lagmhor Pilot Site

The Lagmhor MAR Pilot Site (MAR01) is a 0.9 ha recharge basin, inland from Tinwald (see Figure 3-1). The relevant discharge consent is CRC210830. Pre-construction modelling and infiltration testing suggested potential maximum infiltration/recharge rates of 300-500 l/s, with significant lateral as well as down-gradient influence on groundwater levels and water quality. The actual infiltration rate achieved during the first two years (2016-18) was approximately 80-100 l/s, with the primary water quality influence following a southeasterly groundwater flow direction. During Year 3 (2018/19), potential improvements were trialled: a deep soakage system, removal of accumulated sediment from the recharge basins and up-gradient delivery channel, and a higher basin depth. Maximum recharge rates (including the recharge race) increased to approximately 180 l/s following these enhancements. The most recent addition to this site has been the installation of an automated control gate connecting the neighbouring ADC water race to the MAR01 intake, so that supply can continue while the MHV Water distribution system is unavailable (due to capacity constraints or maintenance requirements).

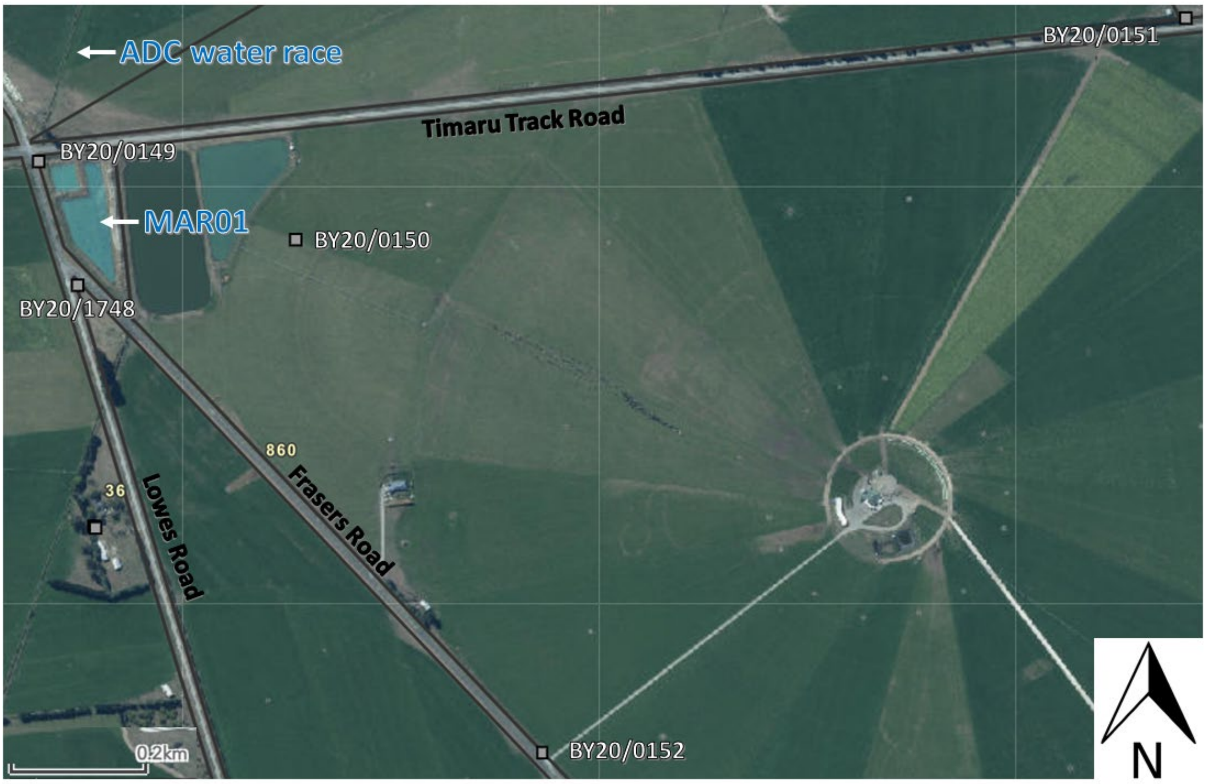

Figure 3-1: MAR01 (Lagmhor MAR Pilot Site) locality and nearby monitoring (Source: Canterbury Maps)

Figure 3-2 presents recharge flows and local monitoring since just before operations began in mid-2016. Discharge flows (in hundreds of litres per second) are shown in yellow and in 100 l/s increments on the right axis. Measured nitrate-N concentrations (at a 29 m deep well 1 km down-gradient from MAR01) are shown in purple and on the right axis, with an in-situ continuous nitrate-N sensor (in green) providing detailed monitoring until late 2019. Groundwater levels are presented in dark blue on the left axis, with reasonably rapid level changes when MAR begins or ceases.

Cessation of operations is required under certain circumstances: (a) when the local groundwater level is measured at two metres or less below ground level, (b) when the *E. coli* count in the source water exceeds 1,000 MPN/100mL, or (c) when 30 millimetres or more of rainfall within any 24-hour period is measured at the Hinds Plains Rainfall Monitoring Site. Hinds Plains daily rainfall exceeded 30 mm/d five times over four rainfall events between 1 June 2024 and 31 May 2025. After each rainfall event, the site was turned off for at least 48 hours. No shutdowns for high groundwater levels or *E. coli* counts were required during 2024/25.

There have, however, been MAR01 site shutdowns for *E. coli* exceedance in previous years. *E. coli* is an indicator species used for microbial pathogens, which can pose a contamination risk from faecal material. However, *E. coli* is not necessarily an indicator of human health risk and high concentrations can be present that are not associated with any risk (Ishill et al, 2006; ESR, 2019). Through the course of this trial, we have identified four key *E. coli* sources relevant to MAR site management:

1. Birds roosting on water storage ponds;
2. Stock grazing near open water races;
3. Organic plant matter in water races; and
4. Suspended sediment arriving from the Rangitata River.

E. coli research and management considerations for MAR sites are presented in HHWET (2023). From 2023-25, HHWET supported the post graduate research studies of Madeline Inglis. Her thesis is titled "*Pathogen Pursuit: Assessing transport in groundwater of microbial pathogens from the Hekeao/Hinds managed aquifer recharge scheme*". Madeline presented her methods and initial results at the NZ Hydrological Society conference in December 2023 and her final results at the NZ Hydrological Society conference in December 2024. These results showed *E. coli* removal rates (approximately 2,420 MPN/100 ml within 340 m of MAR01) that were consistent with those presented in the literature for similar aquifers, providing additional confidence in HHWET's *E. coli* triggers for site shutdowns. Madeline submitted her thesis in late April 2025.

The BY20/0152 nitrate monitoring record in Figure 3-2 shows nitrate-N at 6-7 mg/l immediately pre-MAR, reducing to 1 – 3 mg/l with MAR. Concentrations exceed 3 mg/l after a period of no MAR and after significant rainfall events (such as May 2021 and July 2023), but quickly drop back to below 3 mg/l once MAR resumes (i.e., the nitrate concentration increase is due to a combination of land surface leaching caused by rainfall and the cessation of MAR due to the rainfall event). The average nitrate-N concentration in 2024/25 at BY20/0152 was 1.8 mg/l, the second lowest on record (with an average of 1.7 mg/l in 2022/23). The average nitrate-N concentration at BY20/0152 since Spring 2016 is 2.3 mg/l.

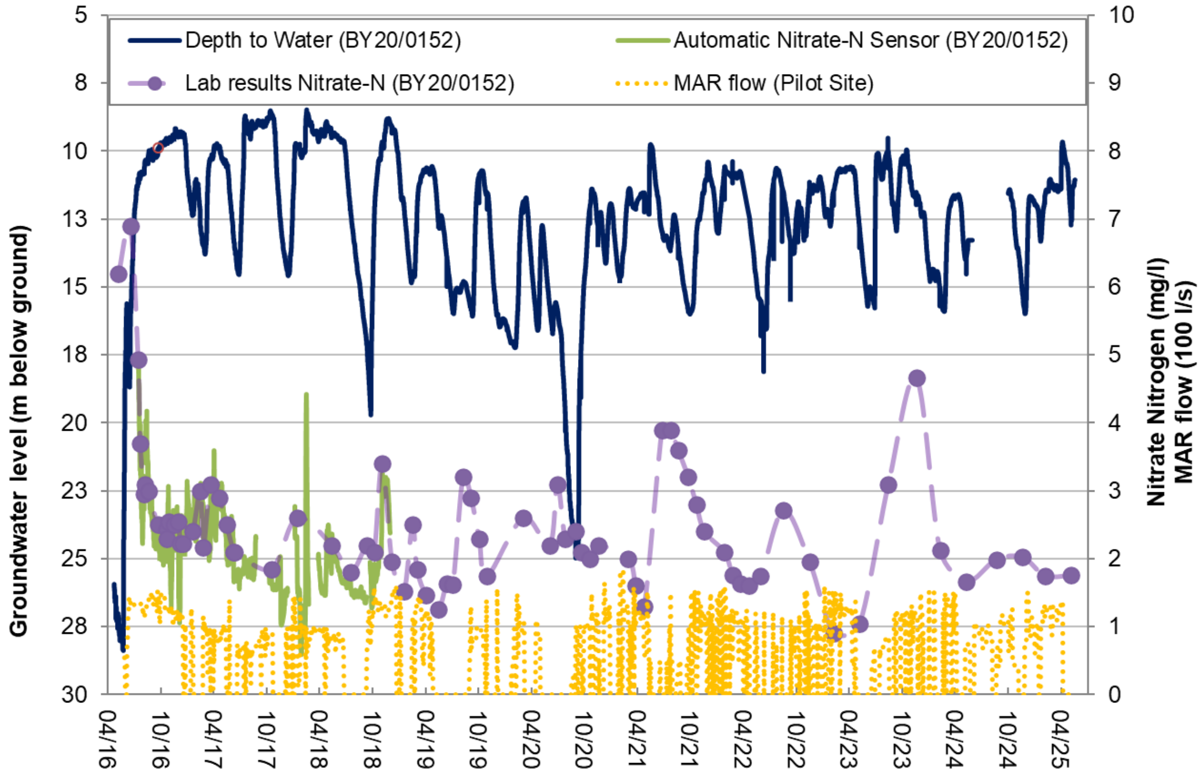

Figure 3-2: MAR 01 (Lagmhor MAR Pilot Site) operational and down-gradient monitoring

The groundwater level dataset for BY20/0152 enables additional analysis of MAR01 influence. Twenty two MAR01 operational periods can be identified between 2016 and 2025, where an operational period is defined by more than 7 days of MAR01 operation with no MAR01 operations for at least 7 days prior to the start of operations. Operations occurred in every year and at different times of the year, enabling the assessment of MAR01 influence during a variety of rainfall and groundwater abstraction influences. The hypothesis to be tested is whether groundwater level change (at an appropriate lag time after the start and after the cessation of MAR01 operational events) is the same or different. To answer this question, for each operational event from 2016 - 2025 the maximum change in BY20/0152 groundwater levels in the 8-15 days after MAR01 started operations were compared with the maximum change in BY20/0152 groundwater levels in the 8-15 days after MAR01 stopped operations. The dataset for maximum groundwater level change following MAR01 starting had a mean increase of 1.28 m (with variance 0.68 m). In comparison, the dataset for maximum groundwater level change following MAR01 stopping had a mean decrease of 0.80 m (with variance 0.09 m). These datasets do not overlap, and a $P(T<=t)$ of $9.5*10^{-10}$ for a One-tail Paired Sample for Means t-Test rejects the hypothesis that the means are equal at the 0.01 level of significance. We can therefore conclude that MAR01 operations result in a statistically significant change in BY20/0152 groundwater levels.

In the HHWET Annual Reports from 2019/20 through to 2021/22, groundwater level and water quality monitoring down-gradient from MAR01 was compared to conclusions from the 2019 Master of Water Resource Management Thesis titled "*Quantification of the Probable Environmental Effects of the Hinds Managed Aquifer Recharge Trial using Mathematical Modelling and Advanced Uncertainty Techniques*" by former Environment Canterbury scientist Patrick Durney. The relevant conclusion from Durney's thesis was:

> *"the Hinds MAR trial will successfully raise groundwater levels across a large area and increase stream flows. Further, the trial will improve water quality in groundwater, though it will probably not influence surface water quality. Transport modelling suggests water quality improvements can be*

expected for several kilometres down-gradient of the trial site, though they are unlikely to propagate as far as the lowland streams." (Durney, 2019)

The analysis of results in HHWET Annual Reports continue to concur with Durney's conclusions. Figure 3-3 shows that the nitrate-N concentrations in wells close to (or down-gradient from) MAR01 are 80-90% lower than nearby well BY20/0151 (cross-gradient from the site, which also shows an increasing trend from 2016 until monitoring ceased in 2022). BY20/0152 and K37/1748 also show nitrate concentration increases following extended periods of no MAR01 recharge (some of which occur after a significant rain event).

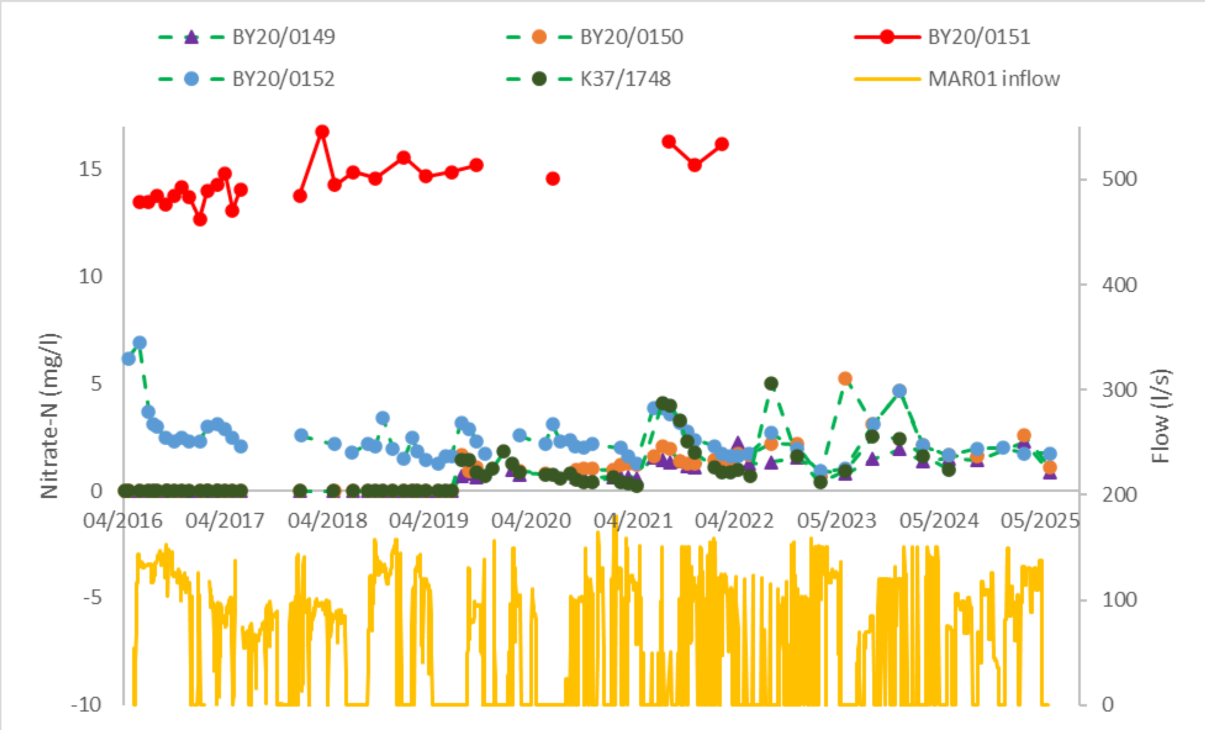

Figure 3-3: Nitrate-N concentrations for wells close to MAR01 (Source: HHWET, CRC)

As noted by Durney (2019), MAR water quality influence at a distance greater than a few kilometres down-gradient from MAR01 becomes increasingly challenging to distinguish due to the mixing of MAR with local groundwater and other recharge sources. Potential MAR influences were detected in the first few years of operation when initial water chemistry changes (e.g., nitrate, electrical conductivity, chloride, and hardness) were detected after lag times that were consistent with water particle travel time estimates (1-1.5 years for wells up to 5 km downgradient and at least 2 years for wells greater than 6 km downgradient). Since initial detection of potential MAR influence, the relationships between MAR operations and nitrate concentrations in bores greater than 3 km downgradient from MAR01 have been unclear (e.g., see Chapter 4 of HHWET, 2023).

In addition to on-going quarterly groundwater monitoring down-gradient from MAR01, continuous nitrate sensors were installed in July 2023 in two wells approximately 6-7 km down-gradient from MAR01 and an intensive monitoring survey of approximately 60 wells (one sample per well) was conducted from December 2023 to January 2024. Summarised results of this survey are presented in Figure 3-4. These results show nitrate-N concentrations less than 3 mg/l within 1 km of MAR01, then an increase to 8-11 mg/l nitrate-N for the next ~5 km downgradient. Figure 3-4 also shows a variation in nitrate-N concentrations approaching Winslow from the northeast (~5-19 mg/l) and northwest (~12-19 mg/l). The highest nitrate-N concentrations can be found just west of Tinwald (~12-23 mg/l). A key contributor to the high nitrate-N concentrations in the Tinwald "hotspot" was described by Stewart and Aitchison-Earl

(2020) as recirculation of irrigation return flow (leaching), with accumulation of nitrate-N through the contributing catchment due to groundwater irrigators not sufficiently considering irrigation nitrate-N concentrations in their nitrogen fertiliser decisions. The contribution of nitrogen from irrigation water is a significant finding and HHWET continue to promote and support irrigation nutrient recycling in this catchment for reducing nitrate concentrations in groundwater.

A possible factor affecting nitrate concentrations near this "hotspot" is its position at the interface between moderately light, well drained (low to moderate profile available water) soils and heavy (high profile available water) soils overlying sediments with high clay content (see Figure 3-4). In addition to promoting flow direction changes, nutrient "hotspots" at the horizontal or vertical interfaces between light and heavy soils can be formed by the following factors:

1. Nutrient accumulation: The high cation exchange capacity (CEC) of the clay particles effectively "strips" passing water of positively charged nutrient ions (K^+, Mg^{2+}, Ca^{2+}), which become adsorbed to the clay surface. This creates a high concentration of nutrients at the sand-clay boundary, forming a nutrient hotspot. (e.g., Weil and Brady, 2017).
2. Organic matter accumulation and microbial activity: organic matter from both soil types can accumulate near their interface. Light soils contribute organic material that decomposes quickly, while heavy soils retain organic matter longer. Microbes suited to this interface can enhance nutrient release from this organic matter (e.g., Singh and Schulze, 2015).

Wells with multi-year quarterly monitoring nitrate-N datasets near Tinwald are presented in Figure 3-5. This set of wells includes the two wells (K37/0751 coloured blue and K37/3146 coloured green) containing nitrate sensors since July 2023. The mean daily nitrate sensor results are compared with the average of two nearby irrigation pumping records in Figure 3-6 (with potential rainfall correlation also checked and discounted in HHWET, 2024). Nitrate-N concentrations for both sensors are lowest (8-10 mg/l) when there is no nearby irrigation abstraction, and more variable as well as higher (14-20 mg/l) during periods of nearby irrigation abstraction. Nitrate concentration variation often follows the peaks of the chosen pumping records (N.B., these two irrigation wells represent less than 10% of consented abstraction within a 4 km radius of the nitrate sensors).

Figure 3-7 and Figure 3-8 suggest that this seasonal nitrate concentration variation is strongest within about 3 km of the closest groundwater pumping. Figure 3-7 shows consistent seasonal nitrate concentration variation for the wells within this area and Figure 3-8 shows no seasonal nitrate concentration variation for the wells outside this area. Nitrate-N concentrations for K37/2166 (in the Tinwald "hotspot") in Figure 3-8 are approximately 20 mg/l for the 2023-2025 period of overlap with Figure 3-6. With no alternative sources of >=20 mg/l nitrate-N groundwater identified and a much lower level of consented groundwater abstraction near Tinwald than Winslow, the identified relationship between groundwater abstraction for irrigation and nearby nitrate concentration changes suggests that high nitrate water from the Tinwald "hotspot" is transported towards Winslow in a west to south westerly direction during the irrigation season.

Later in 2025 HHWET intend to move one of these nitrate sensors to a well closer to Winslow, to assess whether there is seasonal nitrate concentration variation for nearby domestic water users. Previous analyses (e.g., HHWET, 2021, Chapter 4) have concluded that MAR01 recharge is heading in the direction of this seasonally affected groundwater. During nitrate monitoring surveys, discussions with affected landowners have focussed on the domestic water treatment options for wells at risk of not meeting NZ Drinking Water Standards (2022). Current HHWET resource consent applications are also expected to increase recharge from MAR01 and nearby MAR sites into this area, with the aim of improving groundwater levels and quality.

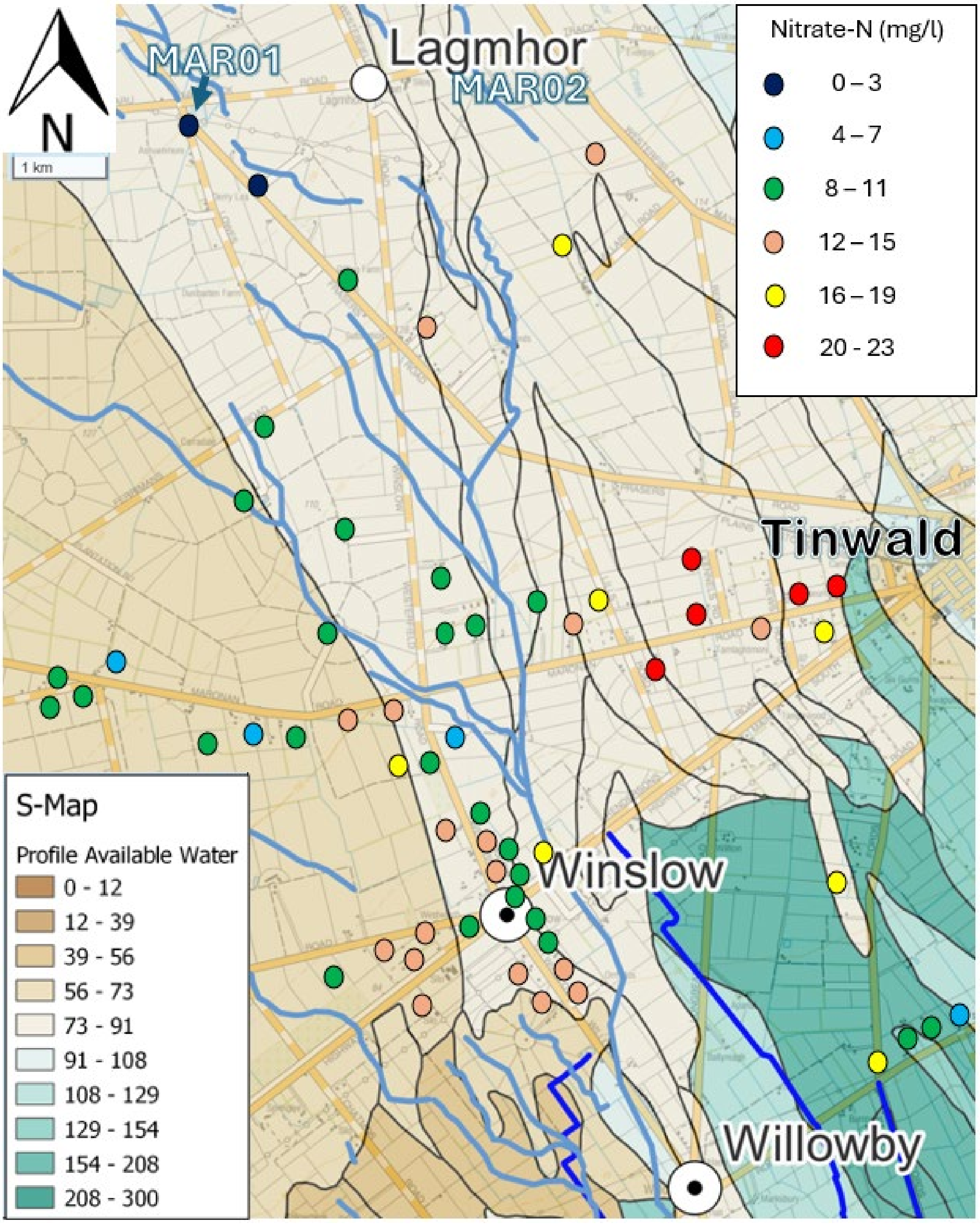

Figure 3-4: Nitrate-N concentrations from 35-60 m deep wells near Tinwald in the December 2023 to January 2024 survey

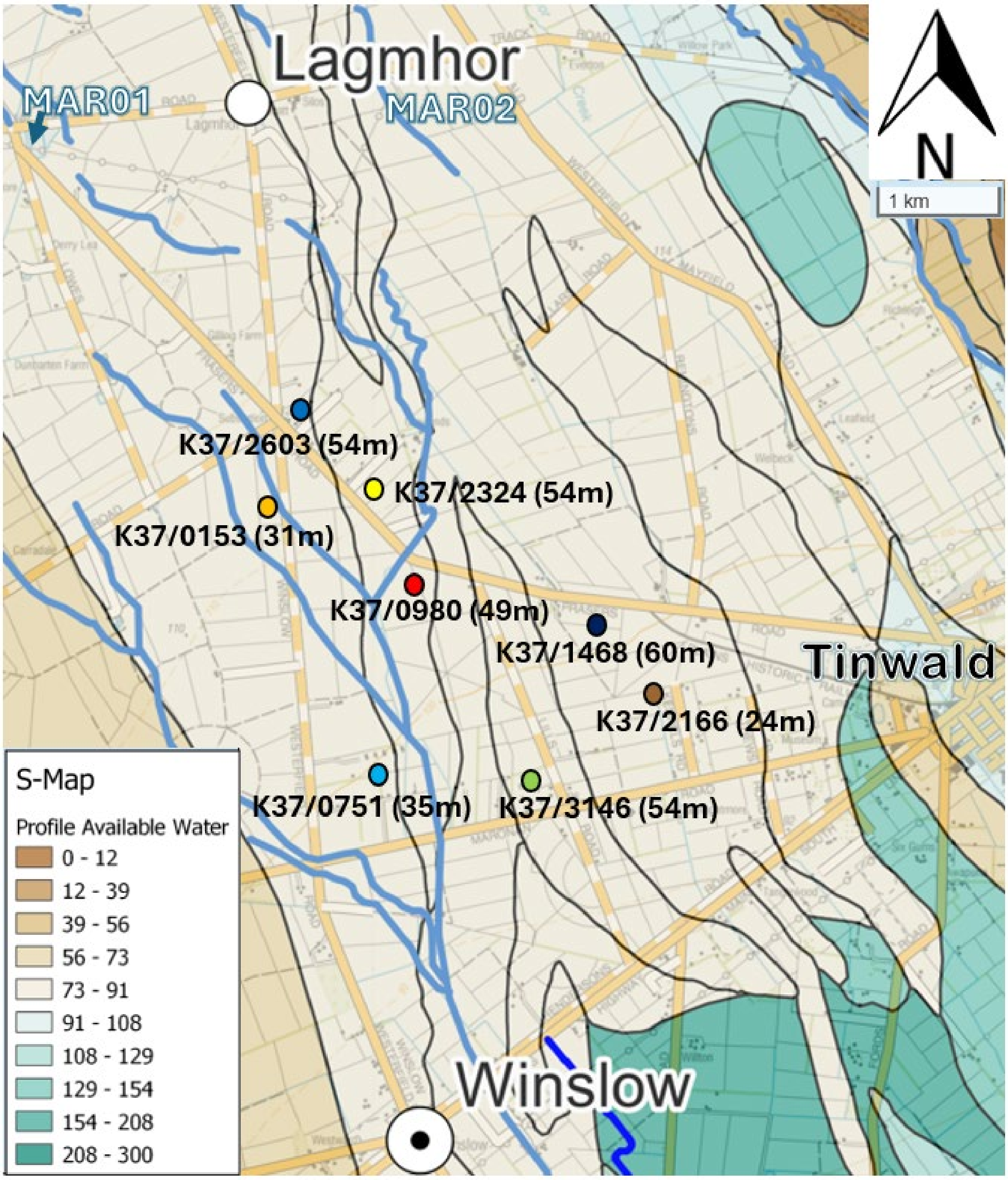

Figure 3-5: Wells with quarterly nitrate-N monitoring near Tinwald

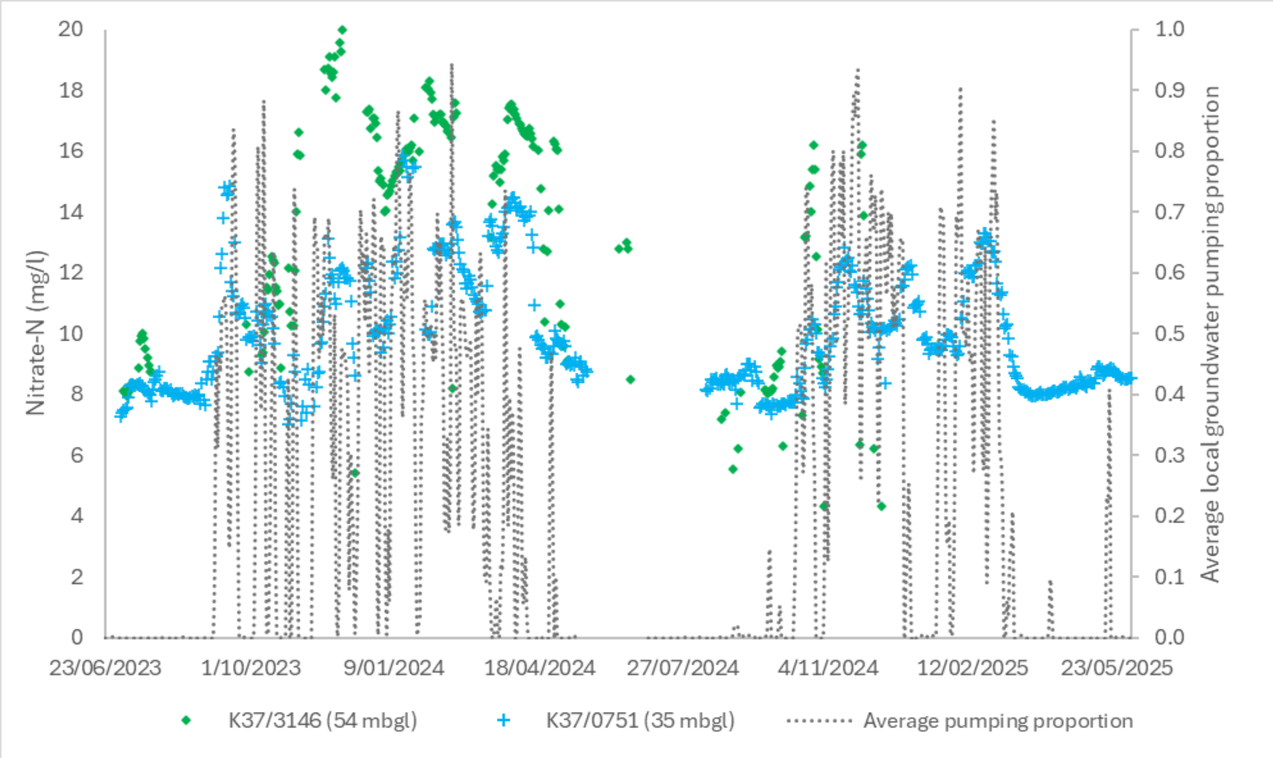

Figure 3-6: Daily Nitrate-N concentrations from two wells near Tinwald and daily cumulative groundwater pumping, as represented by the average of two local groundwater irrigation wells (Source: HHWET)

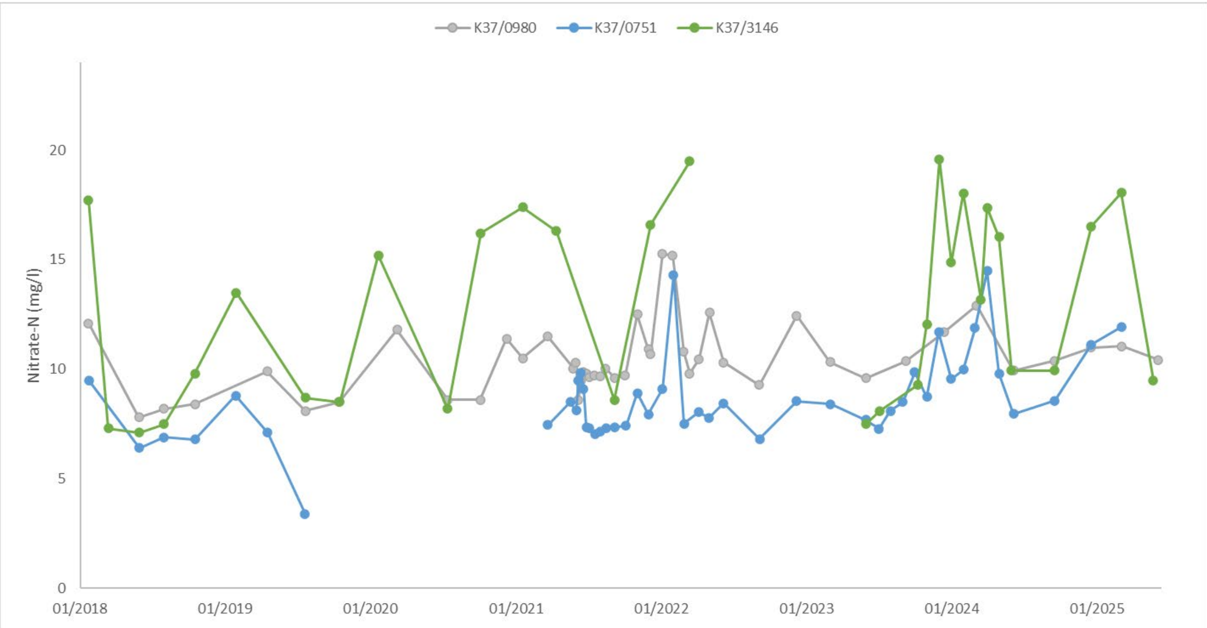

Figure 3-7: Wells near Tinwald showing seasonal variations in nitrate-N concentrations (Source: HHWET, CRC)

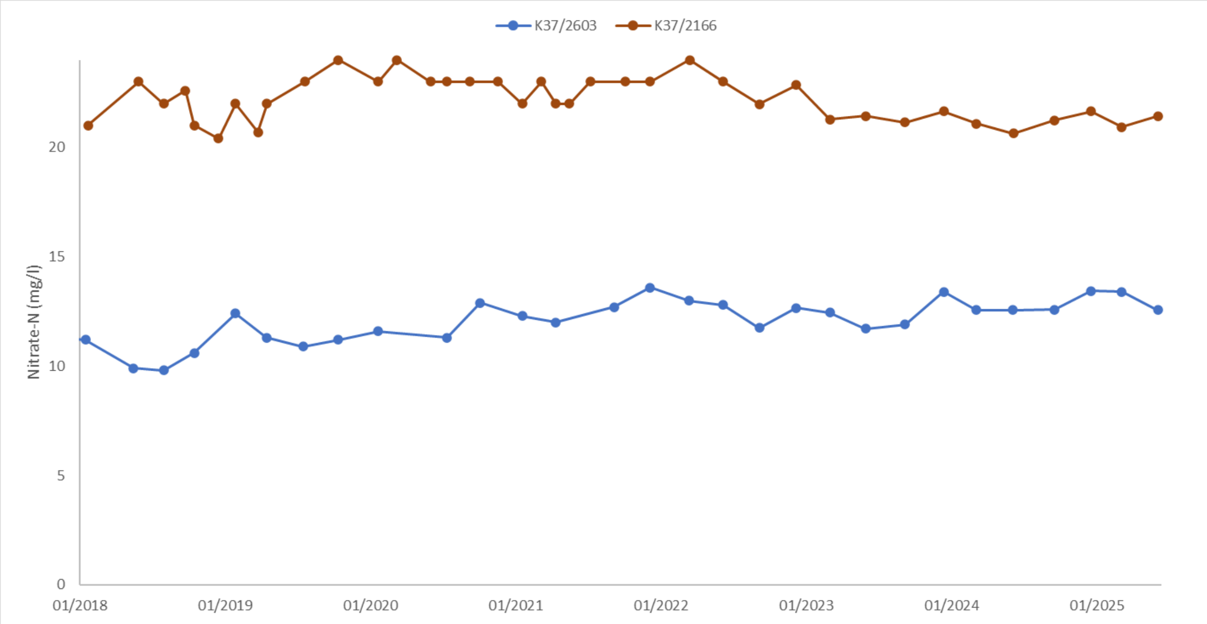

Figure 3-8: Wells near Tinwald not showing seasonal variations in nitrate-N concentrations (Source: HHWET, CRC)

Sidinei Teixeira also analysed water quality results in the vicinity of MAR01 as part of her Master of Water Resource Management research (Teixeira, 2024). Chemical components of groundwater samples were assessed using a combination of statistical analyses to estimate the proportions of the following potential water sources:

- Land Surface Recharge (LSR), comprising irrigation and rainwater that is chemically altered as it travels through the soil.
- Rainfall that recharges groundwater without measurable chemical alteration, e.g., via leaky races and basins as well as low nutrient soil.
- Rangitata River water that recharges groundwater without measurable chemical alteration, e.g., via leaky irrigation races and ponds, stockwater races, and MAR sites.
- Ashburton River water that recharges groundwater without measurable chemical alteration, e.g., via leaky stockwater races, and river recharge in shallow groundwater close to the river.

The highest proportion of chemically ‘unaltered’ Rangitata River water was identified in samples close to MAR01. Apart from MAR, the only alternative explanations for this chemical signature are recharge from leaky irrigation pipes or basins (with MHV Water’s infrastructure monitoring confirming no leaks have been identified) or recharge from historical unlined Valetta irrigation races (with recharge prior to piping of these races in 2014). Teixeira’s research is summarised in Chapter 3 of HHWET (2024).

4 Hekeao/Hinds Groundwater and Northern Drains Surface Water Quality

4.1 Hekeao/Hinds Plains Groundwater Quality

PC2 specifies a groundwater nitrate-N target of 6.9 mg/l to be met by 2035 as an annual median of up to twelve PC2-specified “shallow” wells (screened within 30 m of the water table) across the Hekeao/Hinds Plains. MHV Water, BCI Water and HHWET measure groundwater nitrate-N concentrations at other wells for consent conditions and related projects. Since September 2016, MHV Water have been monitoring groundwater and surface water nitrate-N at further sites across the Hekeao/Hinds Plains, starting with 29 wells in 2016 and increasing to 163 wells and 101 surface water sites in 2024/25. HHWET have been a monitoring project partner since 2020. Samples are tested with a portable nitrate sensor that is regularly calibrated and maintained. A portion of samples are also sent to Hill Laboratories. Database practices adhere to quality assurance and quality control protocols, which (along with the database) have been externally audited.

The annual median groundwater nitrate-N update to 30 June 2025 in Figure 4-1 shows annual median nitrate-N concentrations in PC2-specified “shallow” wells across the Hekeao/Hinds Plains alongside the larger dataset from MHV/HHWET/PC2 “shallow” wells (also screened within 30 m of the water table). Annual rainfall from the Hinds Plains site has been added for context. Rainfall for the 2020/21 and 2021/22 hydrologic years is presented as a complete line (for measured rainfall) and a dotted line (where the 155 mm of rainfall that fell from 29-31 May 2021, is moved to the following year). The dotted line provides a more useful comparison with measured nitrate-N concentrations, as the heavy rain event resulted in significant transport of nutrients through the soil profile, groundwater and surface water systems which were measured throughout 2021/22 and into the 2022/23 hydrologic years.

For the period of dataset overlap (September 2020 to June 2025), the annual median of the PC2-only wells shows greater variation (in terms of differences between annual median of all data) than the larger MHV/HHWET/PC2 “shallow” wells dataset, with both datasets remaining above the 6.9 mg/l PC2 2035 target. The PC2 annual median nitrate-N for 2024/25 was the second lowest for the 2021-25 period (11.0 mg/l), while the larger dataset’s annual median nitrate-N was the highest (10.6 mg/l). The annual medians are calculated from samples collected quarterly. Figure 4-2 presents the median nitrate-N concentrations for each quarterly sample and dataset, alongside the number of wells in each sample (ranging from 8-12 for PC2 and from 44-82 for the larger dataset). The median quarterly nitrate-N concentration of the PC2-only dataset varies by ~5 mg/l, while the median quarterly nitrate-N concentration of the larger dataset only varies by less than 2.4 mg/l.

Various evidence shows that rainfall recharge can be a strong driver of changes in nitrate concentrations in groundwater by transporting available nutrients through the unsaturated zone and groundwater system (e.g., Rutter and Rutter, 2019; CRC, 2023). The nutrient transport time can be measured in nearby wells within days (to weeks) of a rainfall event but can then take much longer (e.g., years to decades) to travel through the catchment to the ocean. There can be significant variability in nutrient transport times, as some pathways (e.g., buried historical river channels) allow much faster nutrient transport than other pathways. Low nutrient water from a MAR or NRR site travels to and through the groundwater system in a similar way, with recharge operations driving this process as well as rainfall events. The travel time (in terms of what is measured at a receptor) is known as the lag time. The water sampled at a particular monitoring site can represent a blend of water that has taken many different pathways and hence will have numerous different lag times. Aquifer recharge (including from rivers, rainfall or MAR), not only results in transport of nitrate stored in the soils and unsaturated/vadose zone, but also increases hydraulic gradients and shortens lag times. These complexities make assessing the relative contributions of on-farm improvements, MAR/NRR, and rainfall to nitrate-N concentration variation in a set of groundwater monitoring wells challenging.

Both datasets in Figure 4-2 show nitrate-N concentration increases in early winter 2021, late winter 2023 and late spring 2024. The Hinds Plains rainfall site records shows that these periods had above average rainfall, including large rainfall events. Nitrate-N concentration increases are usually greater in the PC2 dataset than the larger dataset, as large sample variations are more likely to influence the median value of a smaller dataset than a larger dataset. The larger variation in quarterly values for the PC2 dataset also translates to a larger variation in annual median values, as is evident in Figure 4-1. The introduction of a new monitoring site can also have a disproportionate influence on the median of a smaller dataset, as occurred when a new PC2 monitoring well was added in 2022/23 (with nitrate-N concentrations higher than any other PC2 well). The annual median nitrate-N for the PC2 wells in 2023/24 was 12.3 mg/l with this additional well and 11.7 mg/l without it. The annual median nitrate-N for the larger dataset in 2023/24 was 9.8 mg/l. A five-year moving average for the PC2 dataset has been added to Figure 4-1 to smooth out the annual variations, however this is still 7-14% higher than the larger dataset annual medians so is still less representative of the Hekeao/Hinds Plains “shallow” groundwater nitrate than the larger dataset.

A comparison of annual Hinds Plains rainfall totals in Figure 4-1 shows the 2024/25 year was the third highest since 2006. The rainfall year was characterised by a ~70 mm rainfall event across the upper plains (and 55 mm across the lower plains) in late July 2024 followed by a ~100 mm rainfall event across the upper plains in late October. Rainfall across the lower plains remained well below average from late August to late December 2024. From January to June 2025, rainfall was well above average across the plains with >30mm rainfall events most months. Nitrate-N concentrations in the larger data set presented in Figure 4-2 follow the rainfall events, with a late winter 2024 increase, a more substantial increase to December 2024 (the highest recorded quarterly median yet at 11.1 mg/l) and then high concentrations persisting to June 2025. This combination of three consecutive high concentration monitoring periods led to the highest annual median nitrate-N to date (10.6 mg/l) for the larger dataset, with the number of rainfall events of sufficient intensity to increase nutrient leaching risk likely to have significantly influenced this outcome. As on-farm improvements that result in reduced nutrient leaching risk progress, we can expect to see these nitrate-N concentration peaks reduce.

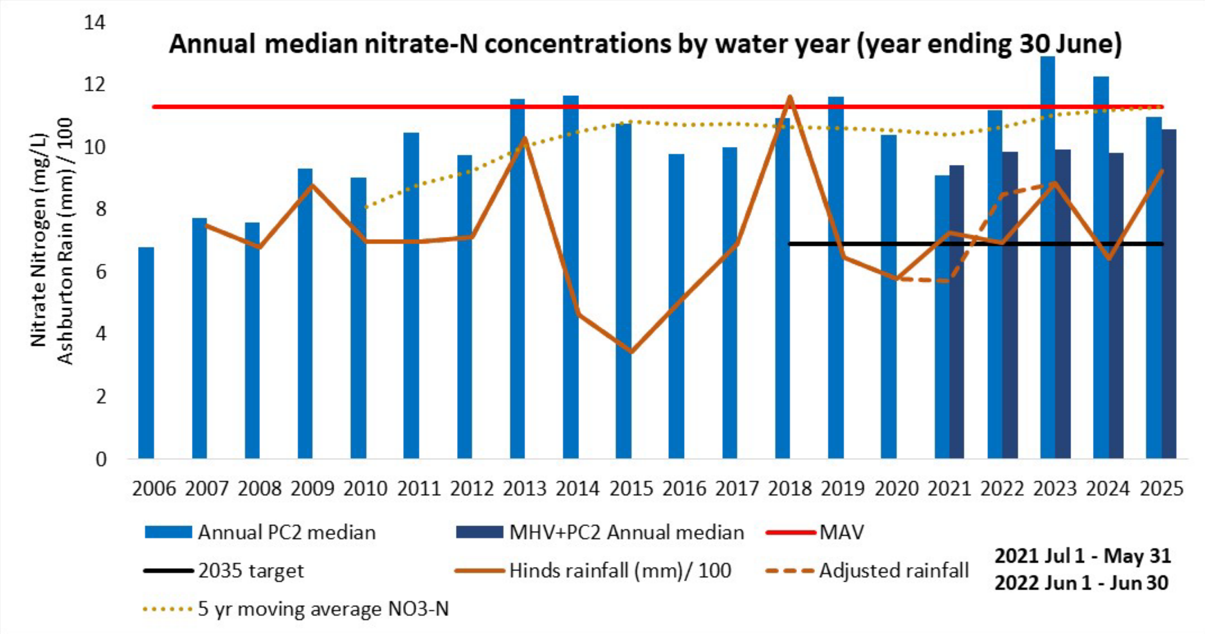

Figure 4-1: Hekeao/Hinds Plains PC2 and MHV Water + PC2 median annual nitrate-N concentrations, plus Hinds Plains annual rainfall (Source: CRC, MHV Water, HHWET)

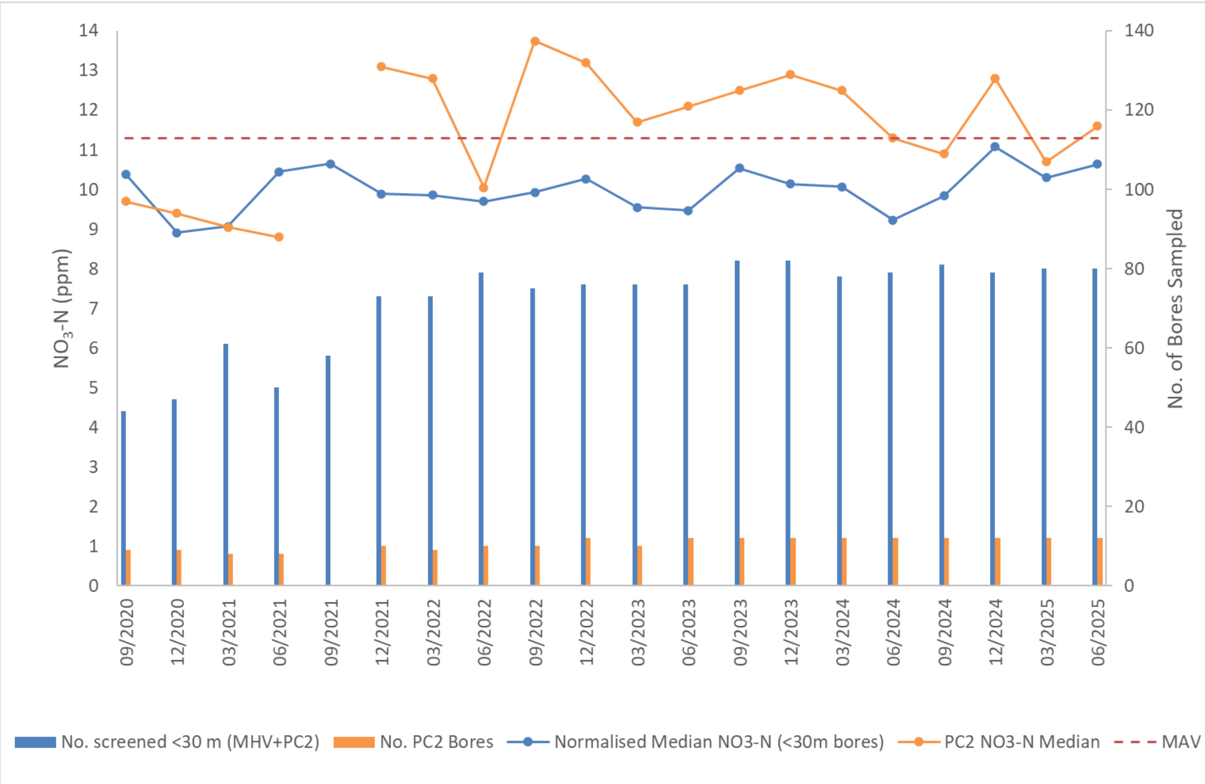

Figure 4-2: 2020-25 Hekeao/Hinds quarterly groundwater nitrate-N monitoring (Source: MHV Water, CRC, HHWET)

4.2 Hekeao/Hinds Northern Drains Surface Water Quality

Consent conditions for MAR01 (Lagmhor MAR Pilot Site) discharge consents require water quality, quantity (flow) and ecology to be monitored in Hekeao/Hinds waterways that are potentially down-gradient. Figure ES 1-1 (Executive Summary) shows several current and potential MAR sites that could assist MAR01 in enhancing ecosystem health in northern Hekeao/Hinds lowland waterways, such as the Flemington and Parakanoi Drains. However, the current lack of MAR discharge consents has meant that only MAR01 could operate in 2024/25, with a delivered volume of 2.25 million cubic metres (equivalent to 71 l/s continuous recharge). As discussed in Section 3.1, this is not sufficient to influence lowland waterways, given the volumes of land surface recharge and groundwater irrigation abstraction in the surrounding catchment. Targeted Stream Augmentation (TSA) has, however, been successfully operating in this area (in Windermere Drain) and could be expanded to other drains where CLWRP rules allow.

Figure 4-3 presents the relevant monitoring sites for the Hekeao/Hinds northern drains. Figure 4-4 to Figure 4-6 present the annual median nitrate-NN concentrations (which are used to assess whether the drains achieve the 6.9 mg/l PC2 target at their lowest monitoring site), while Figure 4-7 to Figure 4-9 present the monthly results (with 95% of monthly samples required to be annually below the 9.8 mg/l PC2 target at their lowest monitoring site by 2035), along with flow and QMCI information where available. In general, Figure 4-4 to Figure 4-9 show that water quality improves from the upgradient springs to the coast on the monitored drains. While it is possible that some denitrification is occurring in these waterways, the most likely reason for this difference is the lower nitrate water from deeper and deeper groundwater that is successively feeding these waterways via springs.

Figure 4-8 and Figure 4-9 (for the Parakanoi and Flemington Drains, respectively) contain significant periods of low or no flow during the dry period from early 2020 to May 2021 as well as a shorter period of no flow during 2024/25. This results in gaps in the water quality monitoring record. Environment Canterbury monitoring at the upper Parakanoi Drain site and both Flemington Drain sites ceased in September 2023. Since then, MHV Water have carried out monthly sampling, initially in the middle of the month but moving to the last week of the month (to align with Environment Canterbury timing) from May 2025. Environment Canterbury have also noted that they have ceased monitoring for QMCI (as of 2025) at the Parakanoi Drain.

Both drains have minimum flow restrictions for irrigation takes (measured at Lower Beach Rd), with trigger levels of 100 l/s for the Parakanoi Drain and 25 l/s for the Flemington Drain. The lowest nitrate-N concentrations in the monthly Parakanoi Drain dataset (Figure 4-8) occurred during the lowest and highest flows. At very low flows, plant uptake and denitrification could be measurably influencing nitrate concentrations, while at very high flows, rainfall runoff can be assumed to be much greater than groundwater discharge via springs.

The Flemington Drain nitrate concentrations (Figure 4-6 and Figure 4-9) were close to achieving the annual and monthly PC2 targets in the 2021 and 2022 hydrological years, although the significant periods of no flow will have had negative ecosystem health consequences. The presented monitoring for Parakanoi Drain shows nitrate and QMCI not meeting their relevant PC2 targets by a significant margin; however, Environment Canterbury records show that a single year of nitrate monitoring in the 2002 hydrologic year met both PC2 targets (with a median of 5 mg/l and 95th percentile of 5.8 mg/l). Multiple stockwater races terminated at or near the drain during this period, providing low nutrient water to balance the higher nutrient spring-fed supply. The New Zealand Freshwater Fish Database (via Canterbury Maps) and Cadwallader (1975) identify multiple historical Canterbury mudfish (Kōwaro) sites near both drains, with only one known site (at Akaunui Farm) still known to have mudfish. Augmentation options for revitalising these ecosystems are being explored.

The Windermere Drain below Boundary Road distributes pumped groundwater supply for the Eiffelton Community Group Irrigation Scheme (ECGIS). As the deep groundwater pumped by ECGIS is lower in nitrate-NN than the spring-fed supply to the Windermere Drain, the nitrate-NN concentrations of the influenced drain reach decrease and the flow increases during the irrigation season. This enhances aquatic habitat during what is usually the most challenging time of the year for ecosystem health (due to lower flows and higher temperatures). The Hinds Drains Working Party recognised the potential of this waterway for ecological and biodiversity values, and proposed instream (removal of fish barriers and creation of riffles/pools) and riparian planting initiatives, which have since been implemented by the Lowlands Catchment Group and CSI Fish and Game. ECGIS have also voluntarily pumped groundwater into the Windermere Drain over and above any irrigation demand (including out of the irrigation season) to maintain drain flows for ecosystem health. This is known as Targeted Stream Augmentation (TSA), with ECGIS TSA activities described in Calder-Steele (2019). TSA activities were further supported by an ECGIS/MPI/HHWET project in 2021 to power one of the ECGIS pumps by a new solar panel array. ECGIS and HHWET then began exploring ways to enhance flows as required year round (including a voluntary minimum flow target of 80 l/s when irrigation supply is not occurring), with the Windermere Drain Enhanced TSA (eTSA) project beginning in May 2024. In late 2024, ECGIS and HHWET agreed in principle to form a joint venture to install a second solar array (powering a key ECGIS pump for irrigation and TSA).

Figure 4-4 and Figure 4-7 show that Windermere Drain nitrate-NN concentrations at Poplar Road and Lower Beach Road are similar except for the dry years (2016 and 2021), when the gaps in the nitrate-NN monthly record and low Poplar Road flows suggest that the drain flow ceased upgradient from Lower Beach Road. The best year on record for annual and monthly nitrate-NN concentrations at the Windermere Drain PC2 monitoring site (Lower Beach Road) was 2024/25, with nitrate-NN in every month below the PC2 95th percentile target (though not collectively low enough to also meet the annual median PC2 target). This is the first achievement of a mid to lower plains 2035 PC2 water quality target. The voluntary 80 l/s minimum flow at Poplar Road was also achieved, except for three days. Figure 4-7 shows that there have been no extended low flow periods in the lower Windermere Drain since January 2021.

Electric fishing was undertaken pre-PC2 in 2015, annually through to 2019 and again in 2023. Native bullies and long fin eel populations increased significantly within the first year after initial removal of fish barriers and creation of riffles/pools, and have continued to prosper (with the highest number of bullies and average longfin eel length in 2023). Trout populations peaked in 2019 at three times the pre-enhancement population. To complement the electric fishing surveys, environmental DNA (eDNA) samples at four Windermere Drain monitoring sites were collected in early December 2024. These samples identified nine distinct species in the lower Windermere Drain, six species in the mid reaches and four in the upper reaches (see Table 4-1). Only six species in total were identified in the waterway prior to these enhancements. The nine species identified equals the highest number of distinct species found across Hekeao/Hinds Plains waterways (also found in the lower Hekeao/Hinds River). A stream health measure based on the eDNA results was also calculated, with good ecosystem health assessed at all sample sites, and the best ecosystem health immediately below the habitat enhancement trial reach near Surveyors Rd.

These results, while highly encouraging, are not the end of collaborative efforts to enhance the Windermere Drain. In interviews to support post graduate research (Calder-Steele, 2019), the most common top priority was “restoration of native species numbers, habitat, and increased biodiversity”. Restoration of the trout population was also supported by many interviewees. The learnings to date are informing the targeting of further enhancements and the successes to date are encouraging on-going collaborative efforts. This project shows that human requirements (e.g., drainage and water distribution) can work with ecosystem requirements, and that challenging ecosystem health targets can be achieved when collaborative efforts are maintained.

Table 4-1: Fish species present in December 2024 Windermere Drain eDNA surveys (Source: Lowlands Catchment Group)

Species	Windermere Drain Monitoring Sites (Upper To Lower)			
	Boundary Rd	Surveyors Rd	Poplar Rd	Lower Beach Rd
Upland Bully	✓	✓	✓	✓
Common Bully	✓	✓	✓	✓
Inanga			✓	✓
Brown Trout		✓	✓	✓
Longfin Eel	✓	✓	✓	✓
Shortfin Eel	✓	✓	✓	✓
Banded Kokopu				✓
Gobies				✓
Koaro / Climbing Galaxiid				✓

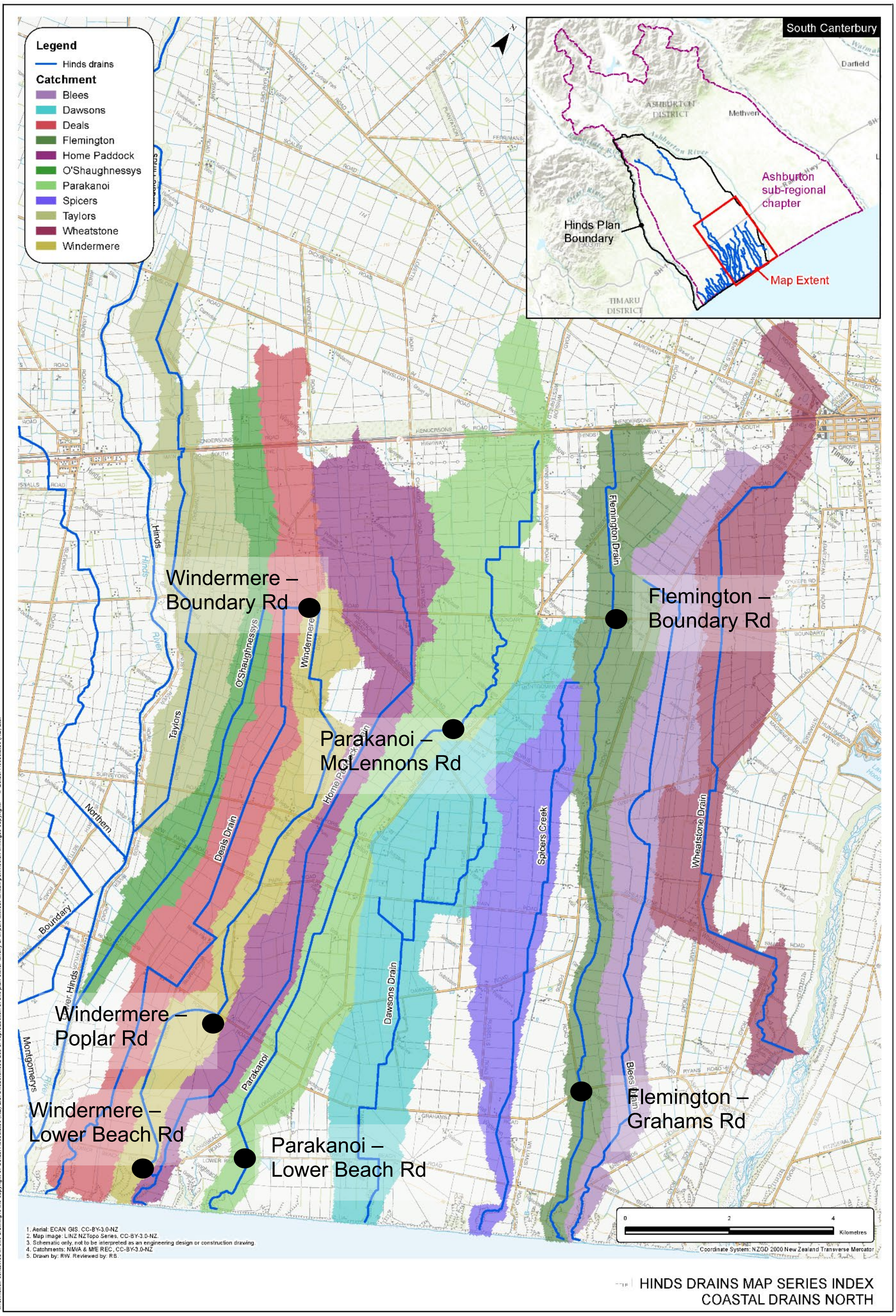

Figure 4-3: Hekeao/Hinds northern drains monitoring sites

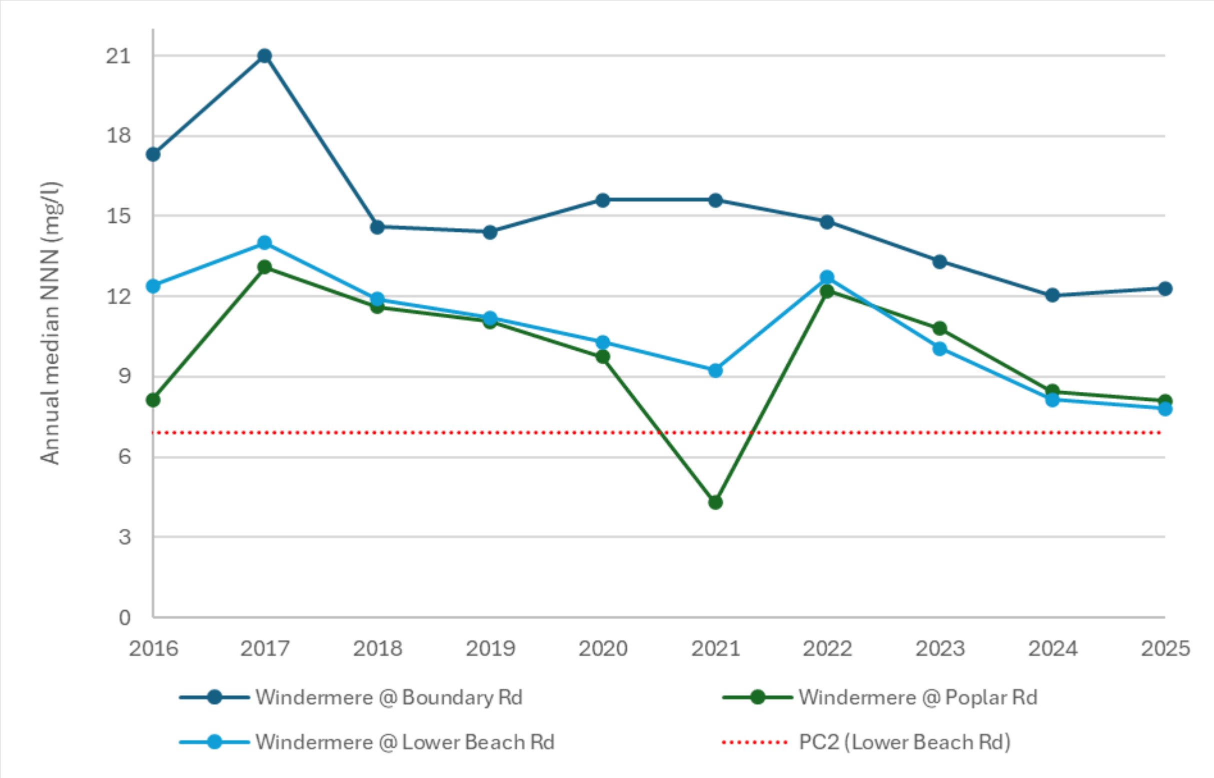

Figure 4-4: Windermere Drain annual median NNN monitoring (Source: CRC, MHV Water)

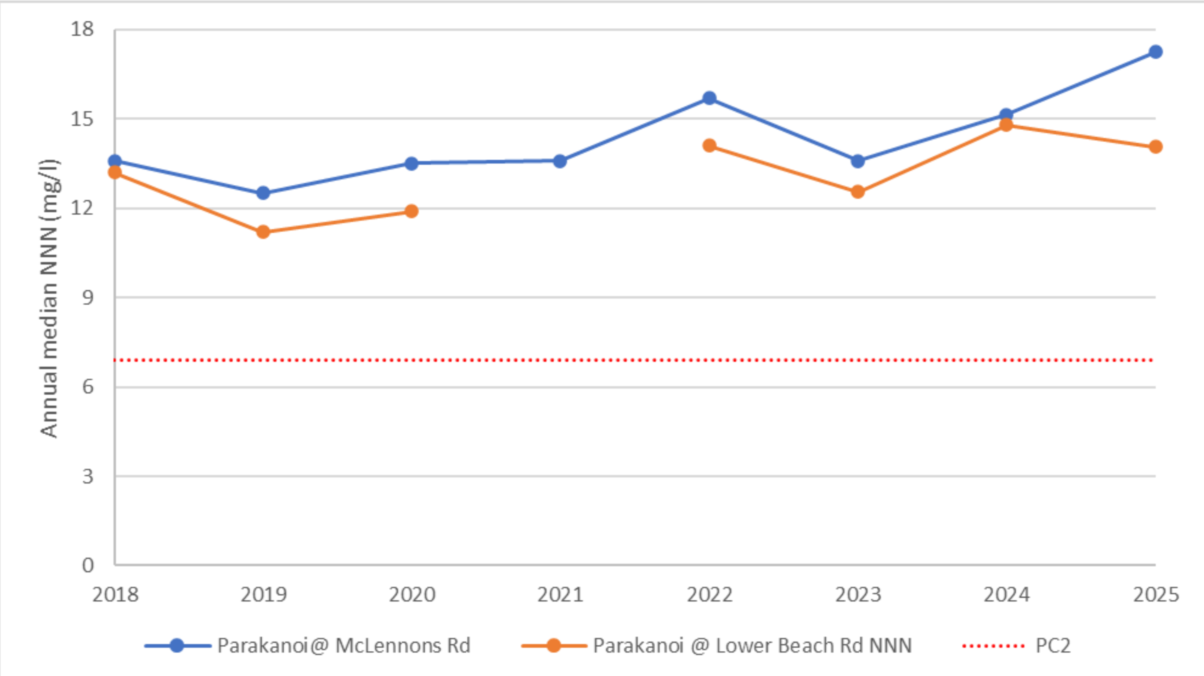

Figure 4-5: Parakanoi Drain annual median NNN monitoring (Source: CRC, MHV Water)

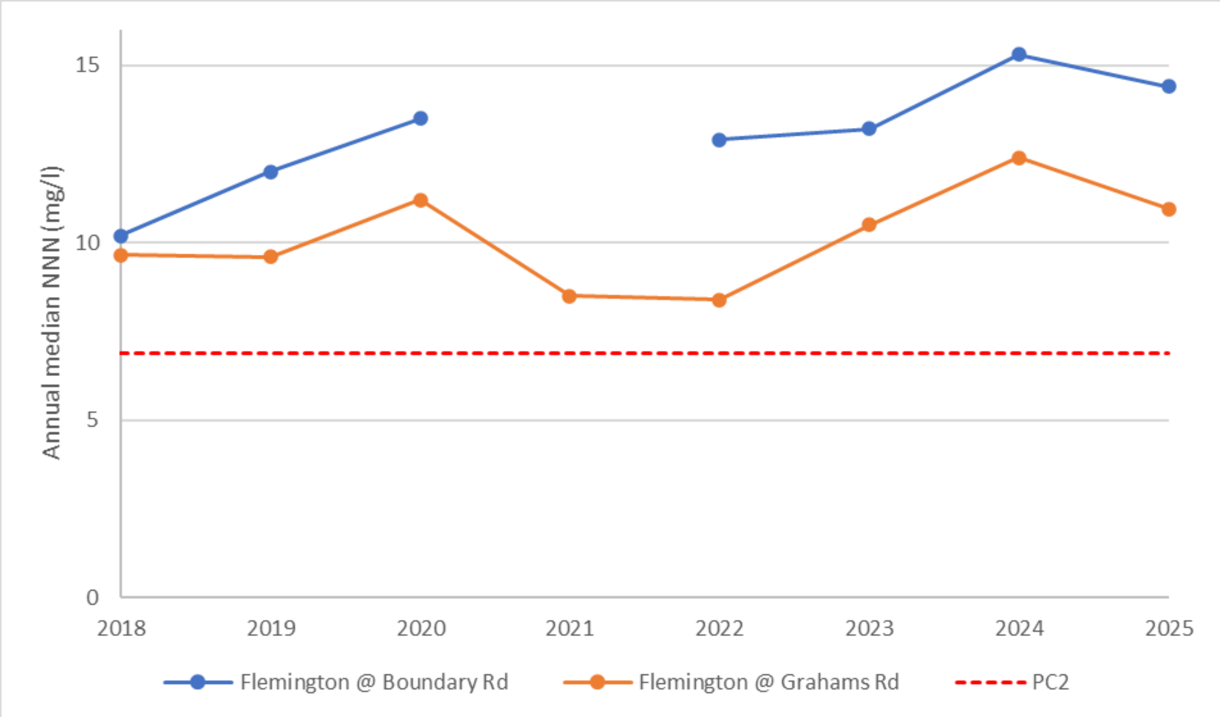

Figure 4-6: Flemington Drain annual median NNN monitoring (Source: CRC, MHV Water)

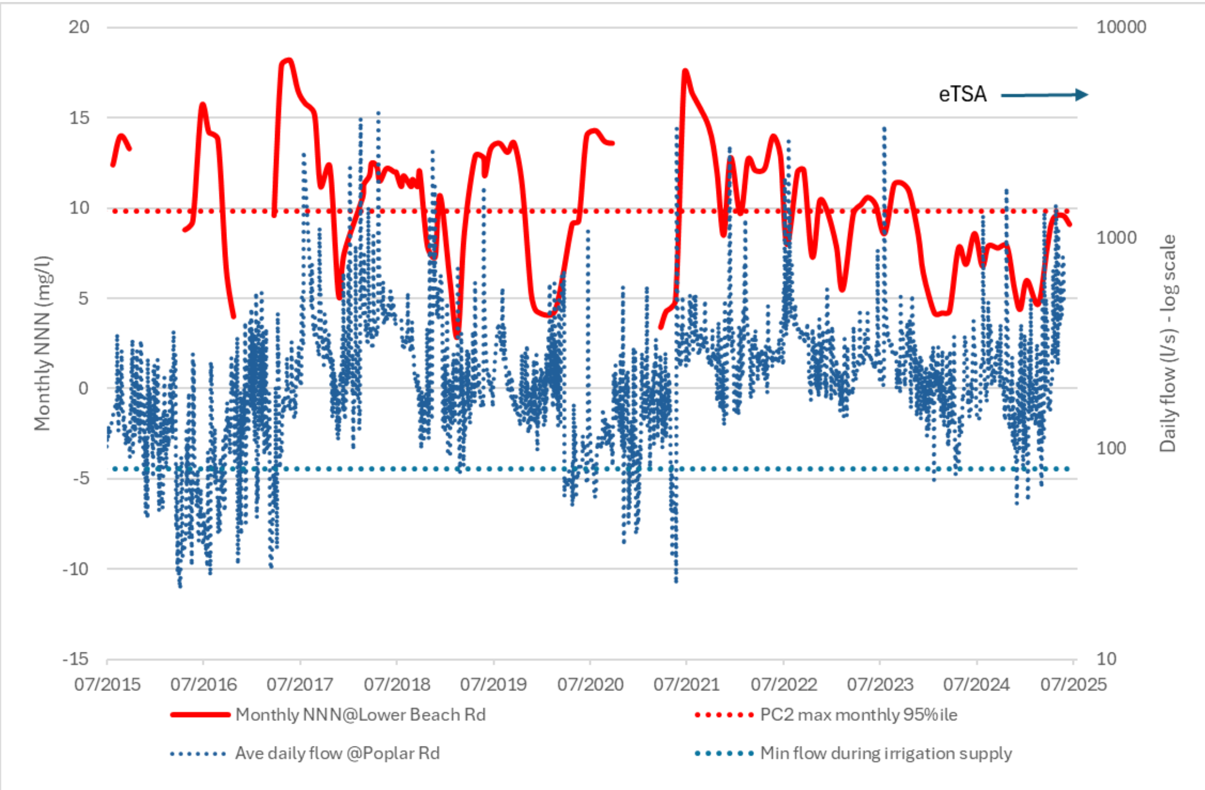

Figure 4-7: Windermere Drain monthly NNN and daily flow monitoring, with the Enhanced TSA (eTSA) project beginning in May 2024 (Source: CRC, MHV Water)

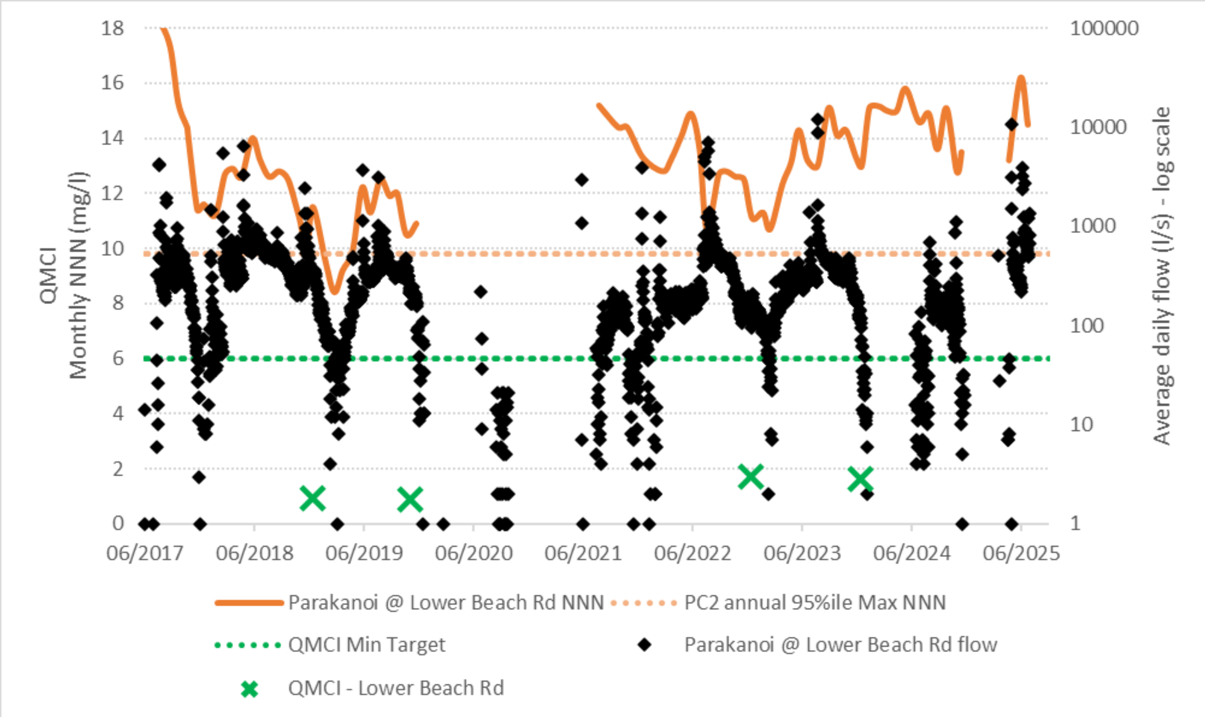

Figure 4-8: Parakanoi Drain monthly NNN monitoring, flow and QMCI (Source: CRC, MHV Water)

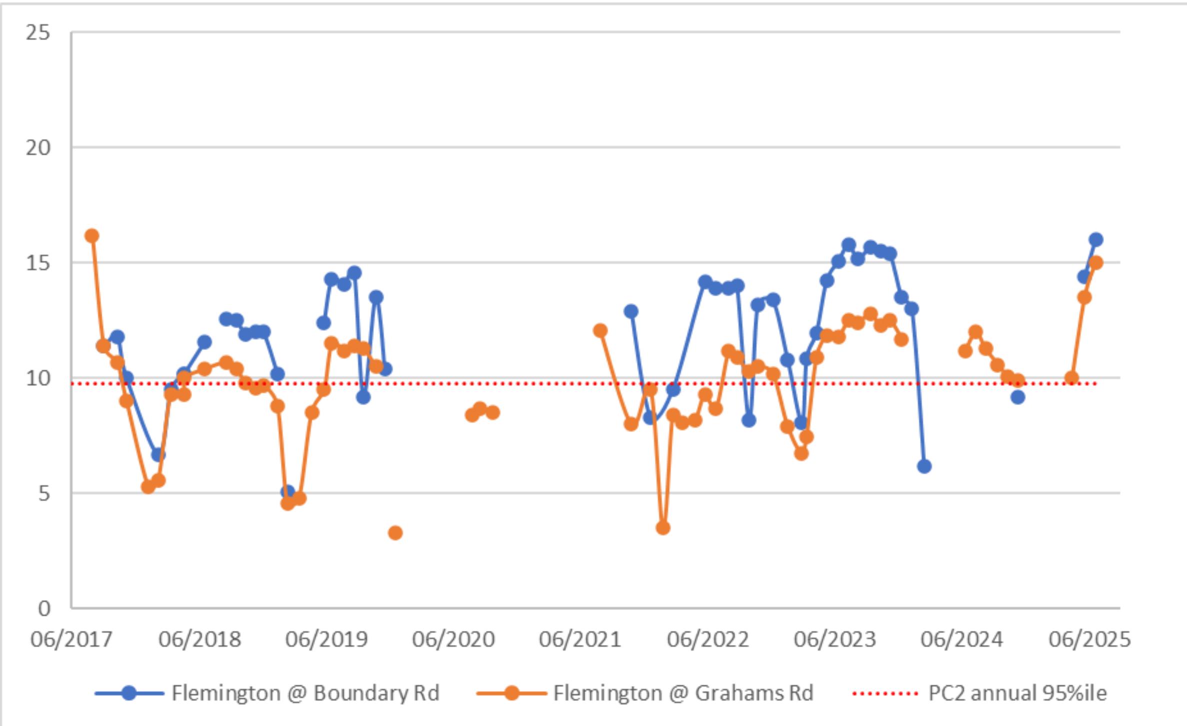

Figure 4-9: Flemington Drain monthly NNN monitoring (Source: CRC, MHV Water)

5 HHWET Objectives and Next Steps

HHWET objectives are set annually in five subject areas. HHWET 2024/25 objectives were met except for those influenced by consenting delays. Year 9 (2024/25) achievements are summarised as follows:

1. Governance

   a. Monthly HHWET meetings took place (except January), attended by HHWET Trustees, Mid Canterbury Catchment Collective representatives, the HHWET Executive Director and contracted minutes secretary.

   b. An annual public meeting and multiple Hekeao/Hinds Science Collaboration Group meetings took place.

   c. HHWET Purposes and Objectives were reviewed and amended for the 2025/26 Business Plan.

   d. A new Deed of Lease with Ashburton District Council (ADC) for MAR01 was confirmed. Deeds of Lease with ADC for MAR21 and MAR22 were also agreed, subject to relevant consents becoming active.

   e. The Updated HHWET Economics report was finalised.

2. Communications

   a. The HHWET website (www.hhwet.org.nz), Facebook page (@HekeaoHindsWET) and LinkedIn page (www.linkedin.com/company/hekeao-hinds-water-enhancement-trust) continued to reach new people.

   b. The HHWET Communications Plan key messaging was reviewed and updated.

   c. Wider communications were achieved through 13 presentations/articles relevant to the wider community, plus 6 presentations/articles relevant to the farming community, and leadership of and/or contribution to 8 wider public communications.

3. Enabling Regulatory Environment

   a. CRC233041, for use of up to 3200 l/s surface water for MAR purposes, supplementary to RDRML consent CRC182542 was granted in April 2025, but appealed in May 2025.

   b. CRC233046, to discharge up to 3255 l/s at up to 34 Managed Aquifer Recharge (MAR) sites (including 14 of the current MAR test sites) was granted in April 2025, but appealed in May 2025.

   c. CRC233851, to discharge up to 410 l/s at Near River Recharge Site #1 (NRR1) was granted in April 2025, but appealed in May 2025.

   d. CRC233852, to undertake works in the bed of the Hekeao/Hinds River (for NRR site construction) was granted in April 2025, but appealed in May 2025.

   e. CRC233853, to discharge up to 200 l/s in total at NRR2 and NRR3 was granted in April 2025, but appealed in May 2025.

   f. CRC234782 and CRC234783 for eClean Bioreactor take, use and discharge was lodged on behalf of Ortongreen Farm in May 2023, granted in June 2024 and activated in August 2024.

4. Access to water

   a. An HHWET-RDRML Water Supply Agreement extension to cover generation shutdown was finalised.

5. Proof of concept

    a. Designs were completed for all priority new MAR/NRR sites.

    b. Upgraded Health and Safety documentation was added to all construction documentation.

    c. Monitoring plans for new and upgraded MAR/NRR sites were completed and accepted by Environment Canterbury's Independent Consenting Officer.

    d. Targeted *E. coli* analysis and discussions took place with catchment groups.

    e. HHWET are a project partner in the trialling of the eClean bioreactor in Hekeao/Hinds. During 2024/25, the required consents were granted, and operations began.

    f. The Windermere Drain Enhanced TSA project with ECGIS resulted in the achievement of the monthly 2035 PC2 nitrate-NN target for the first time.

    g. Madeleine Inglis' (Microbial pathogen risk from MAR) MSc thesis was lodged.

    h. Preliminary design and assessments of effects for three potential lower catchment constructed wetland sites were reviewed, and one site was chosen to progress. Two new constructed wetland sites were then identified. The operating constructed wetland pilot site at Wairuna continued to produce promising nitrate monitoring results.

6. Collaboration

    a. Oversight of the Hekeao/Hinds Science Collaboration Group continued, with local and MPI funding confirmed for the "Missing N" Vadose zone Monitoring System (VMS) project.

    b. Sidinei Teixeira's Master of Water Resource Management (MWRM) thesis titled (*Hydrological drivers influencing nitrate nitrogen changes in an alluvial aquifer*) received first class honours.

    c. Justin Legg's PhD research into *Hekeao/Hinds nitrogen drivers and solutions* produced two peer reviewed papers that were accepted for publication.

    d. 3,000 new native seedlings were planted at MAR01 and maintenance of 17,500 native plantings near MAR/NRR sites continued, which have contributed to the arrival of Australasian Bittern, Marsh Crake, Bellbird, Kingfisher, and White Heron birds near NRR1.

HHWET's next steps were determined in May 2025 by confirming the following objectives through to 30 June 2026, along with a commitment to continue the ICM approach presented in Figure ES 1-1 (Executive Summary) for the achievement of the Hekeao/Hinds Environmental Enhancement Scheme presented in Figure ES 1-2:

1. Governance

    a. Long term agreements in place with Hekeao/Hinds Environmental Enhancement Scheme operators (monitoring and distribution), partners and landowners.

    b. HHWET Purposes and Functions reviewed on an annual basis.

    c. HHWET documentation that aligns with current regulations and requirements.

    d. Annual report and annual accounts externally reviewed on an annual basis.

2. Communications

    a. Communications Plan reviewed and updated on an annual basis.

    b. Communication opportunities identified and actioned (including local organisations, educational institutions, tangata whenua, media, and conferences).

    c. Engage with and inform district, regional and national freshwater processes where relevant.

3. Enabling Regulatory Environment
    a. Long term HHWET Ltd take, use and discharge consents confirmed for a combined maximum MAR/NRR flowrate contribution to the Hekeao/Hinds Environmental Enhancement Scheme of at least 3700 l/s (equivalent to a maximum of 117 million m^3/year).
    b. Consents confirmed for Targeted Stream Augmentation, Constructed Wetland and Bioreactor concepts as required to support Hekeao/Hinds Environmental Enhancement Scheme implementation.
    c. Additional consents and approvals (e.g., construction consents and Flood Protection Bylaw Authorities) secured as required.
    d. Additional permissions (e.g., DOC) secured as required.
4. Access to water
    a. Long term agreements in place with parent consent holders for MAR/NRR supply flowrate of at least 3700 l/s (including a Water Supply Agreement with RDRML for unconstrained water).
5. Proof of concept
    a. Operational MAR/NRR sites in target areas with demonstrated potential to recharge a combined flowrate of at least 2500 l/s (equivalent to a maximum of 79 million m^3/year).
    b. Monitoring Plan reviewed and updated on an annual basis.
    c. Methods of managing bacterial contamination and suspended sediment to reduce MAR/NRR supply shutdowns reviewed and updated on an annual basis.
    d. Hekeao/Hinds Environmental Enhancement Scheme infrastructure in place that provides compliant, safe, efficient, and reliable operation.
    e. Groundwater Irrigation Nutrient Recycling concept actively supported through development and implementation.
    f. Targeted Stream Augmentation concept actively supported through further development and implementation (including implementing the Windermere Solar Array Joint Venture with Eiffelton Community Group Irrigation Scheme).
    g. Constructed wetland and bioreactor concepts actively supported through further development and implementation.
    h. Additional research and development concepts relevant to HHWET Purposes actively considered.
6. Collaboration
    a. Collaborative opportunities actively sought with potentially complementary groups.
    b. Actively engage with stakeholders to ensure strong relationships which foster a high level of trust and collaboration.
    c. Site co-benefits identified and actively implemented on a site-by-site basis, seeking external funding support where possible.
    d. Support (including supervision) provided for tertiary and post-graduate students where their subject matter is relevant to Trust Purposes and Objectives.
    e. Collaborate with local catchment groups in areas of mutual interest and provide technical support as agreed.

f. Collaborate with ADC, local water infrastructure entities and community interests on future management options for Hekeao/Hinds Plains water races.

6 References

Ashburton District Council, 2024, Biodiversity Strategy – Our Natural Place. 40pp. Available at: https://www.ashburtondc.govt.nz/__data/assets/pdf_file/0034/94894/22262-Final-Biodiversity-Strategy-webversion.pdf, accessed on 15 July 2025.

Ashburton Zone Committee, 2014, Ashburton Zone Implementation Plan Addendum, 65p. Available at: https://www.ecan.govt.nz/document/download?uri=2012340, accessed on 15 July 2025.

Cadwallader, P.L., 1975, Distribution and ecology of the Canterbury Mudfish, Neochanna burrowsius (Phillipps) (Salmoniformes: Galaxiidae), Journal of the Royal Society of New Zealand, 5:1, pp 21-30, https://doi.org/10.1080/03036758.1975.10419377, accessed on 15 July 2025.

Calder-Steele, N., 2019, Understanding Eiffelton Irrigation's Targeted Stream Augmentation, Master of Water Resource Management thesis, University of Canterbury, https://ir.canterbury.ac.nz/items/700775fb-ef37-4840-94ac-1e489d7116dd, accessed on 15 July 2025.

Canterbury Regional Council, 2023, "How long will it take?" A summary of information about nitrate time lags in Canterbury, Report R23/02, 41pp, https://www.ecan.govt.nz/document/download?uri=4825996, accessed on 15 July 2025.

Durney, P., 2019, Quantification of the Probable Environmental Effects of the Hinds Managed Aquifer Recharge Trial using Mathematical Modelling and Advanced Uncertainty Techniques, (Master of Science Thesis). University of Canterbury, Christchurch, 136p, https://ir.canterbury.ac.nz/items/f8d5b0d6-7987-4fe7-8c3a-a1089275946f, accessed on 15 July 2025.

ESR, 2019, Transfer of Knowledge and implementation of routine analysis of environmental samples for the presence of naturalised E. coli, prepared for Northland Regional Council, Client Report CSC 19009,https://www.envirolink.govt.nz/assets/Envirolink/Reports/1844-NLRC203.pdf&sa=U&ved=2ahUKEwiYqc3Fj4SQAxUUTGwGHVPvDSsQFnoECAIQAQ&usg=AOvVaw1tVAC1PQxCJ4p1rnR0h0fQ, accessed on 15 July 2025.

HDWP, 2016, Hinds Drains Working Party Recommendations, 411 pp., Available at: https://api.ecan.govt.nz/TrimPublicAPI/documents/download/3024775, accessed on 15 July 2025.

HDWP, 2022, Hinds Drains Working Party Recommendations: 5-Year Progress Review - June 2022, unpublished report, 20pp.

Hekeao/Hinds Water Enhancement Trust, 2020, Hekeao/Hinds Managed Aquifer Recharge Trial Year 4 Annual Report, Available at: https://www.hhwet.org.nz/wp-content/uploads/2024/04/HHWET-Annual-Report-2019-20-FINAL.pdf, accessed on 15 July 2025.

Hekeao/Hinds Water Enhancement Trust, 2021, Hekeao/Hinds Managed Aquifer Recharge Trial Year 5 Annual Report, Available at: https://www.hhwet.org.nz/wp-content/uploads/2024/04/HHWET-Annual-Report-2020-21-FINAL.pdf, accessed on 15 July 2025.

Hekeao/Hinds Water Enhancement Trust, 2022, Hekeao/Hinds Managed Aquifer Recharge Trial Year 6 Annual Report, Available at: https://www.hhwet.org.nz/wp-content/uploads/2023/07/HHWET-Annual-Report-2021-22-FINAL_v2.pdf, accessed on 15 July 2025.

Hekeao/Hinds Water Enhancement Trust, 2023, Hekeao/Hinds Environmental Enhancement Projects: Year 7 Annual Report (2022/23), Available at: https://www.hhwet.org.nz/wp-content/uploads/2024/02/HHWET-Annual-Report-2022-23-FINAL.pdf, accessed on 15 July 2025.

Hekeao/Hinds Water Enhancement Trust, 2024, Hekeao/Hinds Environmental Enhancement Projects: Year 8 Annual Report (2023/24), Available at: https://www.hhwet.org.nz/wp-content/uploads/2024/11/HHWET-Annual-Report-2023-24-FINAL.pdf, accessed on 15 July 2025.

Hekeao/Hinds Water Enhancement Trust, 2025, Annual Compliance Report – CRC210704, CRC210830, CRC210832, 25p.

Ishill, W.B., Hicks, R.E., Sadowski, M.J., 2006, Presence and growth of naturalised Escherichia coli in temperate soils from Lake Superior watersheds, Applied Environmental Microbiology, 72(1), pp 612-621, https://pmc.ncbi.nlm.nih.gov/articles/PMC1352292/, accessed on 15 July 2025.

Legg, J., Mager, S.M., and Horton, S.L., 2025, NO_3-N response domains following a large-scale rainfall event on the Hekeao/Hinds Plains of Mid Canterbury New Zealand, 20pp, Journal of Hydrology, 659, https://doi.org/10.1016/j.jhydrol.2025.133123, , accessed on 15 July 2025.

LWRP PC2, 2018, Plan Change 2 to Canterbury's Land and Water Regional Plan, Available at: https://www.ecan.govt.nz/your-region/plans-strategies-and-bylaws/canterbury-land-and-water-regional-plan/change-2-hinds, accessed on 15 July 2025.

McMurtrie, S., 2020, Canterbury mudfish/kōwaro Management Plan for the South Hinds site: Upper South Branch Hekeao/Hinds River, EOS Ecology Report No. ENV01-20056-02, EOS Ecology, Christchurch.

NZ Drinking Water Standards, 2022, available at https://www.legislation.govt.nz/regulation/public/2022/0168/latest/whole.html, accessed on 15 July 2025.

Rutter, K., Rutter, H., 2019, An assessment of nitrate trends in groundwater across Canterbury: results from a Science Fair project, available at https://www.researchgate.net/publication/341849890_An_assessment_of_nitrate_trends_in_groundwater_across_Canterbury_results_from_a_Science_Fair_project, accessed on 15 July 2025.

Singh, B., Schulze, D.G., 2015, Soil Minerals and Plant Nutrition. Nature Education Knowledge 6(1):1, available at https://www.nature.com/scitable/knowledge/library/soil-minerals-and-plant-nutrition-127881474/, accessed on 15 July 2025.

Stewart, M.K., Aitchison-Earl, P.L., 2020, Irrigation return flow causing a nitrate hotspot and denitrification imprints in groundwater at Tinwald, New Zealand, Hydrol. Earth Syst. Sci., 24, 3583–3601, 2020, https://doi.org/10.5194/hess-24-3583-2020, accessed on 15 July 2025.

Teixeira, S., 2024, Impact of managed aquifer recharge on nitrate concentration changes in an alluvial aquifer, Master of Water Resource Management, 144pp.

Webb, M., 2021, Hinds River fish species monitoring – Update August 2021, Unpublished Memorandum, Central South Island Fish and Game.

Weil, R., Brady, N., 2017. The Nature and Properties of Soils, 15th edition, Pearson Education Inc., Boston, 1071 pp, https://www.researchgate.net/publication/301200878_The_Nature_and_Properties_of_Soils_15th_edition, accessed on 23 October 2025.