



**Hekeao/Hinds Environmental
Enhancement Projects
Year 8 Annual Report**
(June 2023 – May 2024)

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Native fish wetland at Hekeao/South Hinds River NRR1 site in May 2023 (top) and May 2024, showing plant growth during 2023/24 (Source: HHWET)

Chairman's Foreword

This HHWET Year 8 report details the considerable measurable progress the Hekeao/Hinds community has made towards achieving Plan Change 2 to Canterbury's Land and Water Regional Plan (PC2) targets. The HHWET Year 8 activities successfully build on what has been accomplished in our Hekeao/Hinds catchment to date.

It is a privilege and a wonderful opportunity to be able to work with like-minded people on a project that is demonstrating positive environmental gains for our catchment and community.

Hekeao/Hinds Environmental Enhancement Scheme accurately describes the various activities that HHWET promotes; these include Managed Aquifer Recharge, Near River Recharge, Targeted Stream Augmentation, nutrient recycling, bioreactor support, native biodiversity planting, ground and surface water monitoring and wetland promotion. HHWET involvement in these projects is governance, management, operations, promotion and also the support for new initiatives that are showing environmental and/or biodiversity benefits for our catchment.

The HHWET Year 8 report contains data and information that is groundbreaking, and unique to Canterbury and the wider agricultural districts of New Zealand. The Macfarlane Rural Business (MRB) economic analysis contained in the body of the report demonstrates the need and value for money of the HHWET Hekeao/Hinds Environmental Enhancement Scheme.

New Zealanders want clean rivers, streams, and waterways. HHWET clearly demonstrates that this is achievable in the Hekeao/Hinds catchment. In areas of operation, groundwater nutrient levels are reduced to under half of the PC2 required levels, and the water quantity, nutrient levels and river health indices achieved in the Hekeao/Hinds River are showing major improvements year on year.

I would like to sincerely thank all HHWET's partners and contractors for the ongoing support this year. However, it is the Hekeao/Hinds community that that really needs recognition, be it support from Ashburton District Council (ADC), farmers for the on-farm nutrient reductions taking place and supporting HHWET with land for recharge sites, landowners funding this project, and all those providing the expertise to govern and manage the HHWET Hekeao/Hinds Environmental Enhancement Scheme.

Peter Lowe
Chairperson
Hekeao/Hinds Water Enhancement Trust

Acknowledgements

The author wishes to thank the Hekeao/Hinds Water Enhancement Trust (HHWET) for project oversight, Ashburton District Council for access to land and water, Mark Webb (Central South Island Fish and Game) for the fish survey monitoring and analysis, Pattle Delamore Partners for technical 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 TSA Enhancement project, 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. A representative of Central South Island Fish and Game Council is invited to attend meetings and work closely with HHWET as an observer/advisor. 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 environmental 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). These are: on-farm improvements; MAR and NRR for groundwater and river improvements; TSA, bioreactors, and constructed wetlands for spring-fed ecosystems; and managing allocation. This approach is co-ordinated through the Hekeao/Hinds Science Collaboration Group, of which HHWET hold the primary oversight role.

HHWET are contributing to groundwater and surface water ecosystem health via the trialling and implementation of Managed Aquifer Recharge (MAR) and Near River Recharge (NRR) concepts. Additional ecological/biodiversity gains occur in the vicinity of MAR and NRR sites due to land retirement, including native plantings, lizard, bird, and fish habitat. In addition to the MAR and NRR support for spring-fed ecosystems, HHWET are leading and/or supporting the trialling and implementation of Targeted Stream Augmentation (TSA), bioreactor and constructed wetland projects. HHWET are also contributing to 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 2023/24.

The “managing allocation” focus area (Figure ES-1) is about supporting sustainable water allocation, and HHWET’s contribution is to 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.

The reporting of progress towards the above goals focusses on the contribution of the trialled tools to relevant PC2 Targets. Consultation on the new integrated planning process (including the Canterbury Regional Policy Statement and targeted changes to the Canterbury Land and Water Regional Plan) began during the 2022/23 operational year and has continued through the 2023/24 operational year.

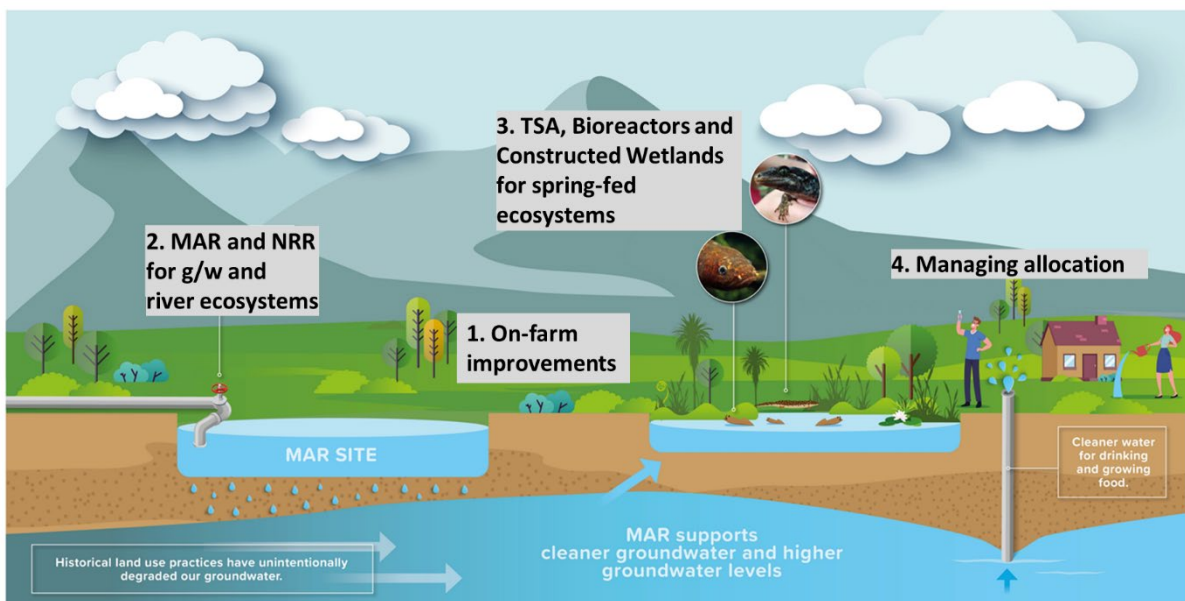


Figure ES-1: Hekeao/Hinds Integrated Catchment Management (ICM) approach.

2023/24 progress:

During Year 8 (2023/24), HHWET continued the project phase that began in 2021 which is funded by a targeted rate to Hekeao/Hinds Plains landowners, through Environment Canterbury's Long-Term Plan. On 26 June 2024, Environment Canterbury adopted their 2024-34 Long Term Plan, which includes continuation of this targeted rate. Arrangements continued with project partners Ashburton District Council (ADC), Rangitata Diversion Race Management Ltd (RDRML), Central South Island Fish and Game (CSIFG), and MHV Water. HHWET Trustees remained the same as 2022/23, though HHWET farewelled Mark Webb (CSIFG) in March 2024 following his retirement as a Fish and Game Officer. HHWET thank Mark sincerely for his contributions over many years and wish him well for his retirement. HHWET met monthly except for January, with meetings focussed on agreements, arrangements, permissions and policies, financial accountability, analysis of evidence, external reporting, and progress toward 2023/24 objectives.

The primary technical focus for 2023/24 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-2). Development of this process has relied on the extensive monitoring and analysis to date. Target areas for Managed Aquifer Recharge (MAR), Near River Recharge (NRR), Targeted Stream Augmentation (TSA), bioreactors and constructed wetlands (BW) have been defined and consent applications lodged for the new MAR/NRR sites (December 2022) and an eClean bioreactor trial (May 2023). A Windermere Drain TSA Enhancement project has begun in collaboration with Eiffelton Community Group Irrigation Scheme (ECGIS), and existing groundwater irrigation consents have been identified for supplementary TSA consent applications. A pilot scale constructed wetland (led by the Lowlands Catchment Group) began operations in 2023/24, and assessments to support larger scale constructed wetland consent applications have progressed.

Potential water requirements for MAR/NRR sites have also been refined and a consent application lodged in December 2022 for the use of up to 3200 l/s of RDRML-consented water. Initial assessments for the Ashburton Zone Implementation Programme Addendum (Ashburton Zone Committee, 2014) which informed PC2 were for a maximum MAR flow of 5 m³/s and an average of 3.8 m³/s. Due to the other high value uses for RDRML-consented water, HHWET have assessed ways of reducing this external water requirement. For the current development phase, this has resulted in a reduction of external water requirements to a maximum combined MAR/NRR flow of 3.7 m³/s, and an average of 2.4 m³/s. An expansion of current TSA, plus successful bioreactor and constructed wetland contributions will be required to compensate for the reduced MAR/NRR provisions. During 2023/24 there have been significant delays in Canterbury Regional Council's processing of HHWET's resource consent applications. The ecosystem health benefits that will occur once the relevant activities are authorised are also therefore delayed.

What we learned:

Key learnings from Year 8 (2023/24) include:

- Analysis methods (equivalent rainfall year comparisons, moving average comparisons and 5 year before/after PC2 comparisons) have been found to be useful methods of presenting water quality and water quantity monitoring information, as they reduce the dominating influence of rainfall on annual statistics (Section 4.1).
- Analysis of LWRP PC2 median annual groundwater nitrate concentrations using the above methods suggests that increases in nitrate-N concentrations peaked around 2015 and have been relatively stable since (primarily following rainfall fluctuations) (Section 4.1).
- When MHV Water/HHWET quarterly water quality monitoring sites are added to the ~12 PC2 monitoring sites, nitrate statistics can be presented for a maximum of 84 shallow groundwater (PC2 definition) sites. Analysis of this dataset shows lower median concentrations and lower

levels of seasonal and annual variation than the PC2 dataset. Due to the larger number of wells and their greater geographical coverage, this expanded dataset provides a more accurate representation of catchment shallow water quality (as defined by PC2) than the PC2 dataset (Section 4.1).

- Median quarterly and annual groundwater nitrate concentrations (as per the expanded dataset) continue to follow rainfall fluctuations, peaking after significant rain events and declining during below average rainfall periods. The only significant rainfall month in 2023/24 was July 2023. Median shallow nitrate-N concentrations in the expanded dataset peaked in Spring 2023 and then declined through to winter 2024, reaching a similar median concentration to Autumn 2021 (prior to the 2021 rain event). The annual (July 2023 – June 2024) rainfall total (634 mm) was slightly below average and not close enough to previous annual rainfall totals to provide a new equivalent rainfall year comparison (previously provided for 2015/16 vs 2020/21 and 2017/18 vs 2021/22).
- Groundwater monitoring in areas influenced by MAR sites continues to show significantly lower nitrate concentrations than both pre-MAR and nearby wells at a similar depth. The key monitoring well 1 km down-gradient from MAR01 (Lagmhor Pilot Site) peaked at 4.7 mg/l nitrate-N in December 2023 after a wet 2023 winter and limited MAR01 operations due to distribution system maintenance. This was its highest concentration since MAR01 operations began. However, by March 2024 the nitrate-N was back within its normal range during MAR01 operations (1-2.5 mg/l).
- Potential MAR influence continues to be monitored in groundwater deeper than 100 m, in a well down-gradient from MAR07. Monitoring of this groundwater will continue so the level of confidence in this analysis can be increased. If confirmed, this would be the first measurable MAR influence in deep groundwater from HHWET activities.
- Hekeao/Hinds River water monitoring and fish surveys show that NRR and MAR sites have supported increased length of flowing reaches, increased flow rates, and improved water quality, which are highly likely to have contributed to increased fish populations. Ecosystem health monitoring of the lower Hekeao/Hinds River suggests that ecosystem health has improved since PC2 and is on track to meet PC2 2035 targets.
- Preliminary results from the Windermere Drain TSA Enhancement project combined with instream and riparian habitat enhancements suggest that this waterway is also on track to meet PC2 2035 targets.

What does it mean?

Monitoring data for Hekeao/Hinds Plains water quantity and quality will continue to be dominated by rainfall variation, but the chosen analysis techniques combined with the increasing number of sites and length of datasets enable the other influences on water quality and quantity to be more visible in surface and groundwater monitoring. Potential influences (on-farm and catchment scale) will continue to be assessed.

The key learnings are consistent with hydrogeological understanding of the Hekeao/Hinds Plains, where on-farm improvements and environmental enhancements are expected to contribute to measurable improvements more quickly in the faster moving Hekeao/Hinds River system and more gradually in the slower moving groundwater system. Groundwater monitoring results down-gradient from MAR sites continue to provide evidence of MAR influences on groundwater quantity and quality, and that increasing the scale of MAR operations toward LWRP PC2 expectations is justifiable, provided the required on-farm improvements also continue according to PC2 targets.

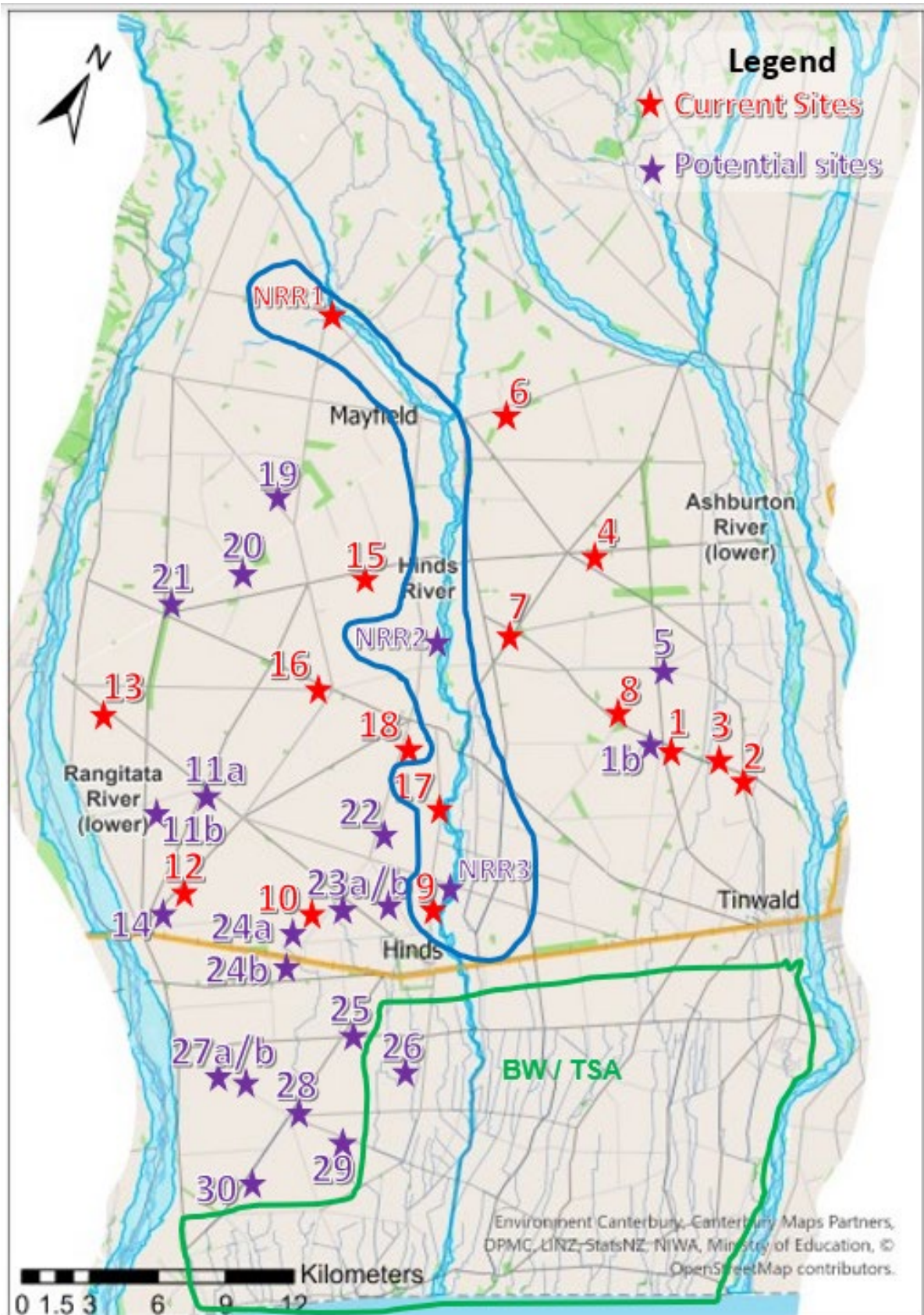


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1 Introduction

Plan Change 2 (PC2) to Canterbury's Land and Water Regional Plan (LWRP) 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 median annual PC2 2035 target for the lower Hekeao/Hinds River is 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 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 during 2023/24 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 target and had 94% of shareholders at Farm Environment Plan (FEP) audit grades of A or better. During 2023/24, the government released a new National Policy Statement on Indigenous Biodiversity (NPS-IB), and Ashburton District Council (ADC) released a new Biodiversity Strategy (ADC, 2024). ADC also released a new community outcome of “A balanced & sustainable environment” (He taiao toitū) in their 2024-34 Long Term Plan, which focuses on maintaining and enhancing the district’s natural environment. 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.”

Table 1-1 shows that the total recharged MAR/NRR volume in 2023/24 (Year 8) was approximately 6.25 million m³. This is the lowest volume since 2018/19. The low annual volume is due to only 2 sites being consented to operate (NRR1/MAR01), with continuation on the remaining MAR sites declined by Environment Canterbury (in January 2023) while HHWET waited for replacement consent applications to be heard. From an operations perspective, a key achievement in 2023/24 was the successful trialling and subsequent approval from Ashburton District Council (ADC) for distribution of MAR01 water down an ADC water race. This enabled MAR01 operations during the peak irrigation season and irrigation off-season when MHV Water pipelines were unavailable due to maintenance requirements. Figure 1-1 shows an increase in delivered volume from June-October compared with the previous two years.

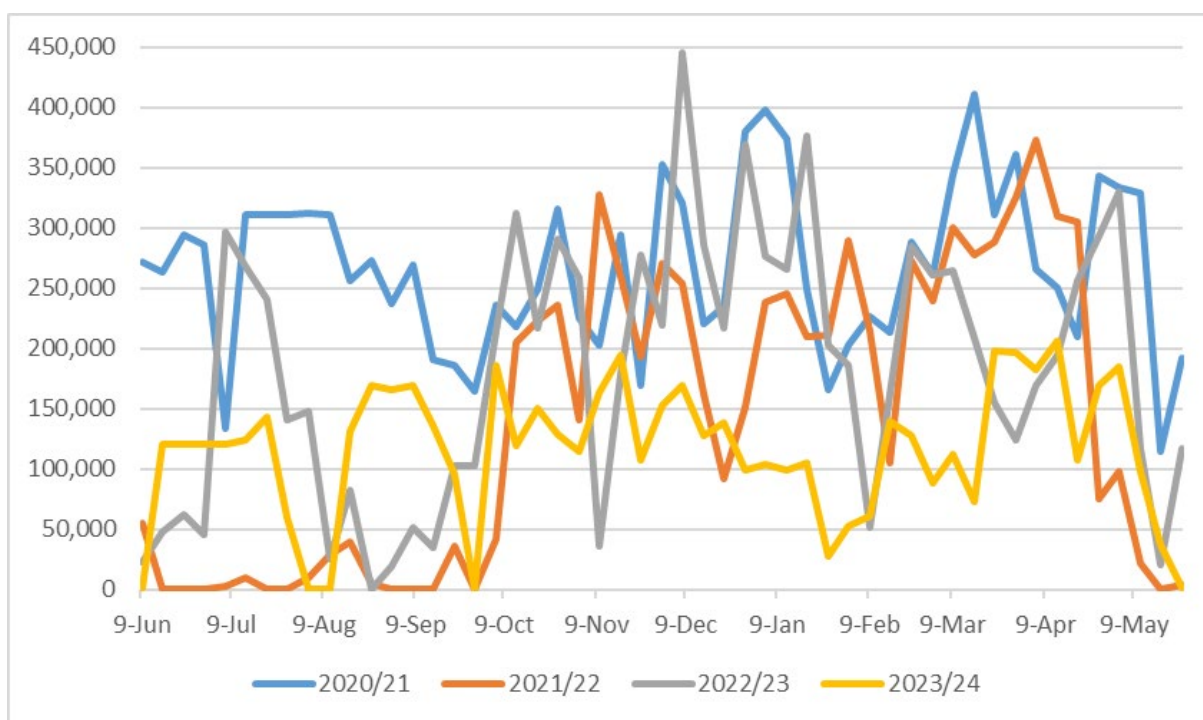


Figure 1-1: Total MAR/NRR weekly volume since June 2020. (Source: HHWET)

Table 1-1: 2023/24 Hekeao/Hinds MAR/NRR recharge

	MAR volume (cubic metres)
Delivered to South Hinds NRR1 Site	4,202,232
Delivered to MAR Pilot Site MAR01	2,049,248
Total 2023/24 recharged flow	6,251,480

The annual median groundwater nitrate-N update to 30 June 2024 in Figure 1-2 shows annual median nitrate-N concentrations in PC2-specified “shallow” wells (screened within 30 m of the water table) across the Hekeao/Hinds Plains alongside the larger dataset from MHV/HHWET/PC2 “shallow” wells. Annual Ashburton rainfall is also provided in Figure 1-2. 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, the annual median of the PC2-only wells shows greater variation than the larger MHV/HHWET/PC2 “shallow” wells dataset, with both datasets remaining above the 6.9 mg/l PC2 2035 target.

Median quarterly nitrate-N concentrations for PC2-specified “shallow” wells and MHV Water/HHWET/PC2 water quality “shallow” wells are presented in Figure 1-3 alongside the number of wells measured each quarter for the overlapping period (September 2020 to June 2024). The median quarterly nitrate-N concentration of the PC2-only dataset varies by ~5 mg/l during this period, while the median quarterly nitrate-N concentration of the larger dataset only varies by less than 2 mg/l. There are up to 12 PC2 wells monitored each quarter; the addition of MHV Water and HHWET “shallow” wells increases this dataset to a maximum of 83 wells. The nitrate-N concentration of the PC2 quarterly samples ranged from 1.8 to 24 mg/l. Analysis of factors influencing the PC2-only well median value from September 2020 to June 2024 showed that variation in the PC2-only well median values was primarily due to the small number of wells, the large concentration variation between samples, the addition or deletion of a monitored PC2 well, and due to well concentrations responding with different lag times to rainfall events. The same wells were included in the larger dataset, but the total number of wells in this dataset was sufficient to smooth these variations.

Various evidence shows that rainfall recharge is a strong driver of changes in nitrate concentrations in groundwater (e.g., Rutter and Rutter, 2019; CRC, 2023). Rainfall recharge events can result in the transport of nutrients through the unsaturated zone and groundwater system. 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. Low nutrient recharged 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 will represent a blend of water that has taken many different pathways and hence will have numerous different lag times. Aquifer recharge (including from rainfall or MAR), not only results in transport of nitrate stored in the soils and vadose zone, but also increases hydraulic gradients and shortens lags 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.

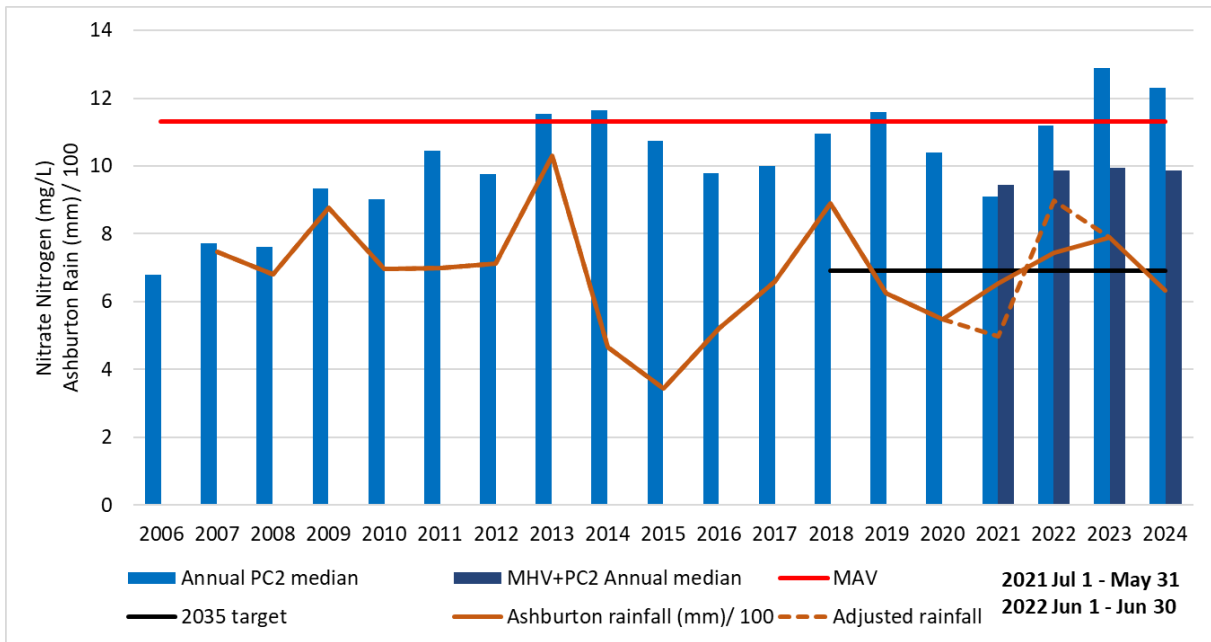


Figure 1-2: Plan Change 2 to Canterbury’s Land and Water Regional Plan (PC2) – Hekeao/Hinds Plains median annual nitrate-nitrogen concentrations plus Ashburton annual rainfall (Source: MHV Water, HHWET, CRC)

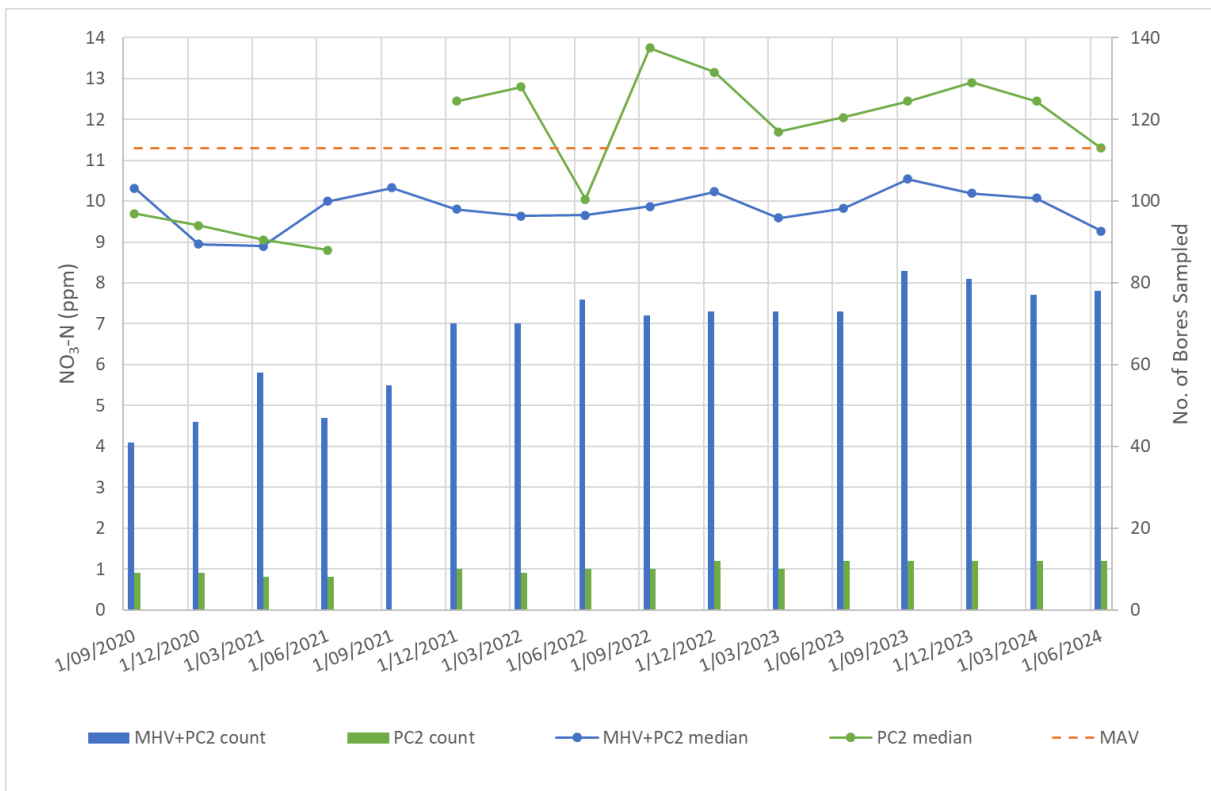


Figure 1-3: Plan Change 2 to Canterbury’s Land and Water Regional Plan (PC2) – Hekeao/Hinds Plains median quarterly nitrate-nitrogen concentrations and quarterly sample sizes (Source: MHV Water, HHWET, CRC)

Previous HHWET Annual Reports (e.g., HHWET, 2023) have presented the 5-year moving average as one way to smooth out annual rainfall variations and provide an annual nitrate concentration trend. Applying this analysis to the annual median PC2 bore concentrations suggests that nitrate-N concentrations increased until 2015 then stabilised (HHWET, 2023). A decreasing trend based on this 5-year moving average is not yet evident. However, the reported on-farm nitrogen leaching reductions

combined with increased MAR volume (when consented) can be assumed to result in a decreasing catchment-wide nitrate trend in the coming years.

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 enhancements HHWET are involved in, which are at an earlier stage of development. Consent compliance monitoring results are presented in the Annual Compliance Report (HHWET, 2024).

Figure 1-4 presents the NRR and MAR sites operational during 2023/24 as well as sites that were constructed but unable to be operated due to CRC declining HHWET’s consent continuance request. Table 1-2 presents the key performance indicators of operational sites. CRC’s consent continuance decline resulted in a reduction from 14 to 2 operational sites, which had a significant impact on total recharge volume and resultant environmental benefits.

Table 1-2: MAR site performance information for June 2023 – May 2024 inclusive (Year 8)

June 2023-May 2024	Maximum weekly ave recharge rate (l/s)	Total recharge volume (m ³)	Weeks in operation	<i>E. coli</i> shutdowns
1 – Lagmhor Pilot	141	2,049,248	37	0
NRR1 - South Hinds	200	4,202,232	50	0

Testing of MAR source water ensures that it is of high quality. Nitrate-N, suspended sediment and *E. coli* are the key source water parameters (as indicators of water quality, recharge site clogging risk and down-gradient drinking water risk respectively). Source water from the Rangitata River remained very low in nitrate-nitrogen (<0.2 mg/l) throughout 2023/24 monitoring, and turbidity was similar to 2022/23. Guidance documents (Golder, 2020; NRMCC, 2009) recommend keeping turbidity in MAR source water less than 10 NTU. Table 1-3 shows that 10% of flow was less than 34 NTU (and therefore less than 10% of flow was less than 10 NTU at the RDR Intake during 2023/24), however turbidity does reduce as the water travels through the distribution system (particularly in water storage ponds). There were no MAR site shutdowns for *E. coli* exceedance in 2023/24, however this is unsurprising as only one MAR site was operational.

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 human health 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). During 2023/24, 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, with further results to be available from mid-2024.

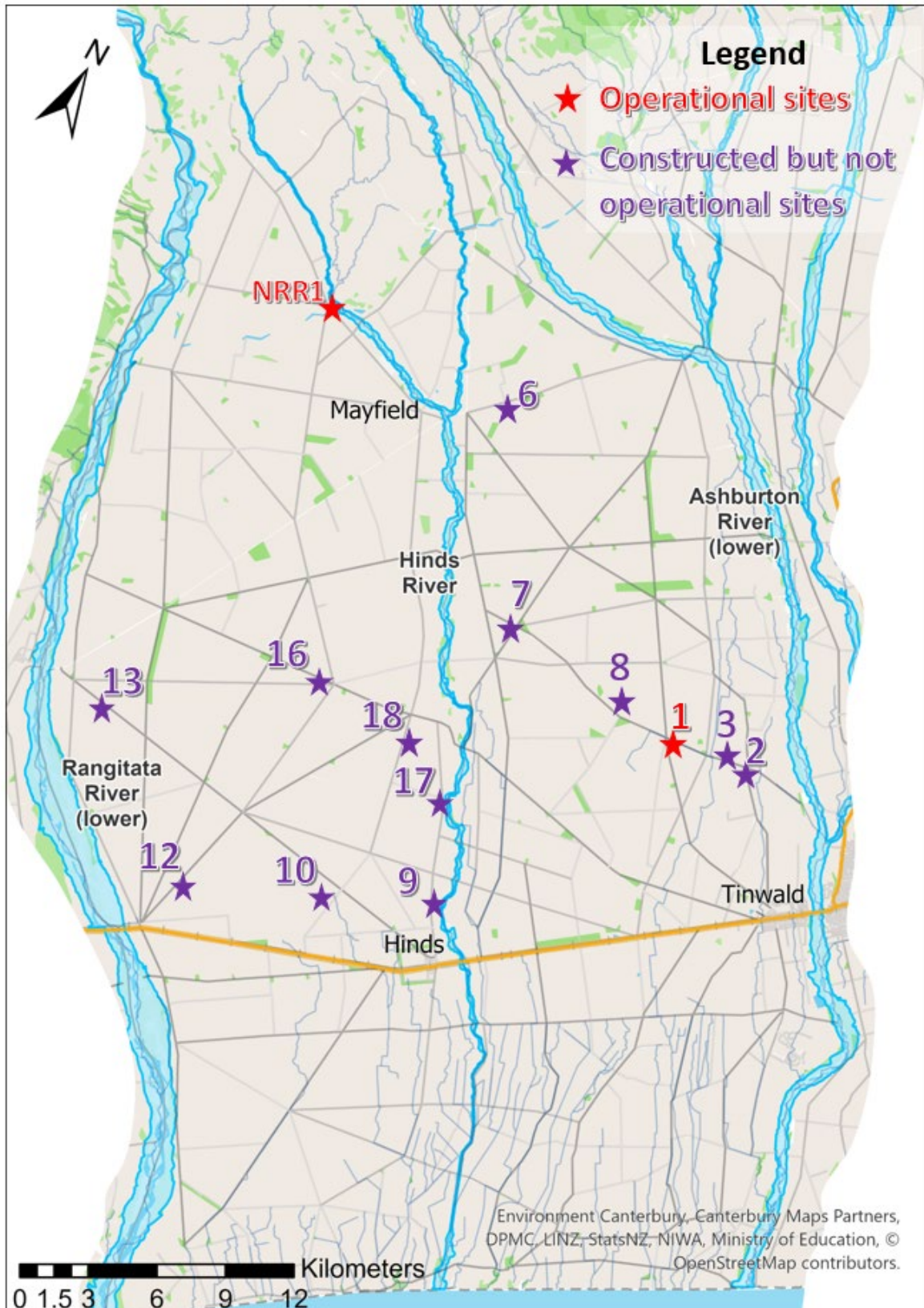


Figure 1-4: Hekeao/Hinds NRR/MAR sites for 2023/24

Table 1-3: RDR Intake turbidity distribution for 2022/23 and 2023/24 (percent of flow less than prescribed turbidity)

Percentile	2022/23 Turbidity (NTU)	2023/24 Turbidity (NTU)
10	28	34
20	31	36
30	33	39
40	38	44
50	47	49
60	60	58
70	84	78
80	138	123
90	345	358
100	2833	2832

2 Hekeao/Hinds River

Chapter 2 of the Year 5 HHWET (2021) Annual Report introduced the Hekeao/Hinds Plains hydrogeology, and the components of the Hekeao/Hinds Environmental Enhancement Scheme focussed on the Hekeao/Hinds River. These components have been chosen for the purpose of trialling potentially complementary ecosystem enhancements for the whole Hekeao/Hinds River system (in combination with relevant on-farm enhancements). 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 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. 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 NRR sites.

Figure 2-1 shows the location of four current and 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 during 2023/24 due to CRC’s decision to decline consent continuance. Assessment and preliminary design processes for NRR2 and NRR3 began in 2021 to support consent applications which were lodged in December 2022. The hearing for these consent applications is expected to be in late 2024.

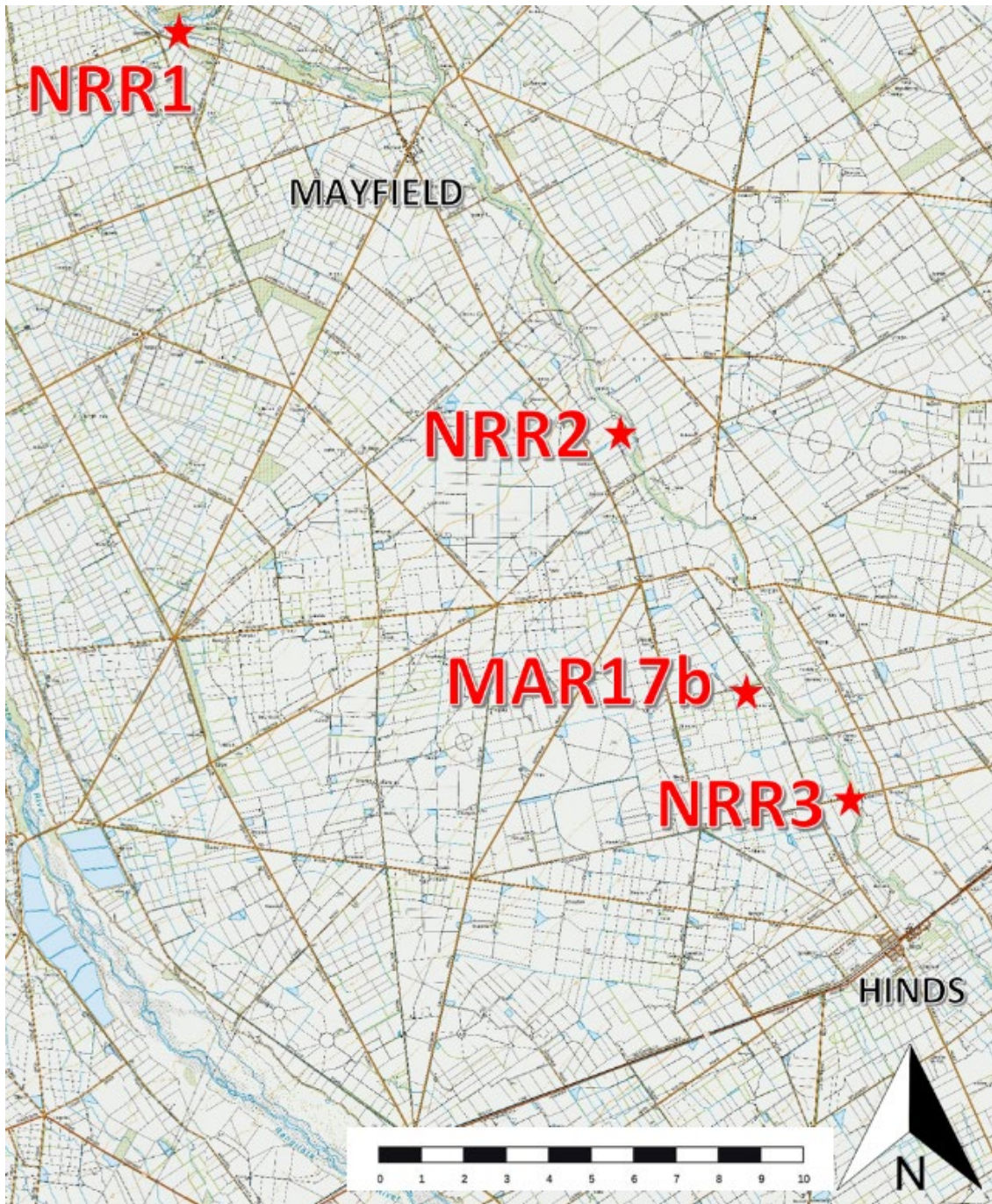


Figure 2-1: Current and potential sites targeting the Hekeao/Hinds River

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 a long-term discharge consent (which was lodged in December 2022). 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 by the landowners and retired, and approximately 17,000 native plants (wetland and dryland)

have been reintroduced, including in two further historic wetlands (Figures 2-3 to 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.

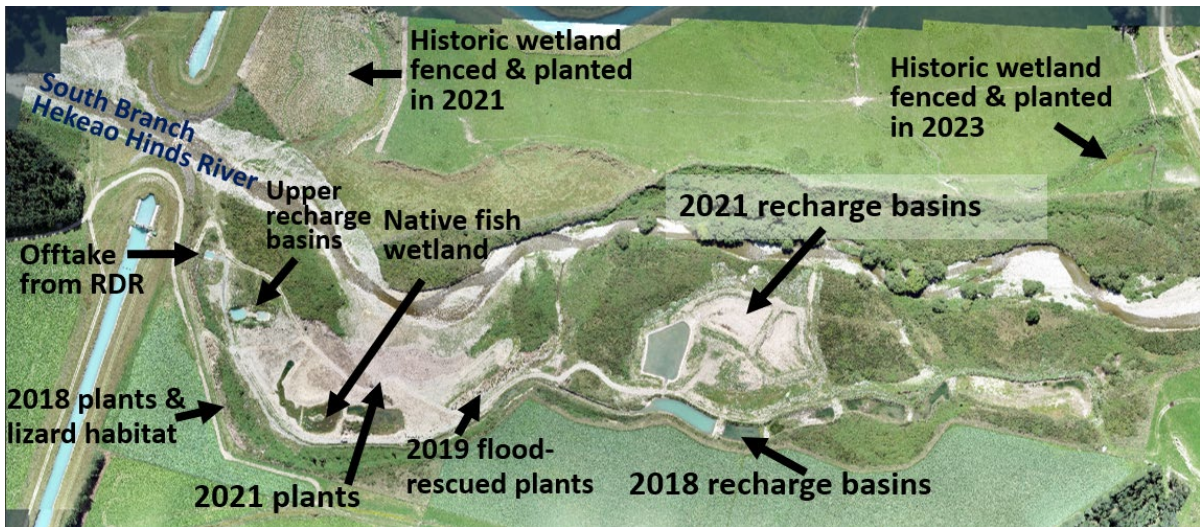


Figure 2-2: NRR1 site overview (2023/24)



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



Figure 2-4: NRR1 2019 planted area, with plants dug out of the May 2021 flood sediment (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 2-9 present the monitoring requirements for NRR1 consent CRC210704, with key compliance monitoring results presented in the annual compliance monitoring report (HHWET, 2024). 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 2-10 present the turbidity and NRR1 flow analysis for 2023/24. Site shutdowns to date for high turbidity in past years have occurred up to 33% of the time, but only occurred less than 10% of the time during 2023/24. A comparison of Tables 1-3 and 2-2 shows that NRR1 intake turbidity is significantly lower than RDR intake turbidity. This is because sediment drops out of suspension at the RDR Sandtrap and in the RDR canal before reaching the NRR1 intake. The NRR1 site is also shut down when there are high flows in the adjacent south Hekeao/Hinds River (>5000 l/s), which, to date, have occurred 1.6% of the time (and on a single occasion in 2023/24, see Fig 2-8).



Figure 2-8: NRR1 during highest South Branch Hekeao/Hinds River flow (25 m³/s) in 2023/24.



Figure 2-9: NRR1 monitoring points (Source: HHWET, July 2021)

Table 2-1: NRR1 Monitoring (CRC210704)

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, <i>E. coli</i> bacteria	Monthly sampled by ADC
	Site groundwater quality	BY19/0107	Nitrate-Nitrogen, <i>E. coli</i> bacteria	Monthly
	Source (recharge) water	Project Discharge Siphon	Nitrate-Nitrogen, <i>E. coli</i> bacteria, Turbidity, TSS	Monthly, except Turbidity which is measured hourly
	River upstream (control)	Site Inflow Source (#SQ35799)	Nitrate-Nitrogen, <i>E. coli</i> bacteria, Turbidity, TSS	Monthly
	River downstream (receiving waters)	Temporary Gauge on South Branch at Lower Downs Bridge	Nitrate-Nitrogen, <i>E. coli</i> 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 1/6/2023 to 31/5/2024 (percent of flow less than prescribed turbidity)

Percentile	Turbidity, 1/6/2022 - 31/5/2023 (NTU)
10	5
20	6
30	6
40	6
50	8
60	13
70	20
80	34
90	89
100	3000

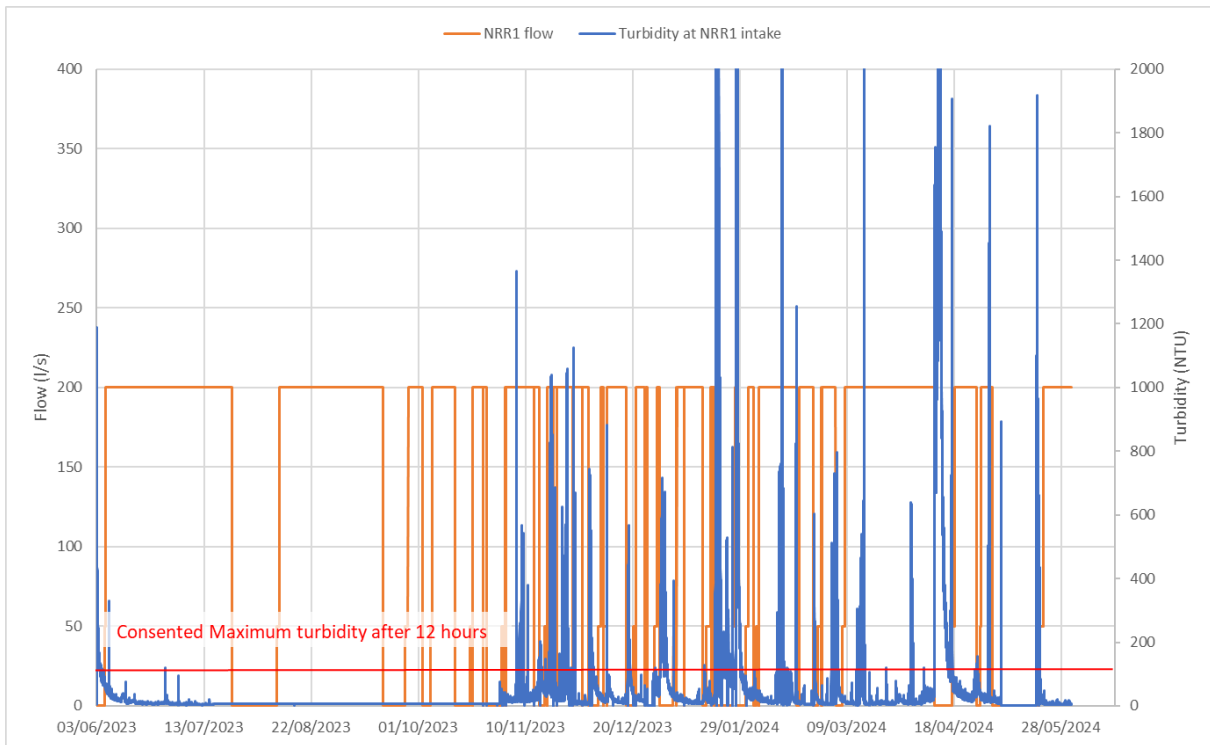


Figure 2-10: 2023/24 NRR1 intake turbidity and flow monitoring (Source: RDRML/HHWET)

2.1.1 Water quantity monitoring

Figure 2-11 compares up-gradient Hekeao/Hinds River flow (RDR Siphon #69101) with NRR1 flow. Down-gradient river flow (Lower Downs #69106) was also monitored until May 2021, when a flood destroyed the flow recorder. This flow recorder has not been re-established. Chapter 2 of HHWET (2021) presented the combined monitoring analysis, which shows significant flow improvements to benefit aquatic life in the influenced South Branch Hekeao/Hinds River reach. Figure 2-11 shows a low flow period above the NRR1 site in spring 2023, followed by an extended low flow period from December 2023 until April 2024.

Figure 2-12 shows the near dry riverbed of the South Branch Hekeao/Hinds River at RDR Siphon in December 2023 and Figure 2-13 shows flows downriver (below the NRR1 recharge basins) on the same day. The December 2023 electric fishing undertaken by Mark Webb (CSI Fish and Game) of a 500 m reach identified many (in the thousands) upland bullies and Canterbury galaxiids, one adult trout with a fresh bite mark from a large tuna/eel and one juvenile trout. With no flow in the up-gradient or down-gradient (as described below and in Figure 2-12) river system for many months from late 2023, these fish would have died, and re-population would be unlikely to occur until sustained flows connected the reach with a populated reach. The concept of managing flows in a river reach with suitable habitat to safeguard fish populations during dry periods is similar to the concept of a castle keep.

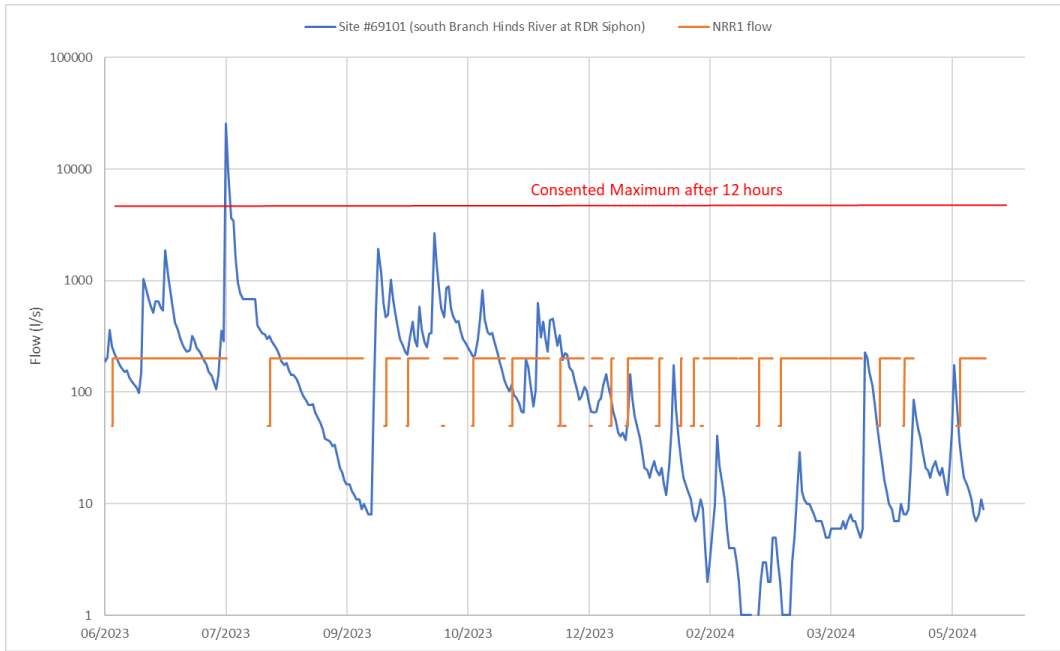


Figure 2-11: NRR1 and Hekeao/Hinds River flow (Source: HHWET, CRC)



Figure 2-12: South Branch Hekeao/Hinds River @ RDR Siphon, December 2023 (Source: HHWET)



Figure 2-13: Mark Webb (CSIFG) electrofishing at South Branch Hekeao/Hinds River below NRR1 site, December 2023 (Source: HHWET)

NRR1 effects on down-gradient surface flow and nearby groundwater are presented in the Year 4 Annual Report (HHWET, 2020). Figure 2-14 presents the location of groundwater wells and flow site #69106, plus minimum depth to groundwater contours in green (increasing with increasing distance from the river). Barrell et al. (1996) suggested that the Montalto Fault line, adjacent to Lower Downs Rd (site #69106), may cause localised controls on groundwater flow, though there is insufficient data collected for this project to assess this. The 2019/20 study presented in HHWET (2020) showed that, for river flows of up to 450 l/s at the Lower Downs Road Bridge (site #69106 - 6 km upstream from the confluence with the North Branch), all flow is recharged to groundwater by approximately 3 km upstream from the confluence. For higher flows, groundwater recharge in this reach is at least 350-450 l/s, with the remainder of the flow retained within the river. The reduced recharge at higher flows is likely due to the higher local groundwater constraining river recharge rates.

Groundwater levels in the shallow (2.3 m deep) well (BY20/0222) respond quickly to increases in Hekeao/Hinds South branch flows at #69106, with subsequent increases in flow in Silverstream, which occupies a lower elevation just north of the Hekeao/Hinds South branch (i.e., river recharge from Hekeao/Hinds South branch feeds Silverstream). Silverstream also receives recharge flow from the Hekeao/Hinds North Branch (when it is flowing) and from Surrey Hills springs. Silverstream provides the only surface flow at the confluence of the Hekeao/Hinds South and North Branches during low flow

conditions, and during these periods, NRR1 flow can therefore be expected to measurably increase Silverstream flows as well as the Hekeao/Hinds South Branch immediately below the NRR1 site. To improve related ecological/biodiversity values, key reaches of Silverstream have had their banks planted, which will decrease water temperature (via shading) and improve riparian habitat for birds and insects.

The 2020 study also considered NRR1 recharge effects to the true right of the South Branch Hekeao/Hinds River via analysis of the four wells presented in Figure 2-14. Of these wells, K37/0278 is shallow (16 m deep) while the other three are deep (84 to 145 m deep). K37/0278 was found to respond quickly (within days) to freshes of greater than 500 l/s (Figure 2-15a); that is when the Hekeao/Hinds South Branch is expected to be flowing down to its confluence with the North Branch. When only Silverstream is flowing, K37/0278 still shows small fluctuations, suggesting that Silverstream also influences shallow groundwater in the vicinity of the Hekeao/Hinds River confluence. Figure 2.15b 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. This evidence suggests that K37/0278 groundwater levels are positively influenced by NRR1 recharge, particularly during low rainfall periods.

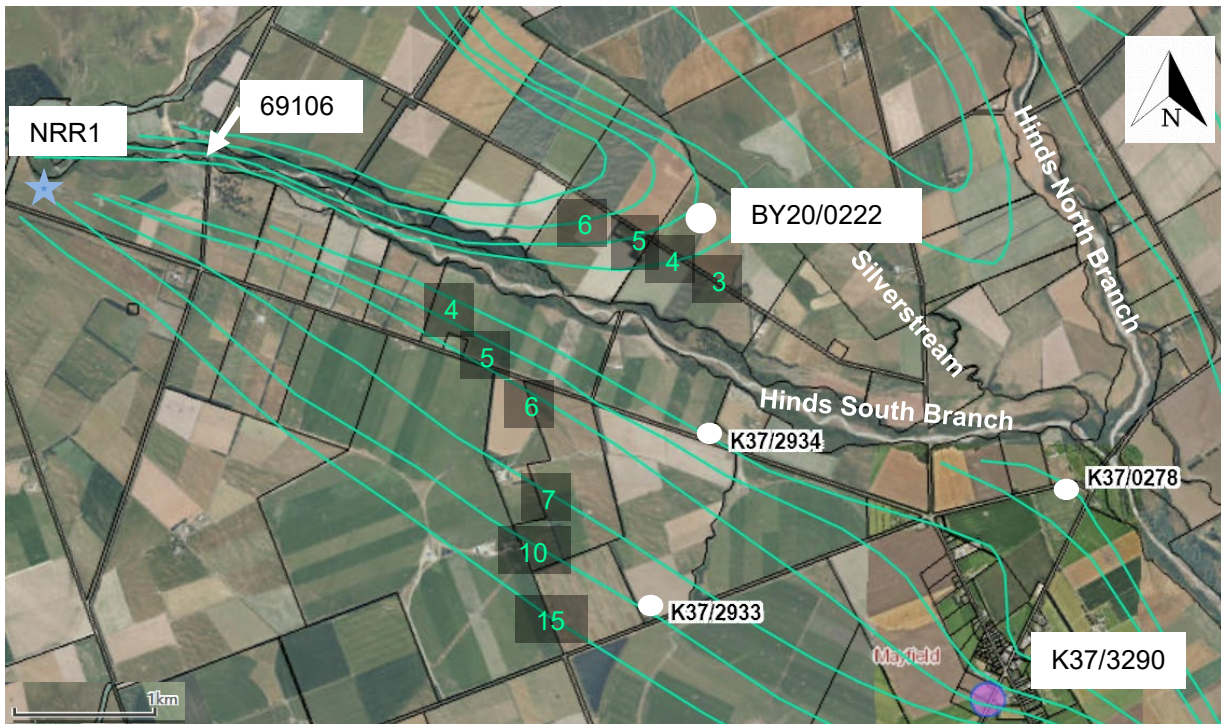


Figure 2-14: NRR1 down-gradient monitoring wells and minimum depth to groundwater contours (in m) (Source: Canterbury Maps)

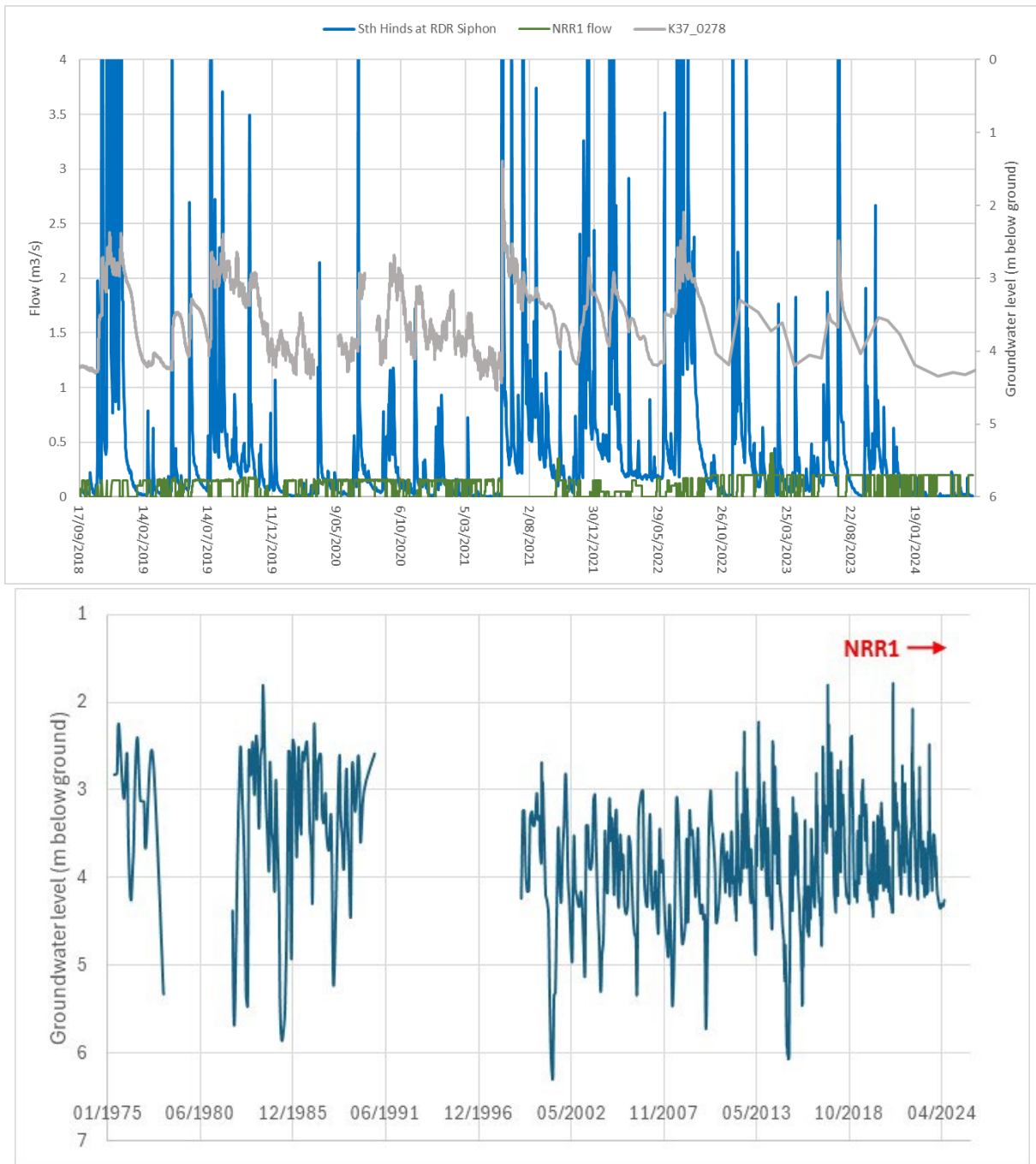


Figure 2-15 (a/b): K37/0278 water level with NRR1 flow and Hinds River flow (a) (Source: HHWET, CRC)

Figures 2-16 and 2-17 compare South Branch Hekeao/Hinds River flows (up to 4 m³/s) at the RDR Siphon (up-gradient from NRR1), NRR1 flow, and depth to groundwater in well K37/2934 and K37/3290 (the Mayfield community supply well). These deep (145 m and 119 m deep respectively) wells show a delayed, damped response to major rainfall events (assuming the rainfall influencing these river flows as presented in Figures 2-16 and 2-17 also provides local land surface recharge) and declining levels at other times. In addition, K37/3290 shows significant daily variations in response to pumping. During the 2015/16 drought the groundwater levels in this well dropped approximately 25 m (from a high in 2014 to more than 119 m below ground level). This evidence suggests the wells are in an aquifer with groundwater level changes primarily determined by significant and sustained weather events and long-term weather patterns.

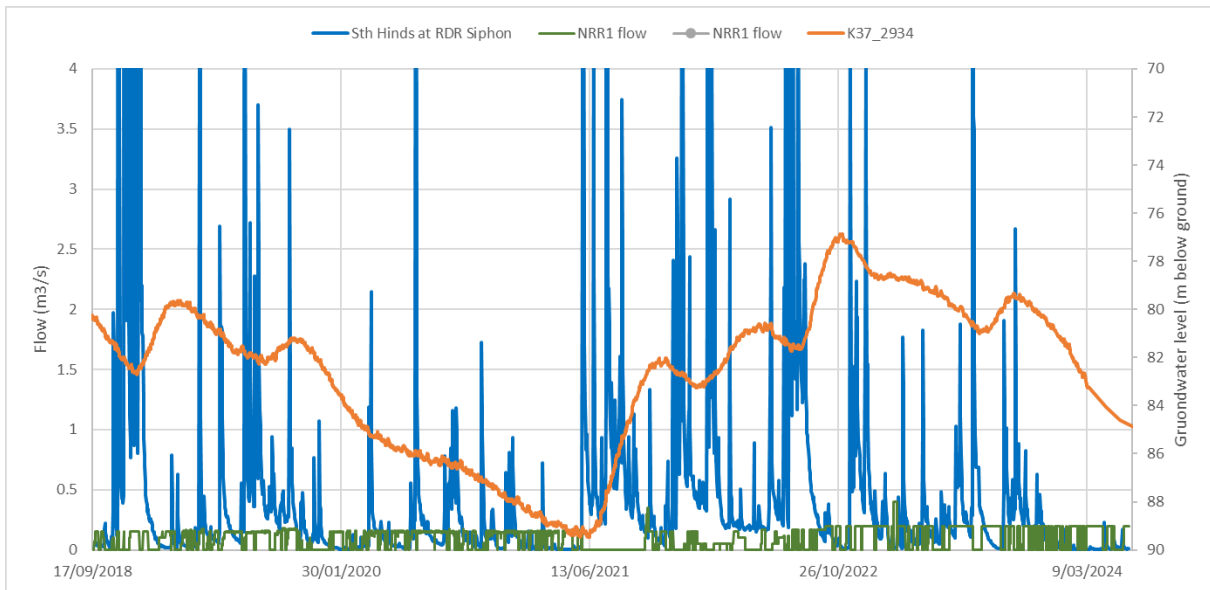


Figure 2-16: NRR1 flow, Hekeao/Hinds River flow and K37/2934 groundwater level (Source: HHWET, CRC)

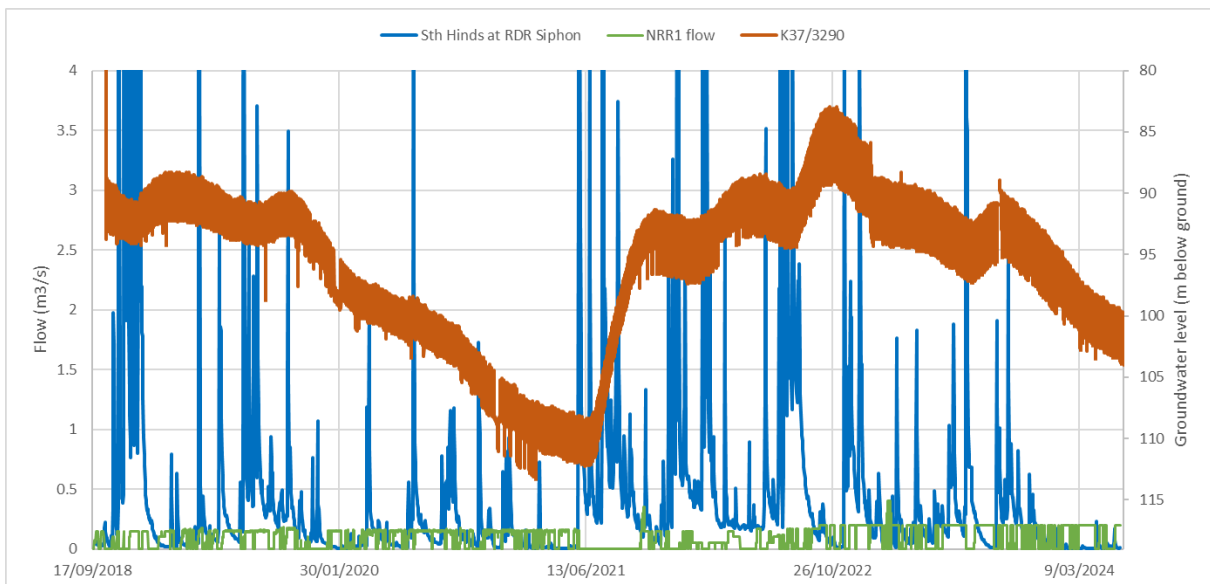


Figure 2-17: NRR1 flow, Hekeao/Hinds River flow and K37/3290 groundwater level (Source: HHWET, CRC, ADC)

2.1.2 Water quality monitoring

The key concerns with regards to source water quality are *E. coli* and nitrate-N. (The advice note for discharge consent CRC210704 required consideration of an *E. coli* and a nitrate source water trigger level for site shutdown following its first year of operation, to ensure protection of the receiving environment). The Year 4 (2019/20) report results (HHWET, 2020) showed that high quality water was being recharged and therefore *E. coli* or nitrate trigger levels for site shutdown were not required, and hence these are no longer monitored. Year 4 (2019/20) analyses showed that water quality in BY19/0107 (6 m deep, see Fig. 2-9 for location) is more representative of nearby river water than NRR1 source water. Therefore, for the proposed replacement NRR1 discharge consent, groundwater monitoring has been moved to BY19/0108, which is situated down-gradient from the upper recharge basins. Although likely unconnected with the NRR site, it is noted that Nitrate-N in the Mayfield community well (K37/3290) has gradually increased from ~2 to ~3.5 mg/l since 2015.

In the up-gradient river reach (as measured at RDR Siphon, at Site #69101), nitrate and *E. coli* was shown to increase after rain events. These increases could be due to overland recharge, local tributaries, and tributaries further up-river. To minimise the potential contribution of nearby Gawler Downs tributaries to potential increases in contaminants (these tributaries entering the South Branch Hekeao/Hinds from the true left, between the RDR siphon and the Lower Downs Bridge), paddocks containing historic wetlands at the base of the tributaries have been fenced off, stock are excluded, and native plants introduced to filter sediment, uptake nutrients and reduce bacteria. The upper site (1.5 ha) was planted in October 2021, and the lower site (1 ha) planted in Autumn 2023 (see Figures 2-6 and 2-7).

2.1.3 Aquatic ecology monitoring

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, along with CRC, implemented monitoring surveys in 2017. Surveys comprise an assessment of fish diversity and abundance by electric fishing at two sites in the lower river, one mid-river site below State Highway 1 (SH1), and one upper river site downstream from the NRR1 site (as detailed in Table 2-1 under aquatic ecology monitoring). 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 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 2-18 shows a step change in upland bully and Canterbury galaxias populations since NRR1 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 marks, found 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.

Additional aquatic ecological monitoring was initiated 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 Dynes, 2020 and HHWET, 2020). A catchment group that includes the upper South Branch and North Branch Hekeao/Hinds River and their tributaries has been undertaking additional monitoring since 2023, using this monitoring to guide additional catchment enhancements such as fencing, planting, land management and land retirement. Further improvements in river ecosystem health can therefore be anticipated in the future.

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/kōwāro. 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 CRC and Central South Island Fish and Game staff identified more than 2100 upland bullies in the three NRR1 wetlands.

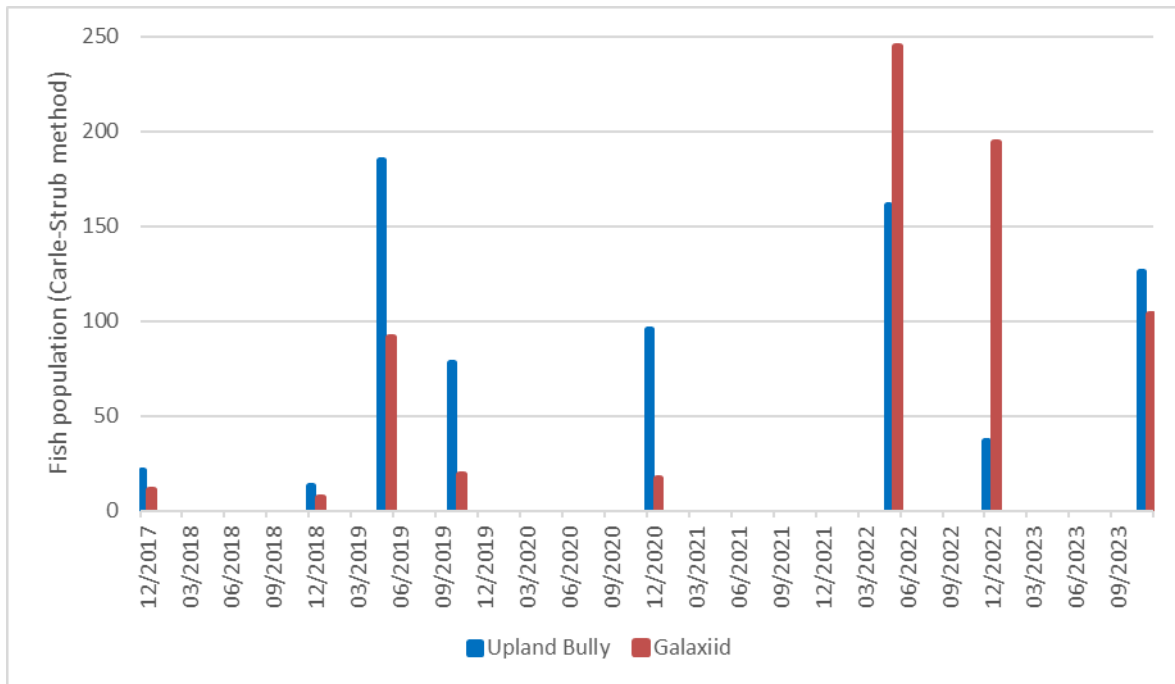


Figure 2-18: Hekeao/South Branch Hinds River at Lower Downs Rd Bridge, annual fish population estimates per 30 lineal metres, 2017 – 2024 (Source: Central South Island Fish and Game)

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 2-19). Water quality and quantity at the Hekeao/Hinds River at 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.

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. 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 are 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, CRC 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 2-19, with Hekeao/Hinds River flow (at Poplar Rd), quality and ecosystem health analysis (at Lower Beach Rd) presented on Figures 2-20 and 2-21. Ecosystem health is represented by QMCI (Quantitative Macroinvertebrate Community Index) in Figure 2-20. 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 (NNN), with Figure 2-21 showing that the 95 percentiles for the last two years have been the best since 2012. For a general assessment, we compared the most recent 5 year averages with the preceding 5 year averages (before and after PC2 enhancements). Rainfall was 10% higher in the most recent 5 year period, which is unlikely to be sufficiently different to measurably influence results. The 5 year comparison shows a 12% improvement (decrease) in nitrate-nitrite-nitrogen (NNN) concentration, an 8% improvement (increase) in QMCI and a 108% improvement (increase) in 7-day Mean Annual Low Flow (the lowest 7-day average flow for each 5 year period).

In winter 2024, MHV Water commissioned 6 eDNA (Environmental DNA) sample replicates for the Hekeao/Hinds River at Lower Beach Road. The median TICI (Taxon-Independent Community Index) score of 109.73 is just below the 'Excellent' ecosystem health category (110.0), and is consistent with recent QMCI results. TICI is an alternative ecosystem categorisation method to QMCI that can be calculated directly from an eDNA sample.

A comparison between annual rainfall and NNN in Figure 2-21 suggests that cumulative rainfall has a strong influence on water quality. On this basis we attempted a more detailed comparison between years of similar annual rainfall using monthly values in Figure 2-20. 'Wet' year comparisons were undertaken between the July 2017 – June 2018 (2017/18) and July 2021 – June 2022 (2021/22) monitoring results, while 'dry' year comparisons were undertaken between the July 2015 – June 2016 (2015/16) and July 2020 – June 2021 (2020/21) results (see annual rainfall totals in Figure 2-21, noting that the rainfall event beginning 31 May 2021 has been shifted to the July 2021 – June 2022 hydrologic year).

For the 'wet' year comparison, the median 2021/22 NNN concentration was 14% better (lower) than 2017/18 and the 2021/22 QMCI was 92% higher (better) than the 2017/18 value (and very close to the PC2 target).

For the 'dry' year comparison, we focussed on low flows; the key flow statistic is the 7-day Mean Annual Low Flow (MALF), which was 81 l/s in 2015/16 and 164 l/s in 2020/21. The 620 l/s maximum potential flow contribution from NRR and MAR sites during this period is expected to have been a significant contributor to this increase (see HHWET, 2021). The median NNN was 7% lower (better) in 2020/21 than in 2015/16, however the QMCI was the opposite, being 14% higher (better) in 2015/16 than 2020/21. Low flows negatively affect QMCI, and the healthier winter flows in 2015 compared to 2020 are expected to have contributed to this difference at the time of QMCI assessment. However, the extreme low flows after the 2015/16 QMCI assessment will likely have reduced ecosystem health and fish survival until flows increased again.

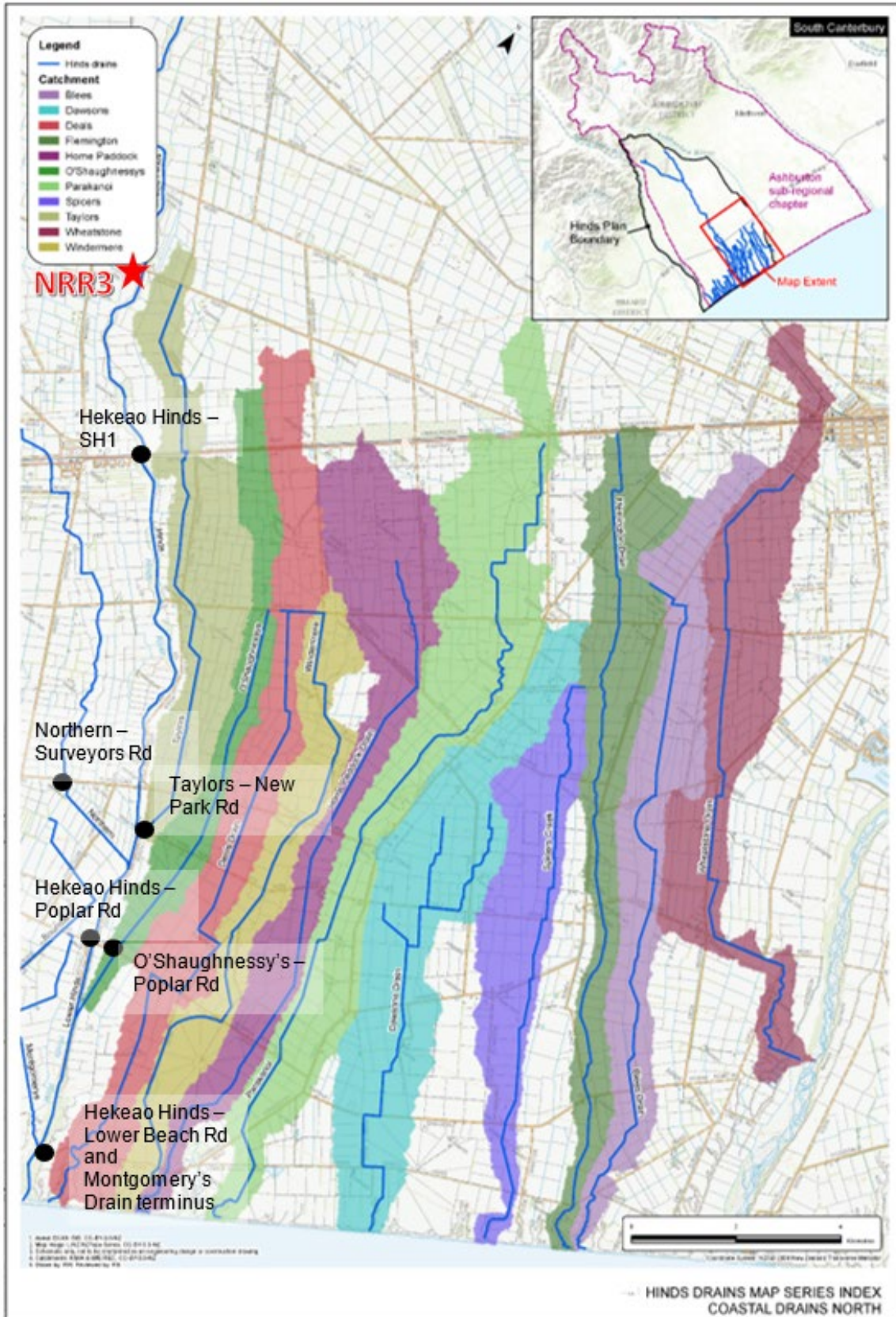


Figure 2-19: Hekeao/Hinds River monitoring sites (Source: HDWP)

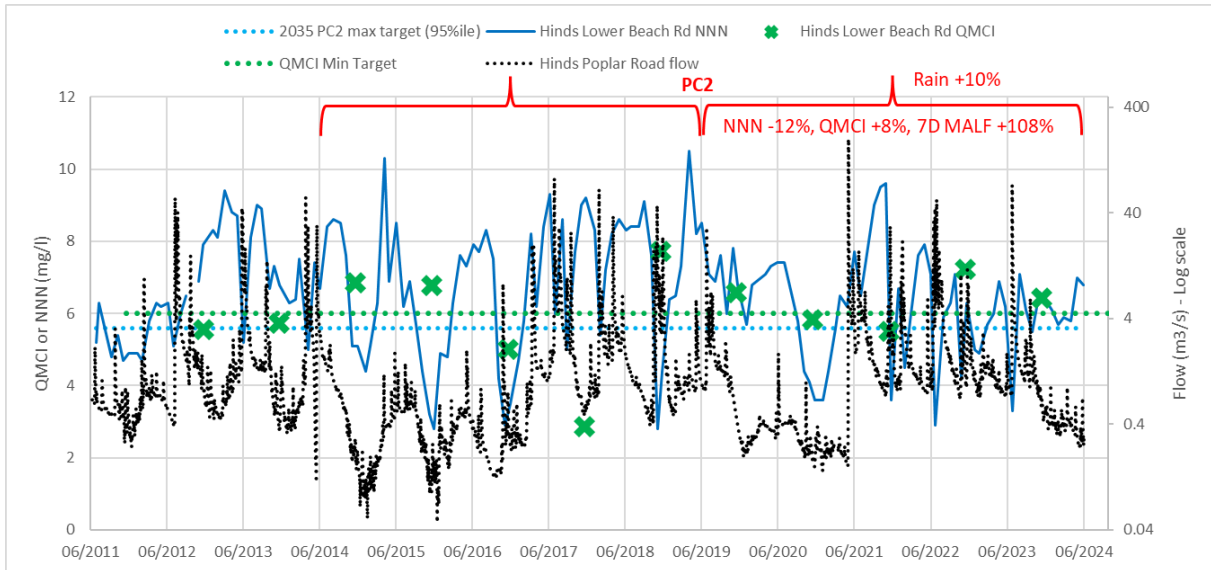


Figure 2-20: Hekeao/Hinds River flow, NNN and QMCI highlighting the 5 year period pre-PC2 and the following 5 year period (Source: CRC¹)

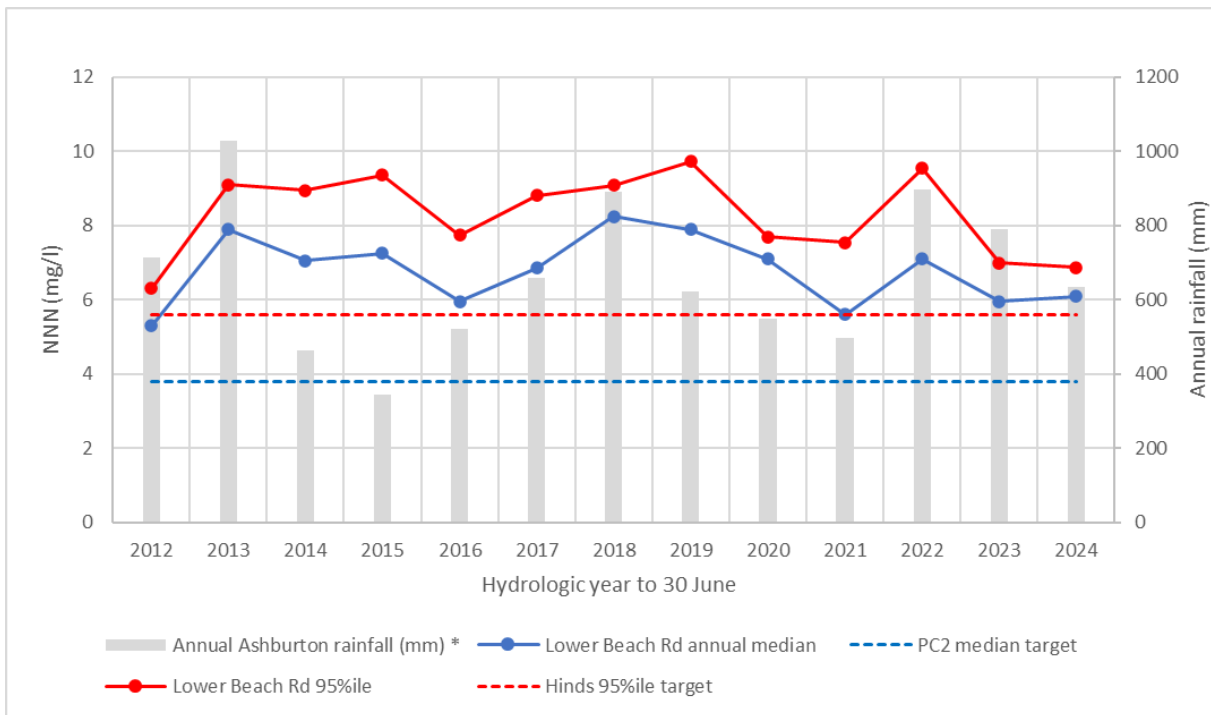


Figure 2-21: Annual (year ending 30 June) Ashburton rainfall and annual median Nitrate-Nitrite-Nitrogen concentrations for the Hekeao/Hinds River at Lower Beach Rd (Source: CRC)

Figure 2-22 compares annual median NNN for the four lower Hekeao/Hinds Drains with their 2035 PC2 target. The two drains with long monitoring records are Taylors Drain and Northern Drain. Taylors Drain shows significant decreases in NNN for both the 'wet' and 'dry' year comparisons, while Northern Drain is similar for the 'wet' year comparison and 16% higher for the 'dry' year comparison. Sections 2.2 and 2.4 of the HHWET 2020/21 Annual Report (HHWET, 2021) provide evidence to support the conclusion

¹ 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.

that NRR is having a positive influence on Taylors Drain water quality and is potentially influencing O’Shaughnessy’s Drain water quality when catchment groundwater levels are below average. Taylors Drain has met its PC2 target every year except 2018, and O’Shaughnessy’s Drain is showing positive progress, albeit with limited data. There are no MAR/NRR sites in the immediate contributing catchment to Northern Drain. In addition to on-farm improvements in the contributing catchment, further enhancements in Northern Drain water quality are the focus of the eClean Bioreactor project and proposed new MAR sites.

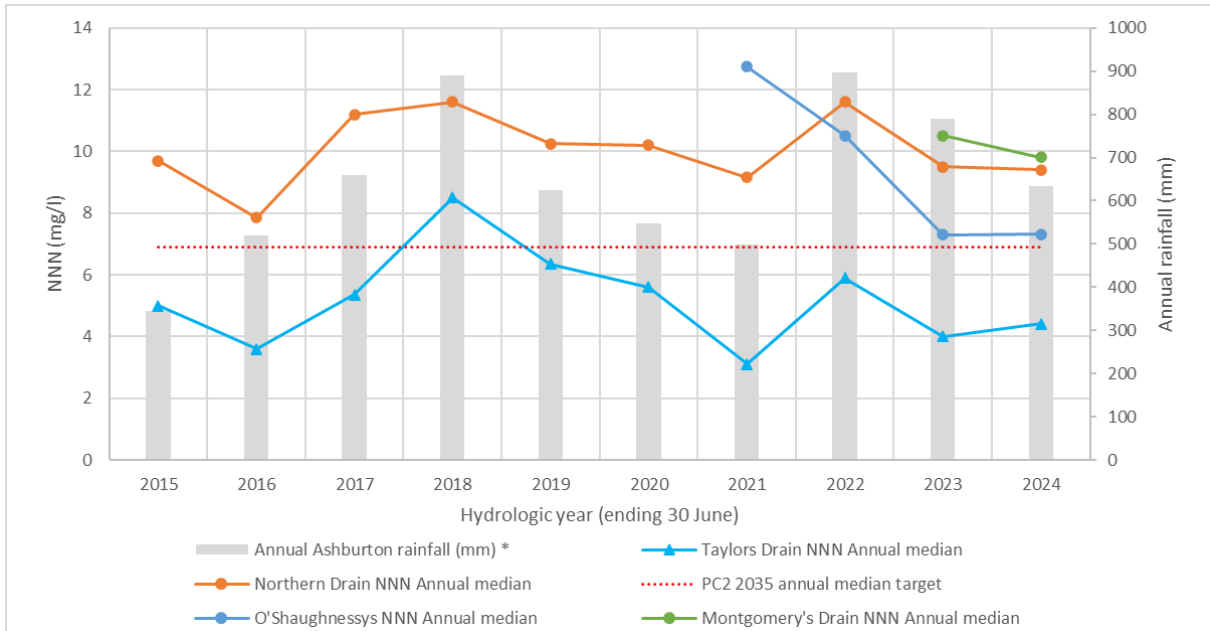


Figure 2-22: Lower Hekeao/Hinds River tributary NNN concentrations (Source: CRC/MHV)

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 above the coastal lagoon and the other just above Poplar Rd (about 6 km above the lagoon). Total estimated population size (from three passes) is presented in Figure 2-23. 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. The 2024 Poplar Rd population was dominated by upland bully and brown trout, while the Above Lagoon population was dominated by bluegill bully and torrentfish. 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.

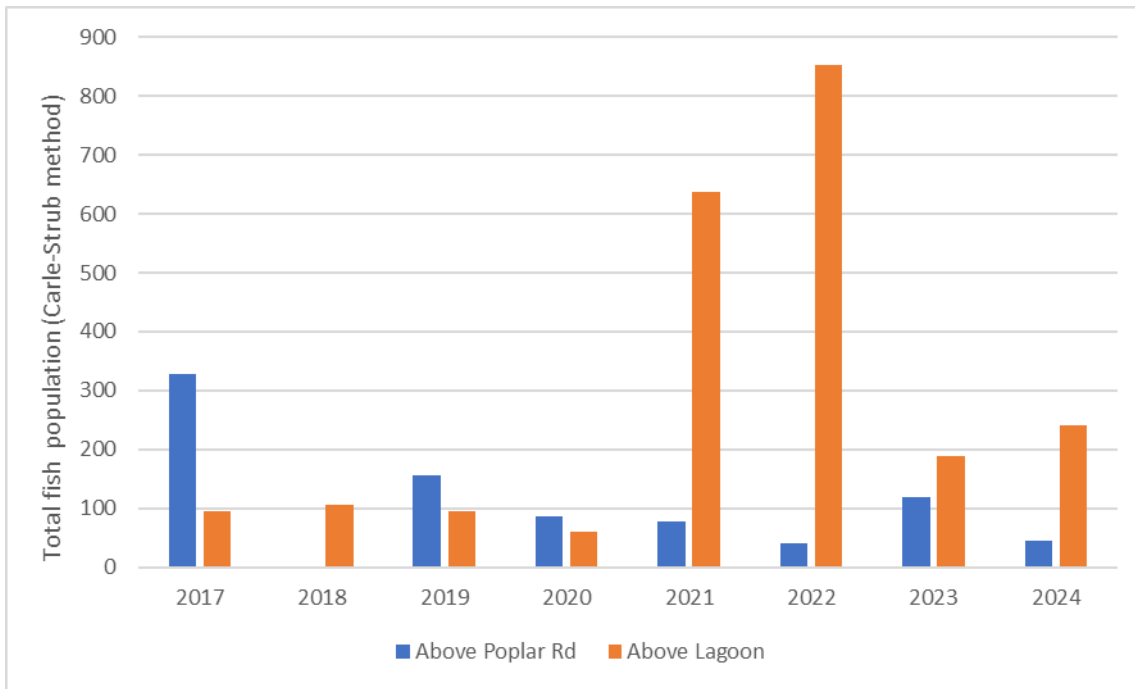


Figure 2-23: Total fish population estimates for two lower Hekeao/Hinds River sites (Source: M. Webb, Central South Island Fish and Game)

3 Hekeao/Hinds MAR Case Studies

An overview of MAR/NRR site operations and monitoring is presented in the introduction, with a total recharged volume in 2023/24 of approximately 6.25 million m³. This is the lowest volume since 2018/19, despite the two operational sites achieving their highest annual total and number of operational weeks to date. The low annual volume is due to continued operations at the remaining MAR sites declined by CRC while HHWET waited for replacement consent applications to be heard. This was a discretionary decision by CRC, 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 status report, detailed assessment of the only operational MAR site (MAR01) is presented in more detail, with a brief monitoring update also provided for MAR07 despite no operations at this site in 2023/24.

3.1 MAR01 - Lagmhor Pilot Site

The Lagmhor 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 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.

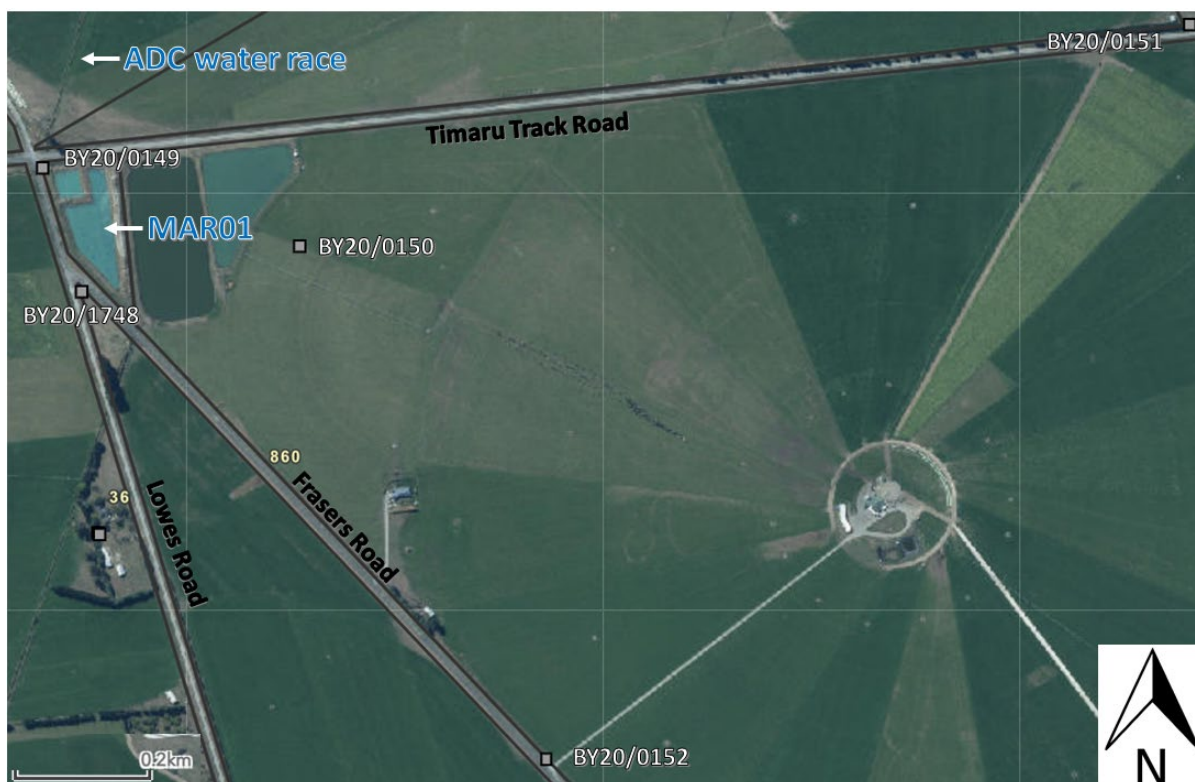


Figure 3-1: MAR 01 (Lagmhor Pilot Site) locality and nearby monitoring (Source: Canterbury Maps)

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. The discharge rate increases following site upgrades can be seen from September 2018. 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. No cessation for groundwater levels or *E. coli* were required in 2023/24, however daily rainfall exceeded 30 mm twice (23 July and 23 November 2023), after which the site was turned off for at least 48 hours.

The nitrate monitoring record 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), but quickly drop back to below 3 mg/l once MAR resumes (i.e., the nitrate increase is due to a combination of leaching caused by rainfall and the cessation of MAR due to the rainfall event). The 2023/24 record includes some of the lowest and highest recorded nitrate-N concentrations at BY20/0152. Cessation of MAR01 operations due to MHV distribution system maintenance combined with the July and November rainfall events were likely to be the key contributors to elevated nitrate concentrations in late 2023 (as is also shown in Figure 4-2), while the absence of rainfall events combined with regular MAR01 operations were likely to be key contributors to the low recorded nitrate concentrations at other times.

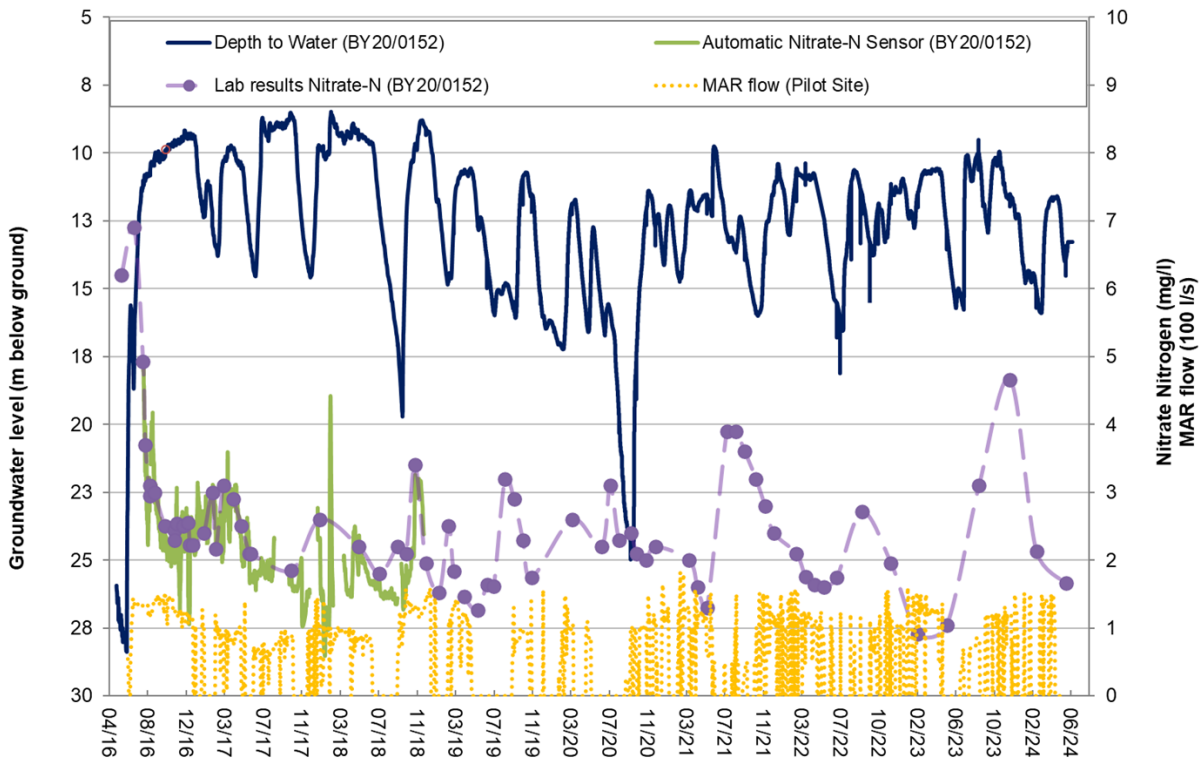


Figure 3-2: MAR 01 (Lagmhor Pilot Site) operational and key down-gradient monitoring

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 CRC scientist Patrick Durney. The relevant conclusion from this 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 2016-22). 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).

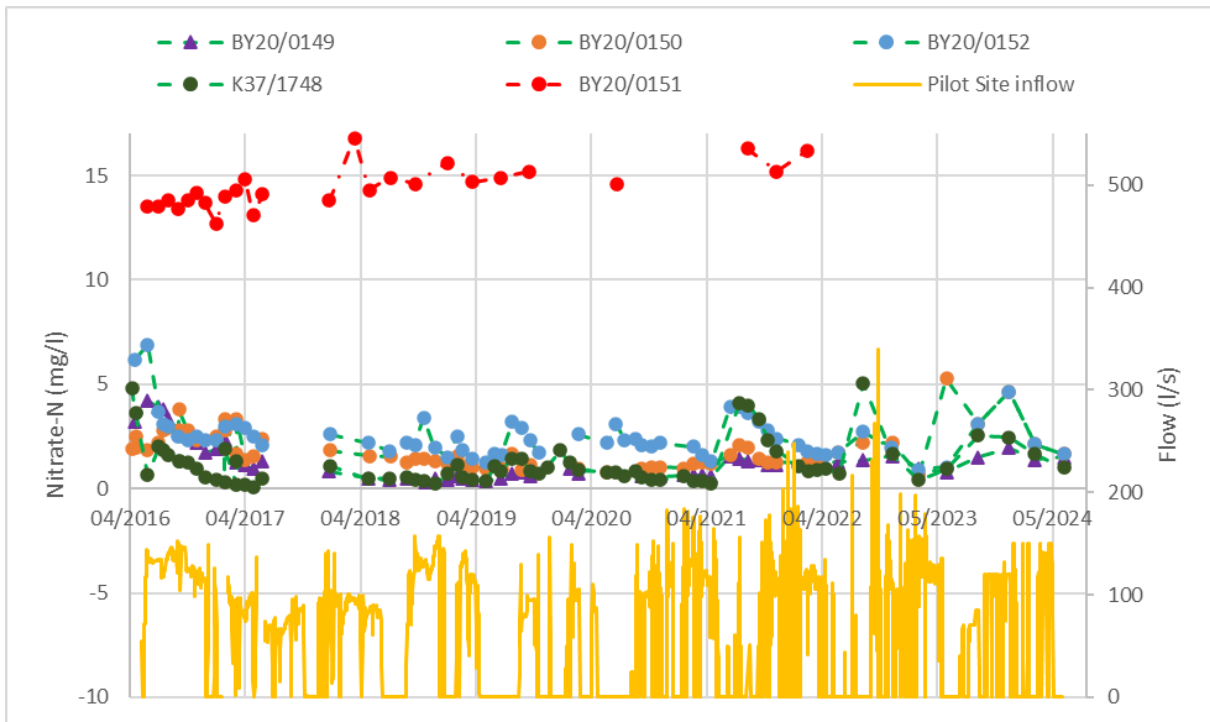


Figure 3-3: Nitrate-N concentrations for wells close to MAR01 (Source: HHWET, CRC)

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 such as 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 in 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 significant 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 to contribute to the reduction of nitrate concentrations in groundwater.

A possible factor affecting nitrate concentrations near this “hotspot” is likely to be 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 other catchments, nutrient levels have also been found to increase at other geological interfaces between light and heavy soils due to one or both of the following factors:

1. Water retention and drainage: Light soils have good drainage and poor water retention. Heavy soils, like clay, retain water well but have poor drainage. At the interface, the balance between these properties can enhance nutrient availability and retention (e.g., Morgan and Connolly, 2013).
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, 2105).

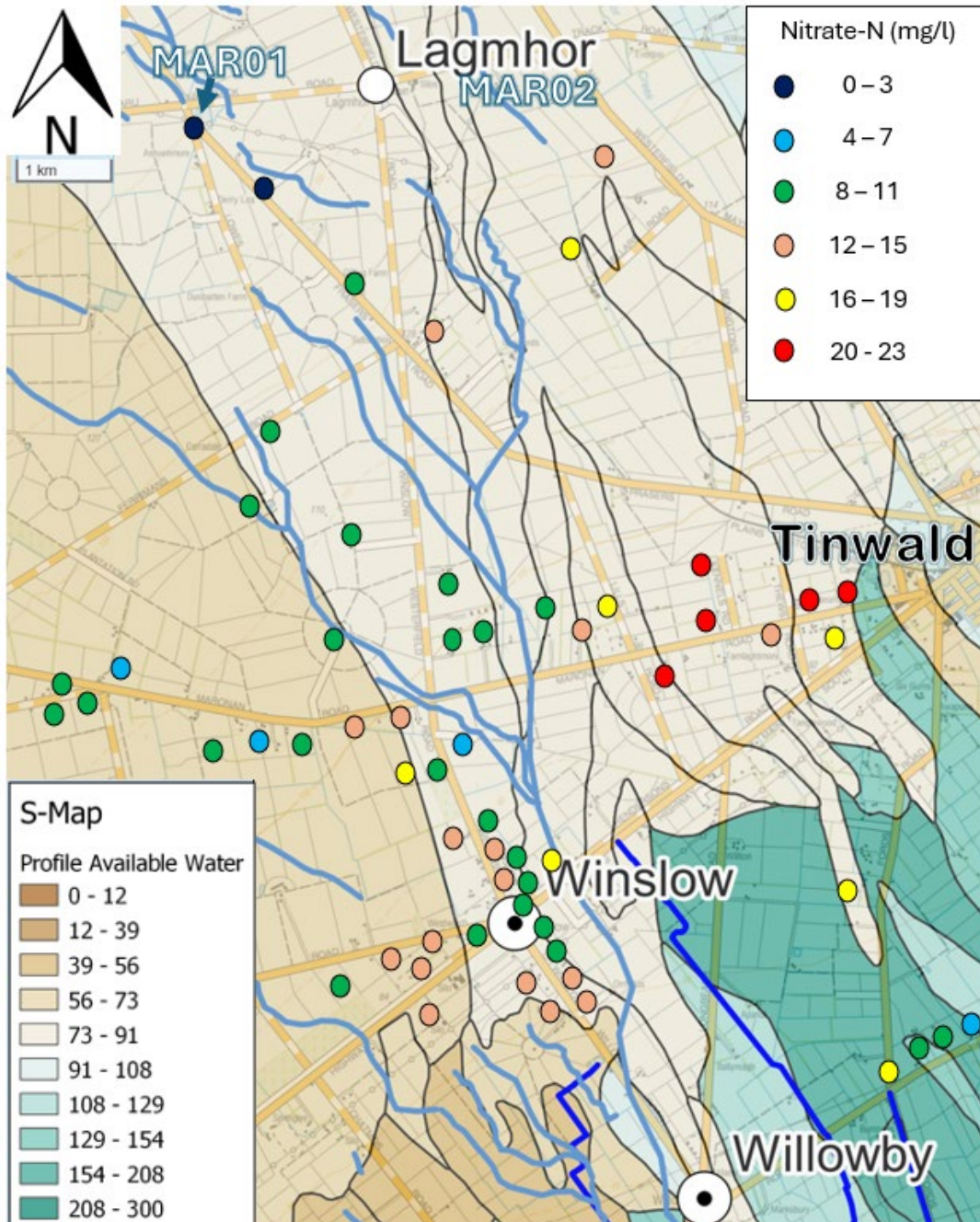


Figure 3-4: Nitrate-N concentrations from 35-60 m deep wells near Tinwald in the December 2023 to January 2024 survey.

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 rainfall in Figure 3-6 and with nearby irrigation pumping records in Figure 3-7. No clear correlation between nitrate concentration variation and rainfall variation is evident in Figure 3-6. This finding is consistent with groundwater age dating nearby for a similar depth well (mean age of 63 years in Aitcheson-Earl, 2019) and with analysis of local nitrate concentration changes following the May 2021 rain event (Legg, 2024).

A clear correlation between nitrate concentration variation and nearby irrigation pumping variation is evident in Figure 3-7 (in terms of the significant change in concentrations when irrigation pumping starts and stops). The close timing of the pumping changes and nitrate concentration changes suggests that high nitrate water from the Tinwald “hotspot” is transported towards the monitored bores in a west to south westerly direction.

Figures 3-8 and 3-9 suggest that this seasonal nitrate concentration variation is strongest within about 3 km of the closest groundwater pumping. Figure 3-8 shows consistent seasonal nitrate concentration variation for the wells within this area and Figure 3-9 shows no seasonal nitrate concentration variation for the wells outside this area. Previous analyses (e.g., HHWET, 2021, Chapter 4) have concluded that MAR01 recharge is heading into this area of seasonally affected groundwater. Communications with affected landowners have focussed on the domestic water treatment options for wells at risk of not meeting NZ Drinking Water Standards (2022). Current resource consent applications are also intended to increase recharge from MAR01 and nearby MAR sites into this area, with the aim of improving groundwater levels and quality.

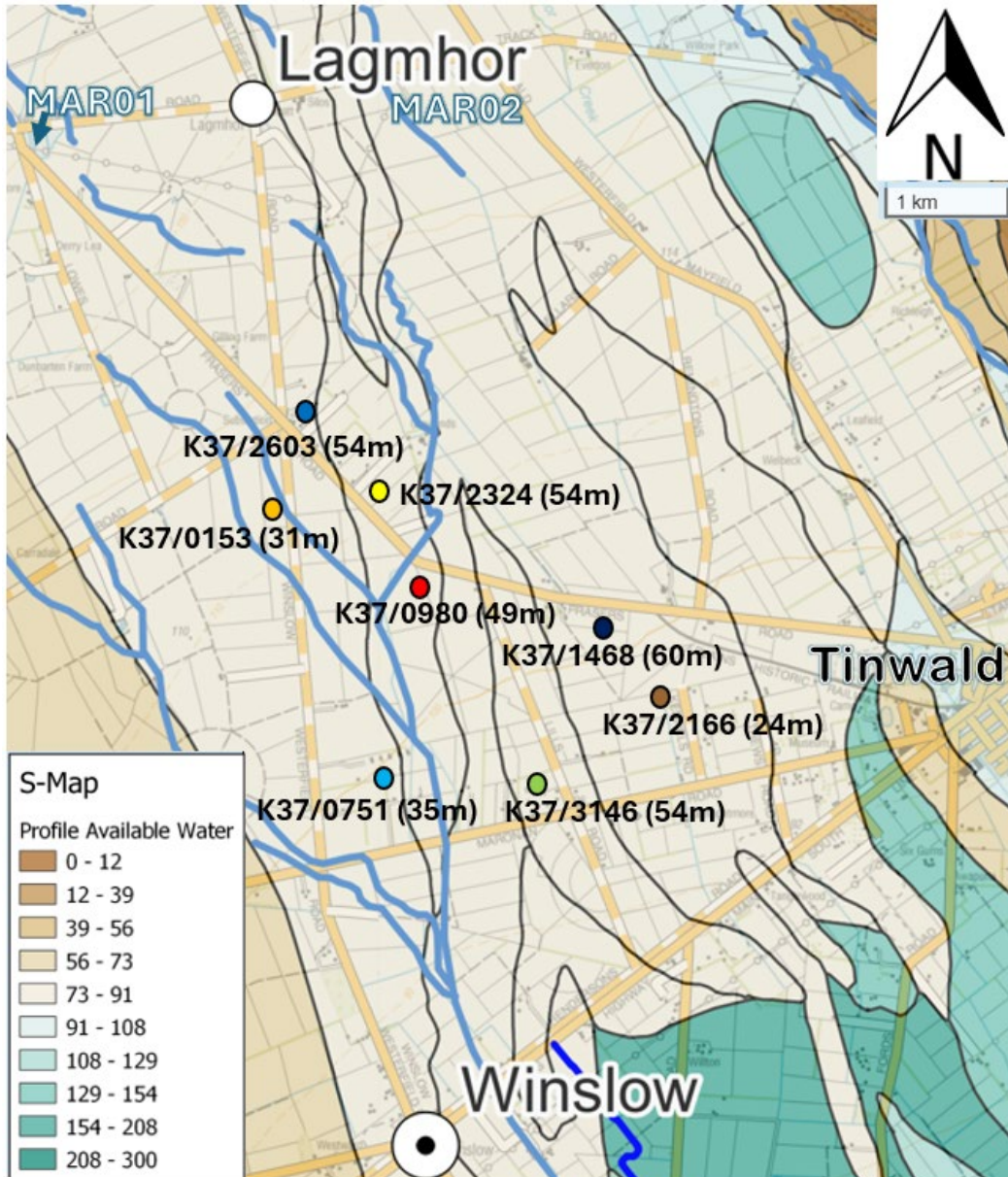


Figure 3-5: Wells with quarterly nitrate-N monitoring near Tinwald

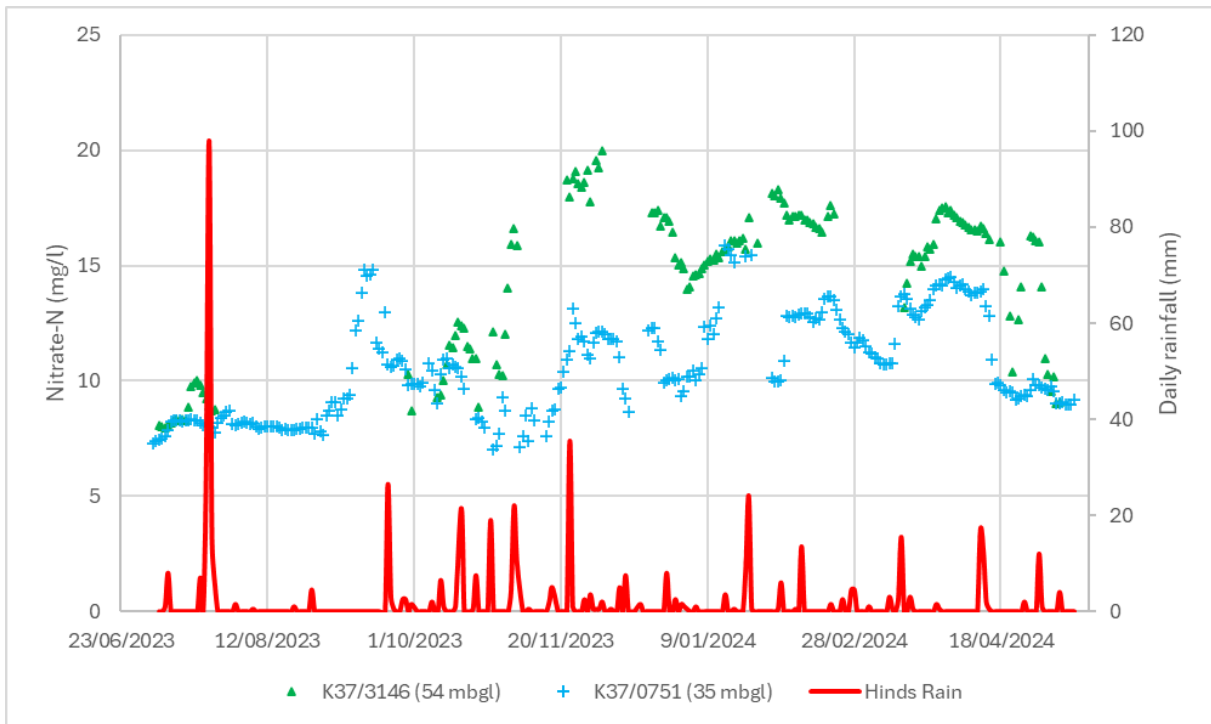


Figure 3-6: Daily Nitrate-N concentrations from two wells near Tinwald and daily Hinds Plains rainfall (Source: HHWET, CRC)

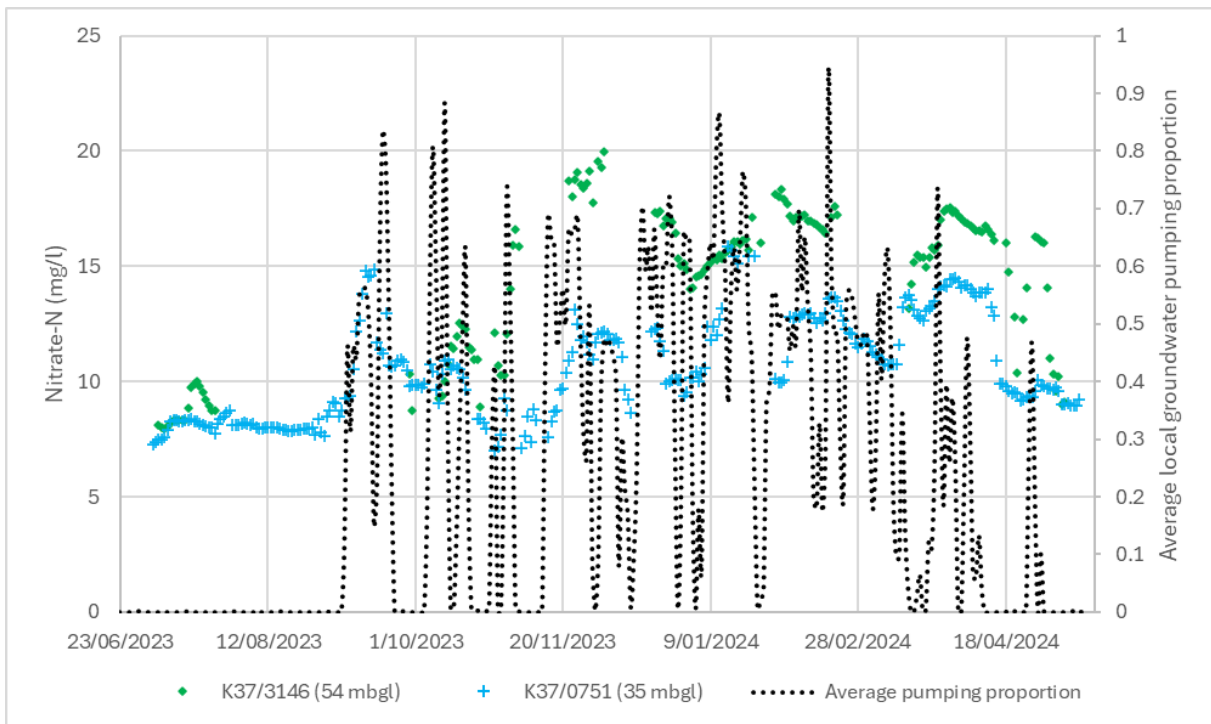


Figure 3-7: Daily Nitrate-N concentrations from two wells near Tinwald and daily cumulative groundwater pumping, as represented by the average of two local groundwater irrigation wells (Source: HHWET)

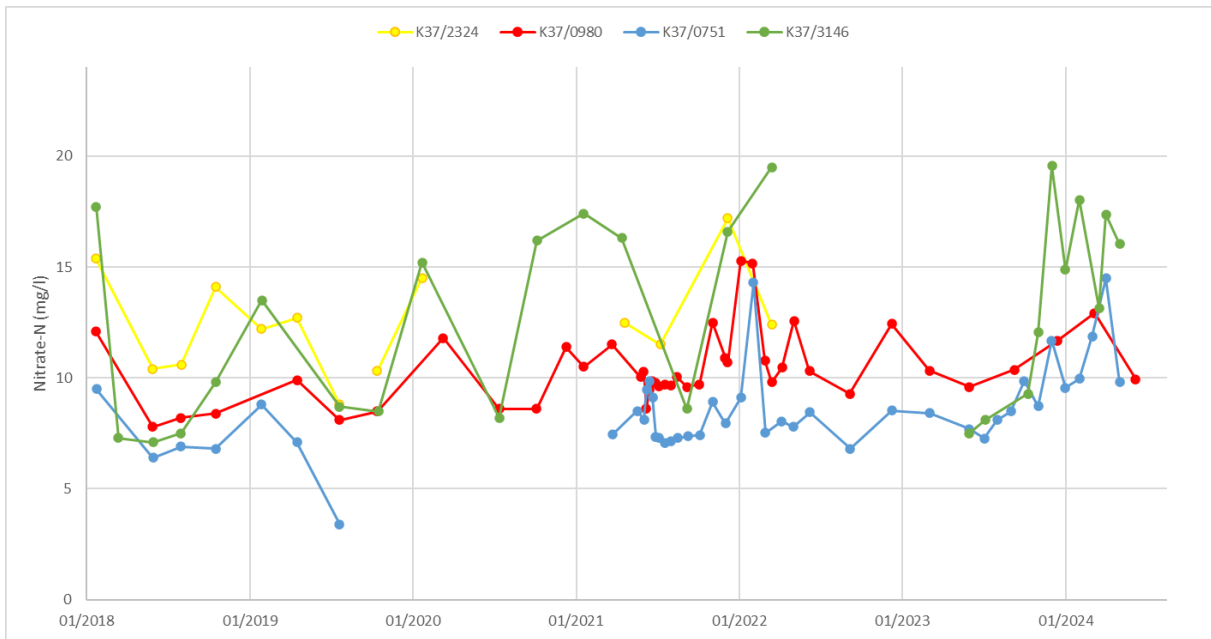


Figure 3-8: Wells near Tinwald showing seasonal variations in nitrate-N concentrations (Source: HHWET)

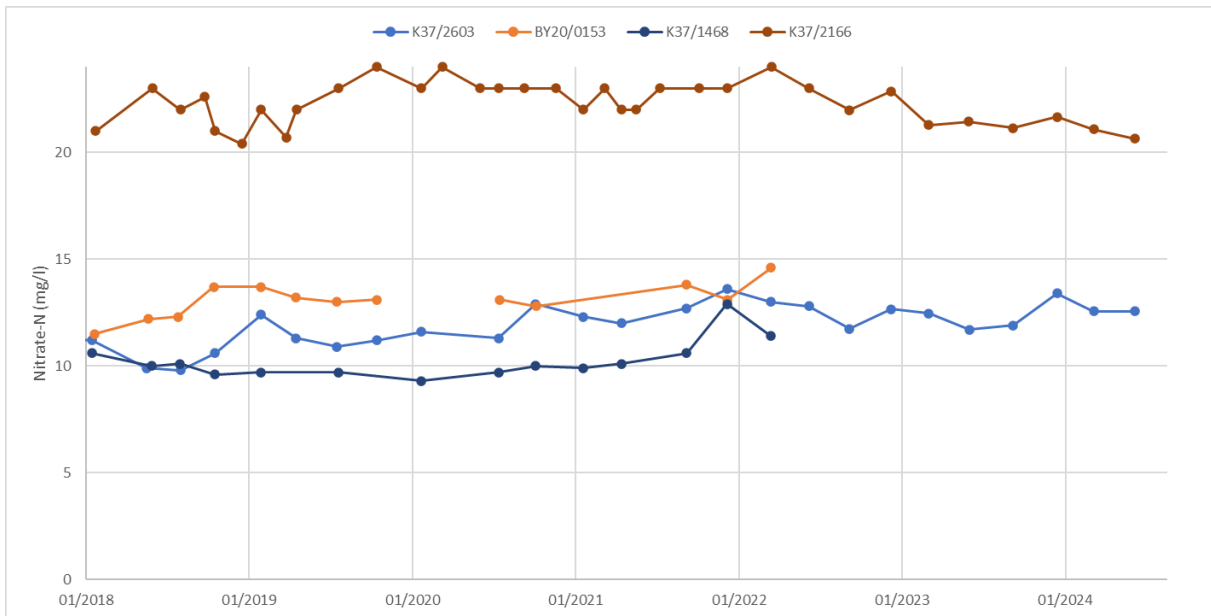


Figure 3-9: Wells near Tinwald not showing seasonal variations in nitrate-N concentrations (Source: HHWET)

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.

Figure 3-10 presents key results for Ashburton Valetta (AshV) plains samples. Chemically 'unaltered' Ashburton River water was identified in all samples, ranging from less than 2% of sample volume to more than 40%. For samples close to the Ashburton River (e.g., wells 1-7 and 17-21 in Fig. 3-10), this contribution is most likely from river recharge or spring-fed race recharge. For the remainder of the wells, the Ashburton River contribution to groundwater can be assumed to be from stockwater race recharge.

Chemically 'unaltered' Rangitata River water was also identified in all samples, ranging from approximately 2% of sample volume to more than 50%. The highest proportions were close to the MAR01 Pilot Site (wells 13 & 14 in Fig. 3-10). Wells 17-21 were also assessed to contain a significant proportion of 'unaltered' Rangitata River water, while wells 22 & 23 were assessed to contain a small proportion of 'unaltered' Rangitata River water. Wells 17-21 are 45 to 60 metres deep and the average age of groundwater in a similar depth well nearby was approximately 63 years. Recharge from historical unlined Valetta irrigation races (including the Timaru Track Road discharge race) could have contributed to these results. Younger water from the three upgradient MAR sites could also have contributed to these wells, if the lag times are similar to those measured in bores downgradient from MAR01. Wells 22 & 23 are less than 16 metres deep and therefore are expected to contain relatively young water, primarily from the locally upgradient catchment.

Chemically 'unaltered' rainfall was identified in all samples, ranging from approximately 1% to 29% of sample volume. The highest proportions of rainfall recharge were in wells 13-16 near MAR01 where it is assumed that rainfall supplemented the supply to the MAR01 basin and upgradient race. For the other sampled wells, a proportion of the chemically 'unaltered' rainfall recharge can also be presumed to occur via irrigation and stockwater races.

This research highlights the importance of water race recharge to Hekeao/Hinds Plains groundwater quality and quantity, as well as adding another key ingredient to assessments of MAR influence.

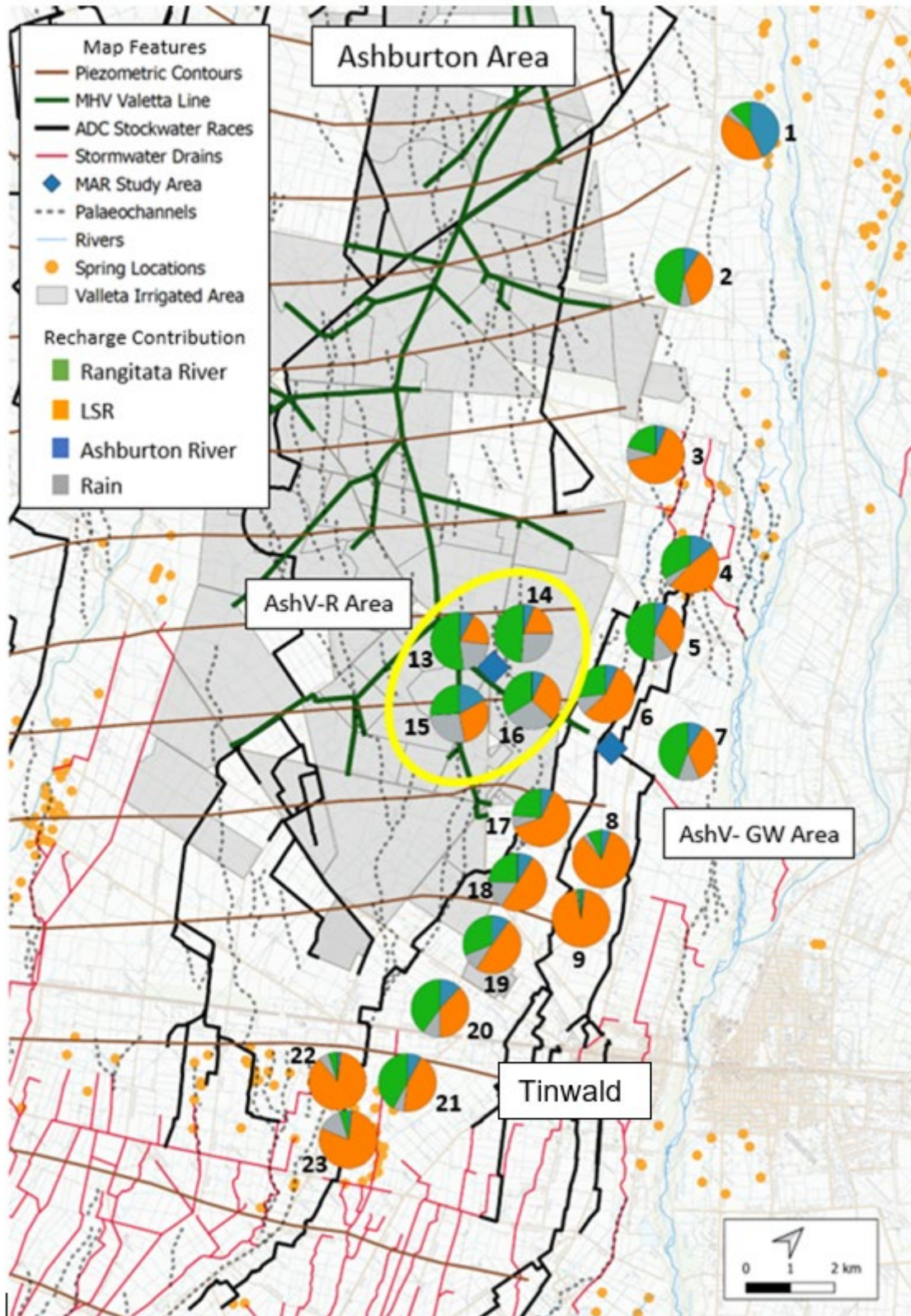


Figure 3-10: Ashburton Valetta (AshV) area: the pie charts illustrate the contribution of four water sources—Rangitata River, Ashburton River, Rain, and Land Surface Recharge—to groundwater quality, determined using a mixing model incorporating conservative ions and water dual isotopes (Source: Teixeira, 2024)

3.2 MAR07 – Timaru Track Road

MAR07 is a managed aquifer recharge basin constructed from an unlined former irrigation pond on the corner of Timaru Track and Maronan Valetta Roads (see Figure 3-10). The site was operational from September 2020 until early 2023, when continuance during the current consenting process was declined by CRC. MHV Water began testing nearby groundwater wells for nitrate-N in September 2020, with additional wells added in the following six months. Well names, locations and depths are presented along with the MAR07 location in Figure 3-10.

Figure 3-11 presents the MAR07 flow rate (compared with the right-hand axis) and the quarterly nitrate-N concentrations (left hand axis) at the four chosen monitoring wells. Available regional piezometric contours (e.g., Canterbury Groundwater Model – Aqualinc Research Ltd, 2007) suggest approximately a south-easterly groundwater flow direction in this area, although changes in flow direction with depth, groundwater abstraction and rainfall recharge will occur.

BY20/0162 is up-gradient from MAR07 and close to the Hekeao/Hinds River. Its low nitrate-N concentration throughout the monitoring period suggests that its primary recharge source is the Hekeao/Hinds River. K37/2986 is down-gradient from MAR07 in an SSE direction and shows no measurable change in nitrate-N concentrations with changes in MAR07 flow. The most significant change is an increase from May to September 2021, most likely due to the significant rain event around 31 May 2021. This suggests that land surface recharge is the primary contributor to K37/2986 water quality.

Nitrate-N concentrations in K37/2372 (133 m deep) were relatively high initially, suggesting that land surface recharge was its primary contributor water quality. Somewhere between December 2021 and March 2022, the nitrate-N concentration at K37/2372 decreased from 6.3 mg/l to 2.8 mg/l and has remained less than 3 mg/l since. For MAR01 testing in 2016-17, an initial lag time between start of operations and water quality changes in 23-48 m deep wells translated to horizontal groundwater velocities of ~8-10 m per day. MAR07 recharge producing horizontal groundwater velocities of ~8 m per day would be required to explain the late 2021 nitrate-N concentration changes at K37/2372. No other reason for this change in concentration has been identified to date. Hekeao/Hinds MAR influence has not previously been identified in wells deeper than 54 m.

As MAR07 has not operated since high flow testing in March 2023, the next step is to assess monitoring through to at least late-2024 to see if the nitrate-N concentrations rise again. If so, then we can be even more confident that MAR07 operations are influencing water quality in K37/2372 and that a deep groundwater flow direction in this area is east of southeast.



Figure 3-11: MAR07 and nearby regular groundwater monitoring sites (Source: Canterbury Maps)

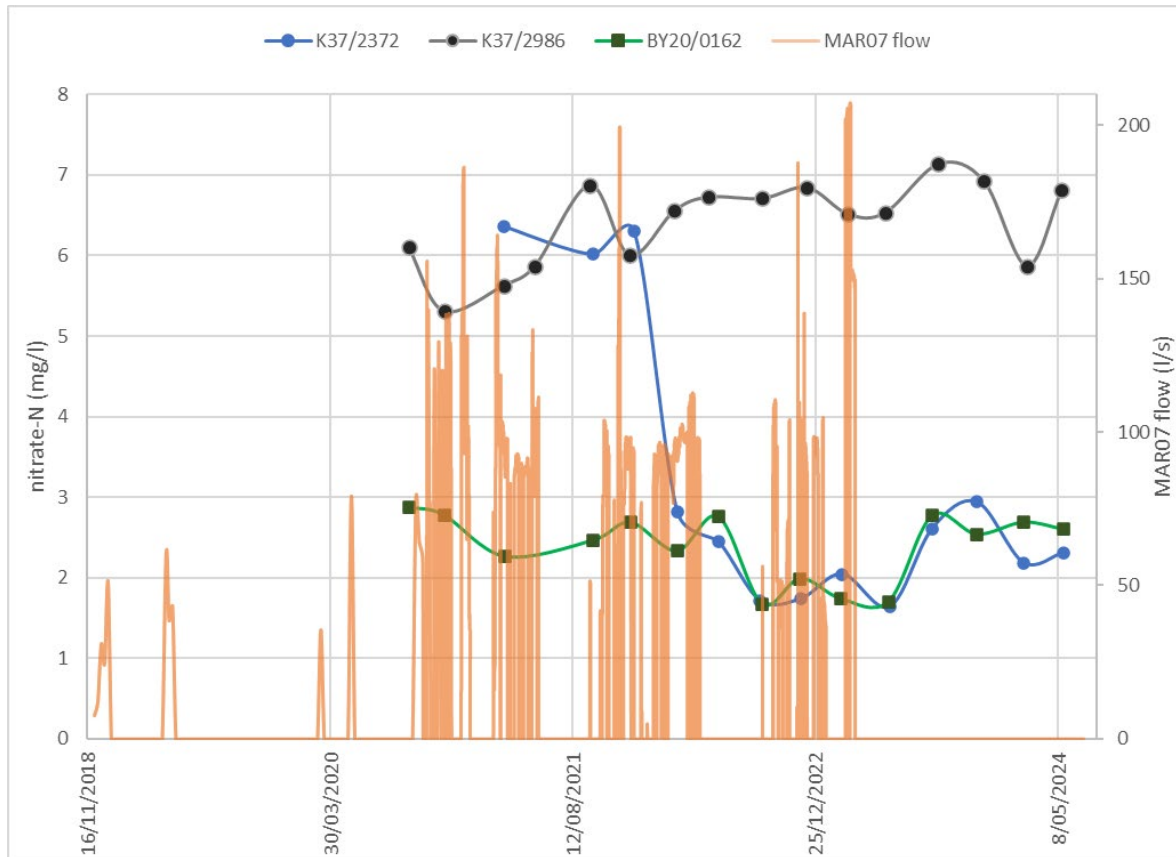


Figure 3-12: MAR07 flow and nearby groundwater nitrate-N concentrations (Source: MHV Water, HHWET)

4 Hekeao/Hinds Groundwater and Northern Drains Surface Water Quality

4.1 Hekeao/Hinds Plains Groundwater Quality

As noted in the introduction, the groundwater nitrate-N PC2 monitoring update to 30 June 2024 in Figure 4-1 (also Figure 1-2) shows median nitrate-N concentrations in PC2-specified “shallow” wells across the Hekeao/Hinds Plains alongside the significantly larger combined MHV Water/BCI/HHWET/PC2 dataset of similarly defined “shallow” wells (i.e., screened within 30m of the land surface), plus annual Ashburton rainfall. Rainfall for the years ending June 2021 and 2022 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 appeared to result in significant transport of nutrients through the soil profile, groundwater and surface water systems, which were measured throughout Year 6 (2021/22).

Figure 4-1 shows the 2023/24 year to be about 10% below average annual rainfall and the second highest year (after the previous year) for annual median nitrate-N concentration of PC2 wells since 2006. However, a closer examination of the data shows that these high results were primarily due to the addition of a new well (BY21/0199) in 2022 with the highest annual median value in the dataset (20-23 mg/l). It also coincided with a jump in annual median value in another well (K37/2314) from 6.5 to more than 11 mg/l. Further analysis of groundwater monitoring in the vicinity of K37/2314 (Legg, 2024) suggests that the 2022-24 increases could be primarily due to lagged responses to the May 2021 rain event, which resulted in peak nitrate concentrations around November 2022 and decreasing concentrations since (with the Autumn 2024 nitrate-N concentration at 2.9 mg/l). Removing these influences, the annual median of the medians for the remaining PC2 wells decreased since 2021/22. Figure 4-1 also shows minimal change in median annual nitrate for the MHV Water/BCI/HHWET/PC2 dataset in the 2022 to 2024 hydrologic years, with a 2023/24 concentration of 9.8 mg/l.

Figure 4-2 (also Figure 1-3, which presents the median of all monitored sites for each quarterly monitoring round, as opposed to the median of the set of annual medians for each monitored site in Fig. 4-1) shows that between 44 and 83 samples have been collected quarterly for the combined dataset compared with 0 to 12 samples for the PC2 dataset. For the 2021-24 hydrologic years the quarterly results from the PC2 wells shows median values vary between 8.8 and 13.8 mg/l, while the larger dataset varies between 8.9 and 10.7 mg/l. The larger dataset shows higher median values in general for the lowest rainfall year (2020/21) and lower median values for the other years. Large dataset results since December 2021 give the highest confidence as to their representation of catchment shallow groundwater quality due to the greatest consistency of measured sites and highest number of monitored wells (>70). Given the importance of the PC2 monitoring results as a key indicator of progress towards PC2 ecosystem health targets, it is important that the PC2 dataset reflects nitrate concentrations that represent catchment water quality. The current number and choice of PC2 wells does not appear to be as representative of catchment water quality changes as the larger dataset. Both datasets will continue to be compared over the coming years and further analyses will be undertaken to identify an expanded PC2 dataset that is more representative of catchment water quality without adding significant cost, and without making so many changes to the set of wells that comparisons back to 2006 are no longer justifiable. The potential impacts of adding or removing wells from a dataset are illustrated by the effect of adding the new well (BY21/0199) to the PC2 monitored wells (as described above).

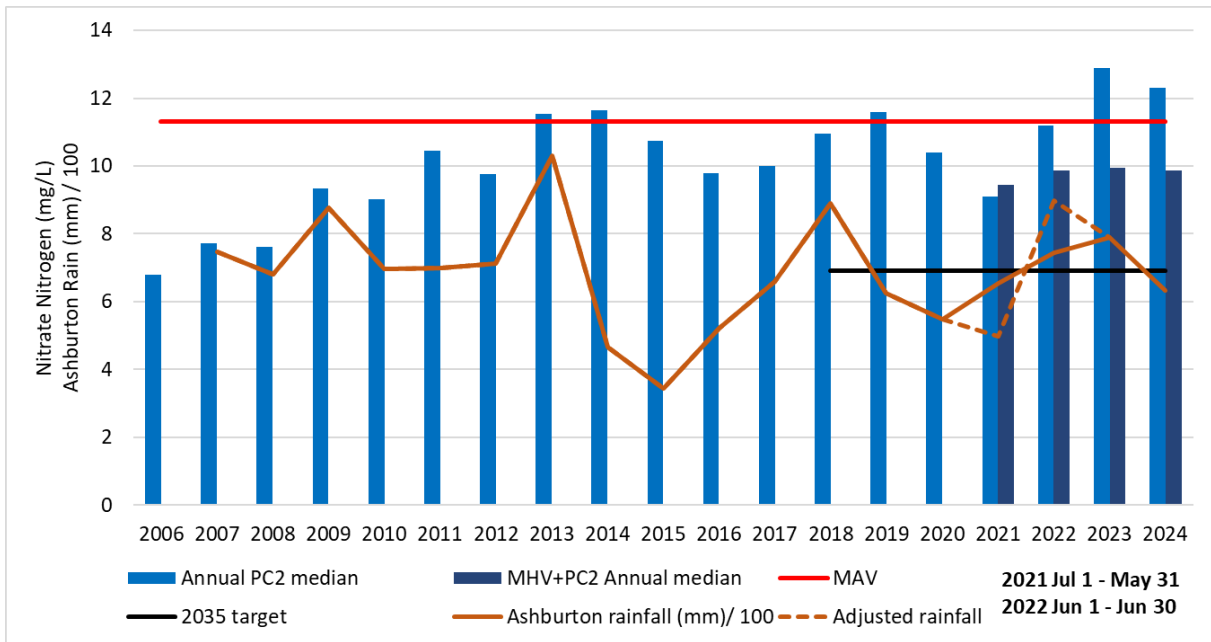


Figure 4-1: Hekeao/Hinds Plains PC2 and MHV Water + PC2 median annual nitrate-N concentrations, plus Ashburton annual rainfall (Source: CRC, MHV Water)

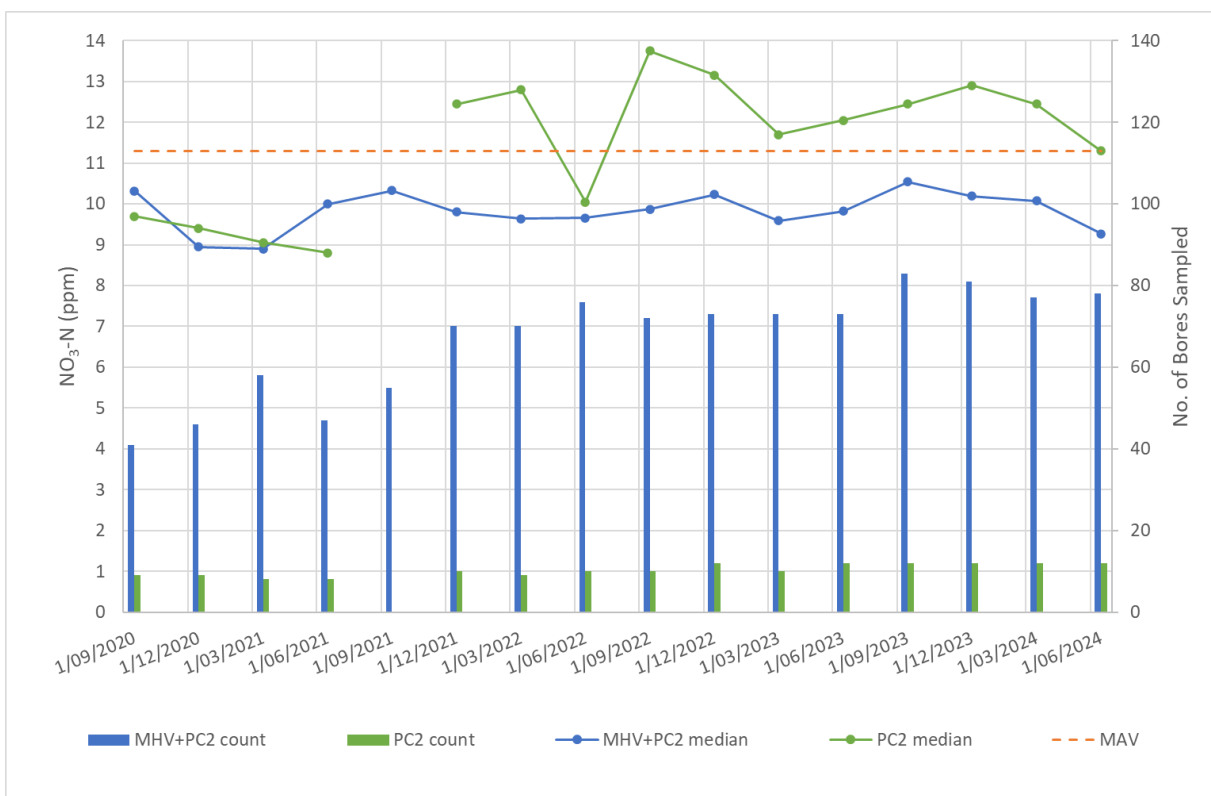


Figure 4-2: 2020-24 Hekeao/Hinds quarterly groundwater nitrate-N monitoring (Source: MHV Water, CRC)

4.2 Hekeao/Hinds Northern Drains Surface Water Quality

Consent conditions for MAR01 (Lagmhor 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-2 (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 2023/24, with a delivered volume of 2.05 million cubic metres (equivalent to 65 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. The Hekeao/Hinds drains monitoring will therefore continue to be regarded as baseline monitoring until MAR volumes in this vicinity increase significantly.

Figure 4-3 presents the relevant monitoring sites for the Hekeao/Hinds northern drains. Figures 4-4 to 4-6 present the annual median NNN concentrations (which are used to assess whether the drains achieve the 6.9 mg/l PC2 target), while Figures 4-7 to 4-9 present the monthly results (with 95% of monthly samples required to be annually below the 9.8 mg/l PC2 target by 2035). In general, Figures 4-4 to 4-9 show that water quality improves from the upgradient springs to the coast on the monitored drains.

Figures 4-8 and 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. This results in gaps in the water quality monitoring record. Both drains have minimum flow restrictions (measured at Lower Beach Rd) for irrigation takes, with trigger levels of 100 l/s for the Parakanoi Drain and 25 l/s for the Flemington Drain. Two nitrate concentration readings greater than 20 mg/l can be seen in the monthly Parakanoi Drain at McLennons Road dataset, though nitrate concentrations in both cases return to normal in the next monitoring period. Both increases occur when drain flows increased suddenly from low or no flow, suggesting a “first flush” effect. Flemington Drain nitrate concentrations vary more significantly than Parakanoi Drain nitrate concentrations, with lower annual median nitrate concentrations and more missing records due to low or no flow. CRC records show that significant decreases in Flemington Drain NNN concentrations usually occur in the summer months after a rainfall event, where rainfall runoff augments the spring-fed drain flow.

Figure 4-4 shows that the lower Windermere Drain met the annual median PC2 target in the 2020/21 year (with key missing Windermere at Lower Beach Rd data replaced by Windermere at Poplar Rd records). Figure 4-7 shows that this was due to a significant period with low NNN concentrations during the irrigation season. However, the period of low NNN concentrations in 2020/21 was not of sufficient duration to meet the PC2 95%ile target as well. The second best year for annual nitrate concentration and the best equal year for number of months less than the PC2 95%ile target was 2023/24.

The Windermere Drain below Boundary Road receives Targeted Stream Augmentation (TSA) in addition to pumped irrigation supply (from the Eiffelton Community Group Irrigation Scheme - ECGIS). Multiple ECGIS wells discharge into the drain and multiple offtakes supply ECGIS irrigators. The TSA component comprises additional water that is pumped into the drain by ECGIS to enhance fish habitat and fish passage. The combined augmentation also lowers nitrate concentrations, particularly during periods of low natural spring/tile drain flow and high irrigation demand. This complements the instream (removal of fish barriers and creation of riffles/pools), and riparian planting initiatives led by the Lowlands Catchment Group and CSI Fish and Game. ECGIS and HHWET began a TSA Enhancement project in May 2024 to provide TSA as required for ecosystem health over and above the ECGIS TSA. The aims of the project are to maintain at least 80 l/s of flow at Poplar Road and nitrate concentrations below PC2 targets where possible. Progress is tracked by graphing flow and concentration as in Figure 4-10. Figure 4-11 presents the equivalent data plus QMCI for the Parakanoi Drain, which is currently at a lower ecosystem health state. The evidence presented in Chapters 2 and 4 of this report showing likely

contributors to improved Hekeao/Hinds River and Windermere Drain ecosystem health suggests that a similar combination of on-farm improvements and MAR/TSA enhancements in the contributing catchment can also improve the ecosystem health of the Parakanoi Drain.

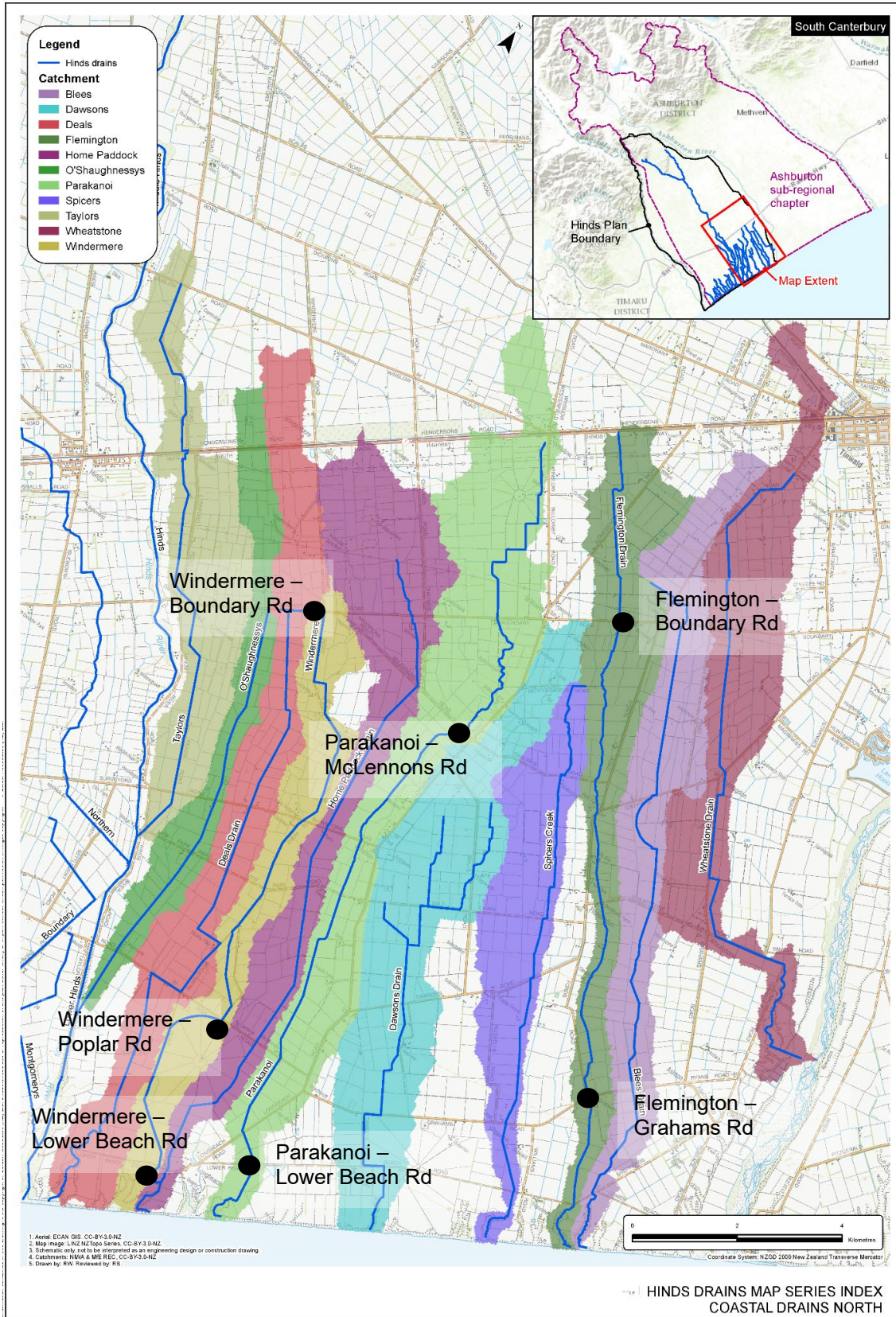


Figure 4-3: Hekeao/Hinds northern drains monitoring sites

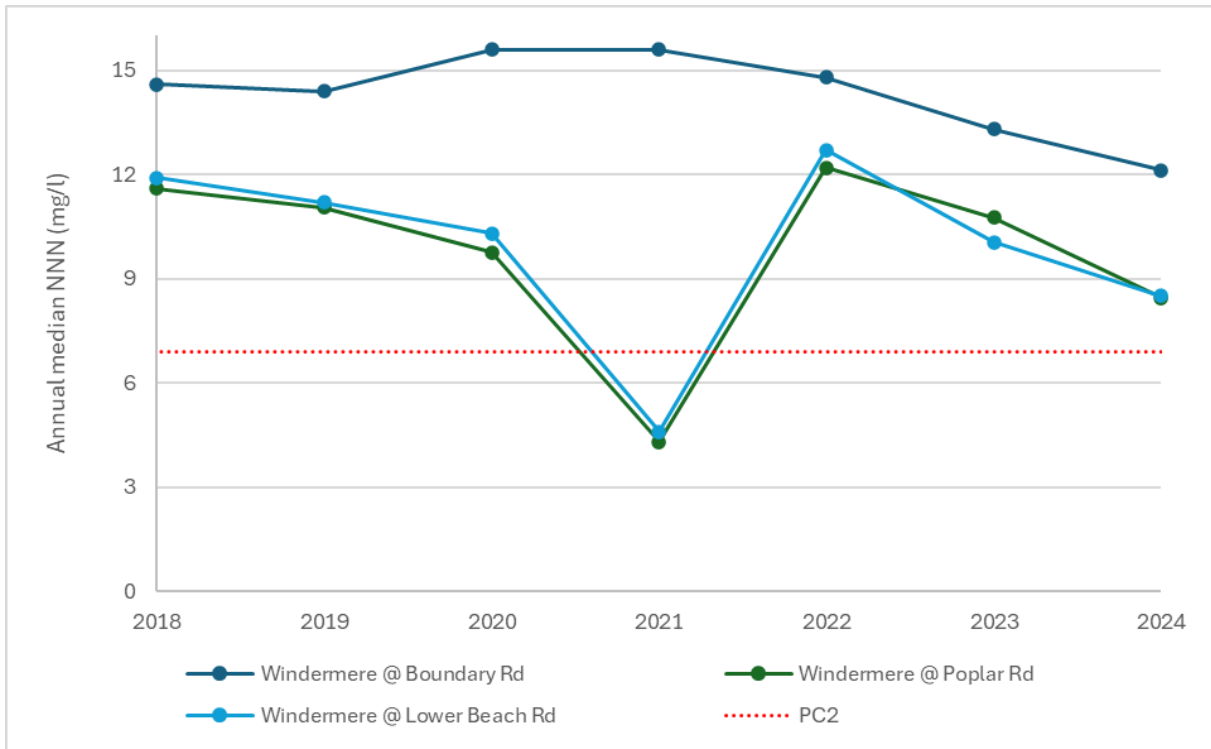


Figure 4-4: Windermere Drain annual median NNN monitoring (Source: CRC, MHV Water)

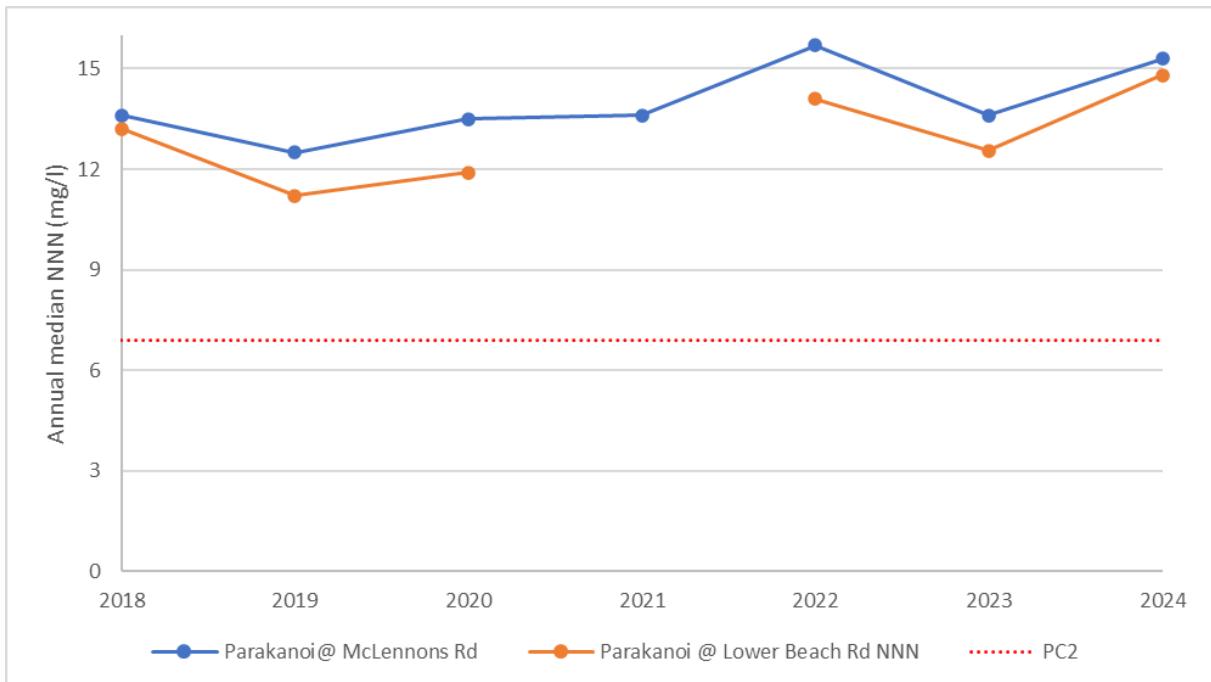


Figure 4-5: Parakanoi Drain annual median NNN monitoring (Source: CRC, MHV Water)

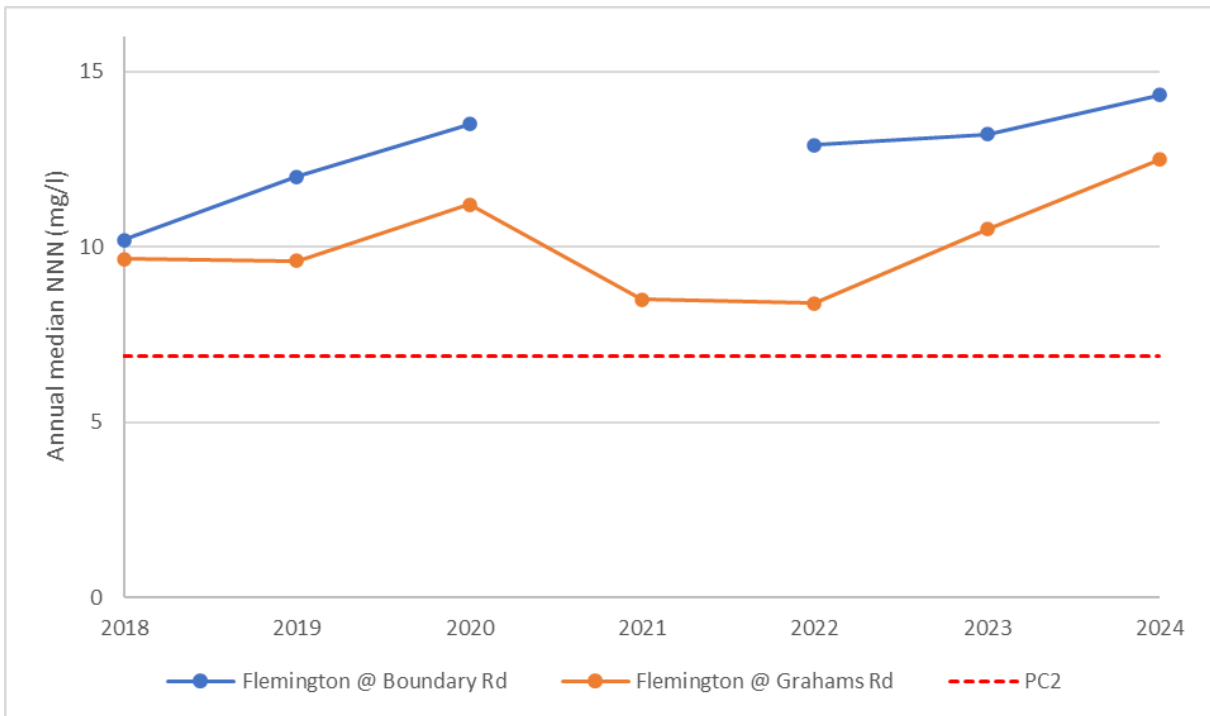


Figure 4-6: Flemington Drain annual median NNN monitoring (Source: CRC, MHV Water)

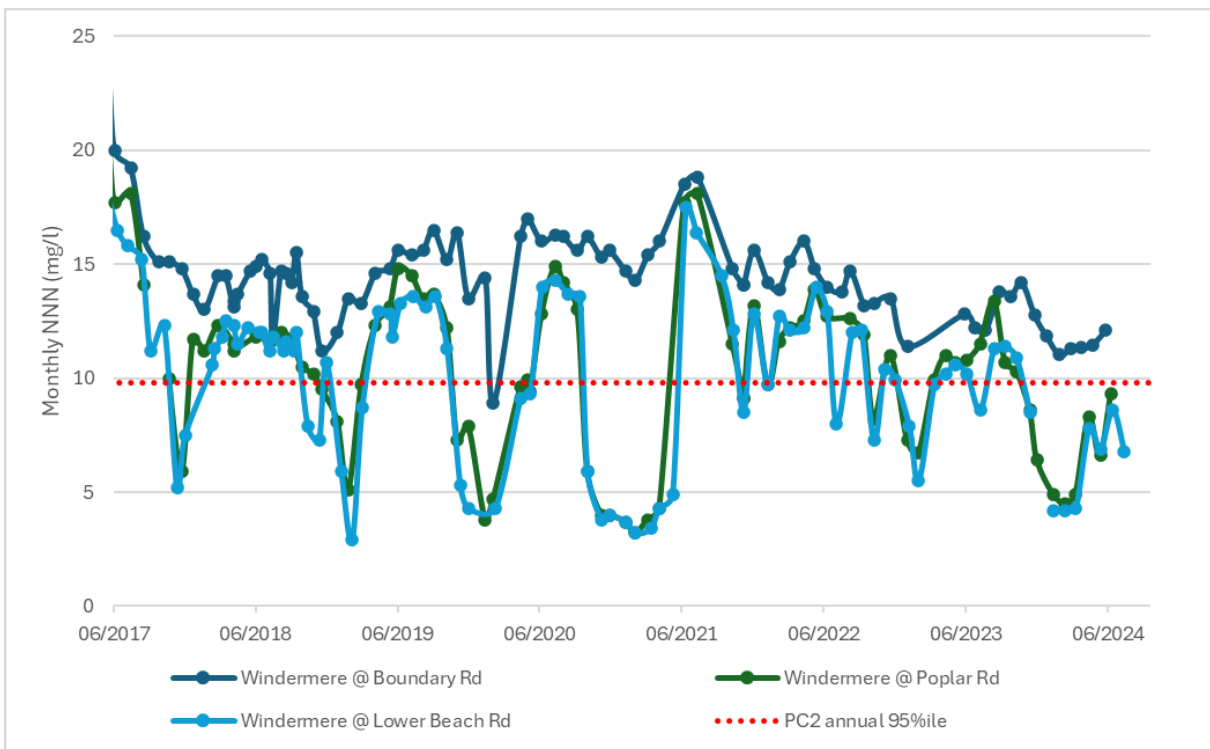


Figure 4-7: Windermere Drain monthly NNN monitoring (Source: CRC, MHV Water)

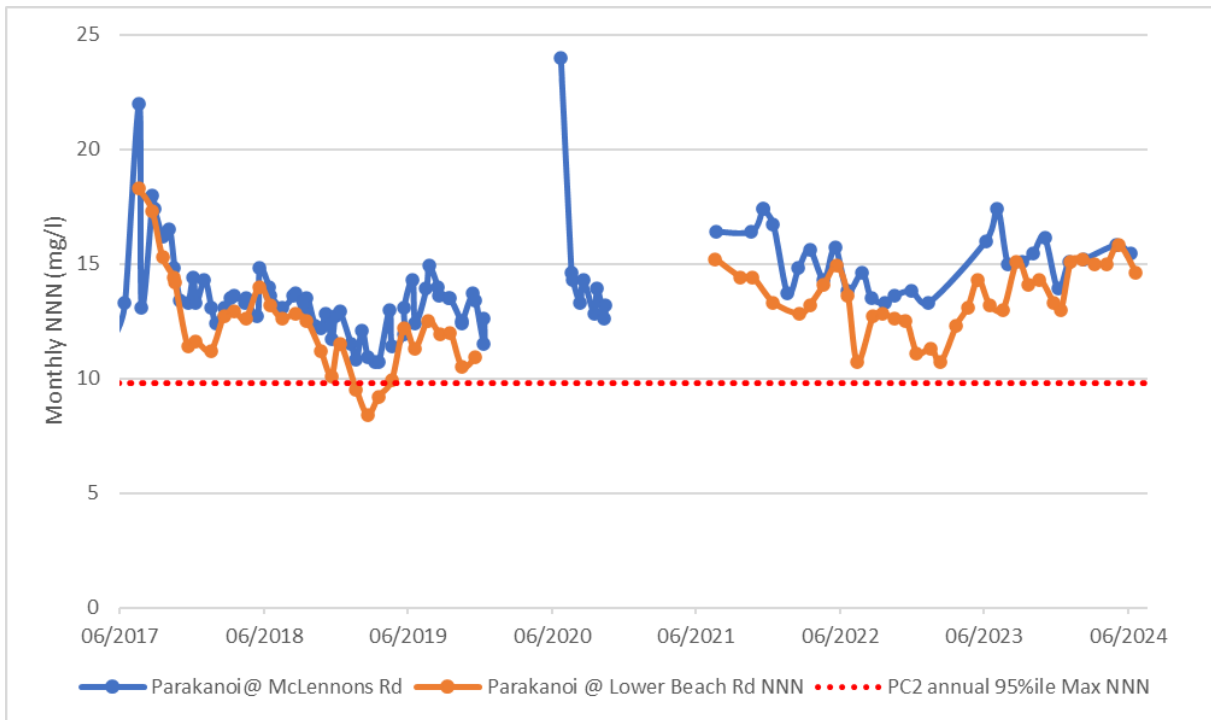


Figure 4-8: Parakanoi Drain monthly NNN monitoring (Source: CRC, MHV Water)

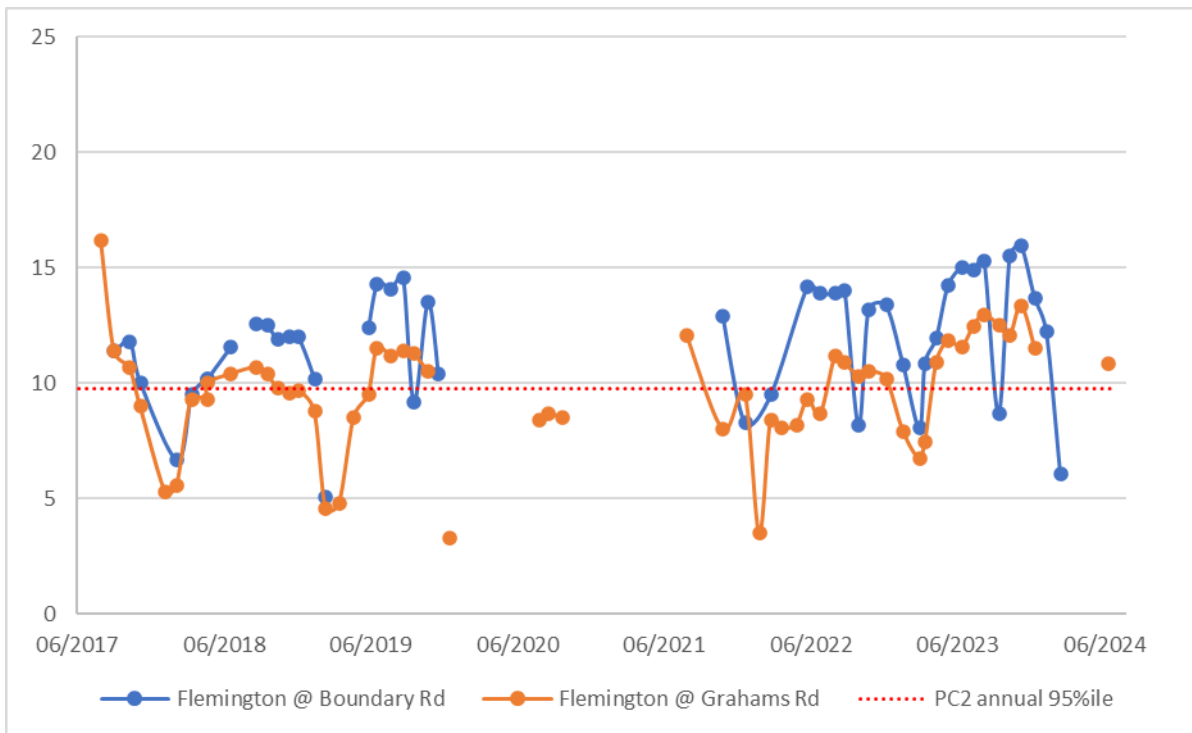


Figure 4-9: Flemington Drain monthly NNN monitoring (Source: CRC, MHV Water)

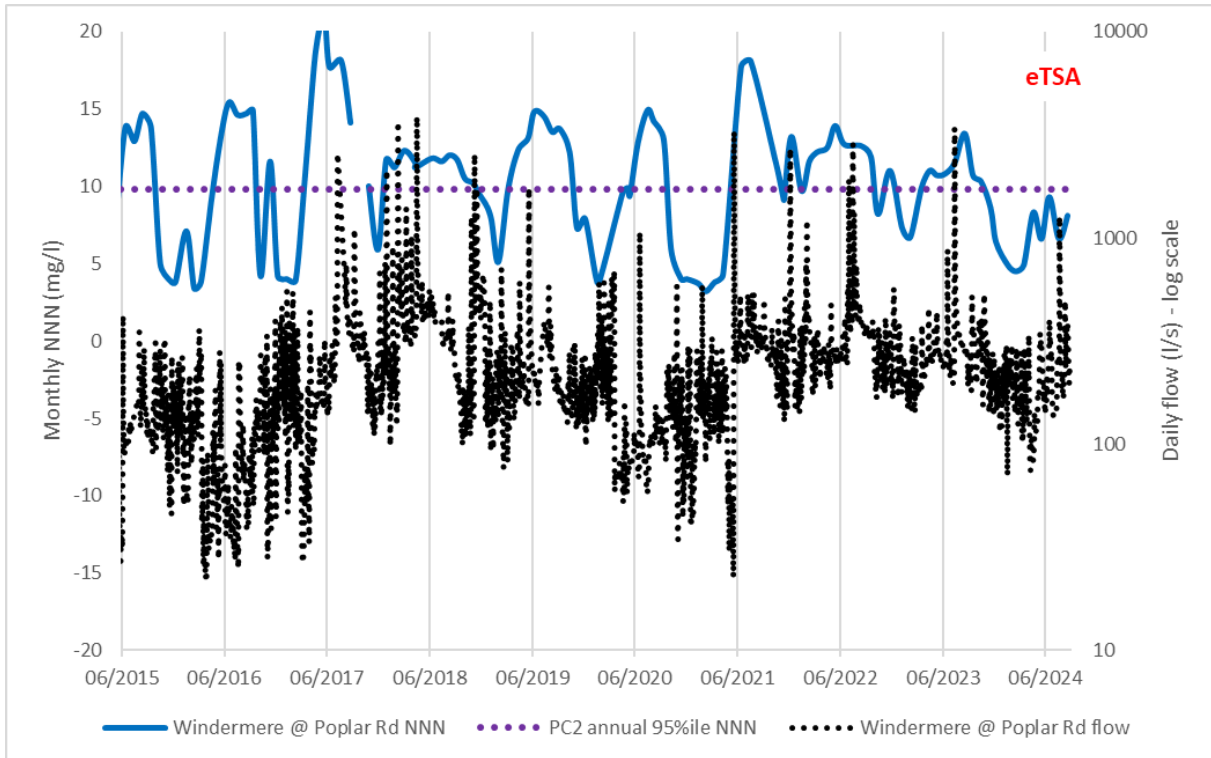


Figure 4-10: Windermere Drain monthly NNN and flow monitoring, with the TSA Enhancement project beginning in May 2024 (Source: CRC, MHV Water)

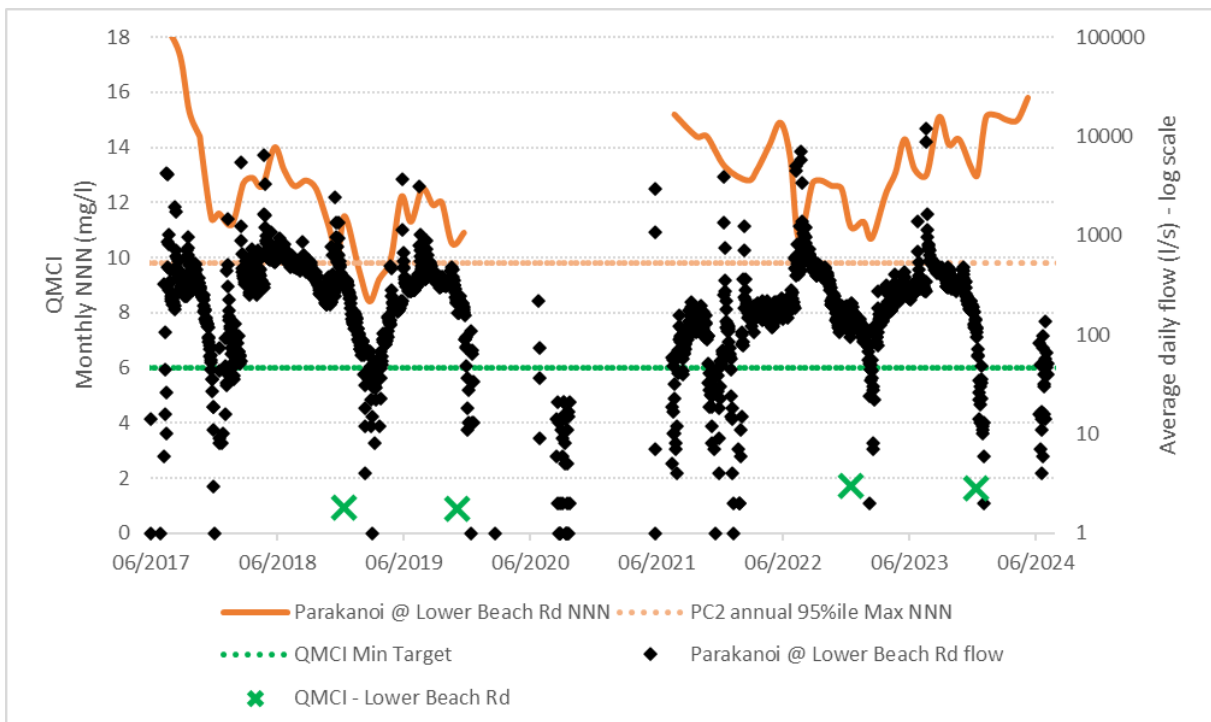


Figure 4-11: Parakanoi Drain monthly NNN monitoring, flow and QMCI (Source: CRC, MHV Water)

5 Irrigation Nutrient Recycling

The Irrigation Nutrient Recycling workstream is a catchment-wide HHWET initiative that focuses on supporting the incorporation of groundwater and drain irrigation water nutrients in on-farm fertiliser management. The need for this was established in Stewart & Aitchison-Earl (2020), who stated “*The chemical concentrations of the groundwater are increased by recirculation of water already relatively high in chemicals {e.g., nitrate}.*” HHWET have worked with agribusiness consultants to develop [case studies](#) for pasture and mixed cropping situations. The concept and case studies have been shared through the HHWET website, HHWET Facebook page, groundwater irrigator meetings, MHV Water shareholder communications, and HHWET presentations. Irrigation New Zealand’s Winter 2022 publication featured an article on this workstream to inform other irrigators and promote wider uptake.

The identified opportunities include:

- lowering down-gradient surface and groundwater nutrient concentrations; and
- lowering the amount and cost of external fertiliser.

However, there are challenges to improving outcomes in terms of groundwater and surface water quality including:

- increased monitoring and analysis costs;
- irrigation using groundwater and drain water covers only part of the Hekeao/Hinds Plains; and
- there are many independent irrigators, each with individual situations.

During 2023/24, this workstream has been discussed with groundwater users and farm advisors across the catchment, with indications that pasture irrigators using groundwater are beginning to incorporate groundwater nutrients in their fertiliser decisions. Cropping farmers have also indicated that they will incorporate groundwater nutrients in their fertiliser decisions when irrigation/fertiliser timing allows. The first farm (beside Isleworth Road, Lowcliffe) was also chosen for detailed assessments, with monitoring equipment installed, and background monitoring begun. This trial will formally start during Spring 2024.

6 Business Case Addendum

HHWET published a Business Case in 2020, supported by 2018 economic analysis from Macfarlane Rural Business (MRB). The 2020 Business Case is available to view at www.hhwet.org.nz/technical-data.

In 2023, MRB conducted an updated economic analysis to inform HHWET’s review of targeted rate funding requirements. The 2023 MRB economic analysis followed a robust, peer reviewed methodology and accounted for:

- updated HHWET cost projections;
- updated farm infrastructure information;
- updated farm systems information;
- currently available ‘levers’ to further reduce on-farm nutrient losses; and
- current economic conditions.

The economic analysis compares HHWET’s costs with regional economic benefits. It demonstrates that continuing HHWET activities saves:

- Hekeao/Hinds Plains landowners an additional one-off decrease in total capital asset value of **\$2.2 billion**;
- Hekeao/Hinds Plains farmers an additional annual reduction in farm gate profit of **\$108 million**; and

- regional businesses an additional annual reduction in spending of **\$355 million**.

To reach these findings, MRB compared the following economic indicators (2018 vs 2023) for two scenarios (with and without HHWET activities). Table 6-1 shows how HHWET activities represent consistent cost savings for farmers and the regional economy.

Table 6-1: HHWET Business Case comparison

Economic indicator	with/without HHWET	2018	2023
Farm asset value change from current (one-off)	with HHWET activities	-\$8,271/ha	-\$3,147/ha
	without HHWET activities	-\$20,077/ha	-\$20,608/ha
Farm Net Profit After Tax (NPAT) change (annual)	with HHWET activities	-\$364/ha	-\$64/ha
	without HHWET activities	-\$420/ha	-\$910/ha
Change in Regional Spend (annual)	with HHWET activities	-\$207 million	-\$243 million
	without HHWET activities	-\$370 million	-\$598 million

The annual cost of HHWET activities (including debt repayment) over the next seven years is expected to range from \$2 million to \$2.6 million. Significant infrastructure investment is planned during this period. The targeted rate noted above covers HHWET's costs. The 2023 benefit for landowners can be calculated from farm NPAT ((910-64)*127,000 hectares) as \$108 million. With these costs and benefits in mind, the benefit:cost ratio of HHWET activities is approximately 50:1 (using \$108 million vs \$2.1 million). For ratepayers, this represents a very strong value proposition for continuing HHWET activities.

The primary risks for HHWET are consenting delays, access to water, and the cost of accessing water. HHWET consider these risks to be acceptable, as mitigations are in place. The primary consenting process has been delayed but is now well advanced, key water supply agreements are in place, and water volumetric requirements have decreased due to improved understanding and complementary lower catchment activities.

7 HHWET Objectives and Next Steps

HHWET objectives are set annually in five subject areas. HHWET 2023/24 objectives were met except for those influenced by consenting delays. Year 8 (2032/24) achievements are summarised as follows:

1. Governance
 - a. Monthly HHWET meetings took place (except January), attended by HHWET Trustees, a Central South Island Fish and Game Council observer/advisor, Mid Canterbury Catchment Collective representatives, the HHWET Executive Director and contracted minutes secretary.
 - b. An annual public meeting and Hekeao/Hinds Science Collaboration Group meetings took place.
 - c. There was a farewell to departing Central South Island Fish and Game Council observer/advisor, Mark Webb.
 - d. A variation to the Access Agreement was finalised with Rangitata Diversion Race Management (RDRML).
 - e. HHWET Purposes and Objectives were reviewed and amended for the 2024/25 Business Plan.

- f. An updated Economic Analysis report was completed by MRB to support a new Business Case Addendum.
 - g. Long term dual (stockwater/MAR) use of an ADC water race to supply MAR01 was agreed with ADC.
2. Communications
- a. The HHWET website (www.hhwet.org.nz) and HHWET Facebook page (@HekeaoHindsWET) continued to reach new people and a LinkedIn page was launched (www.linkedin.com/company/hekeao-hinds-water-enhancement-trust)
 - b. The Hekeao/Hinds Science Collaboration Communications Strategy was approved.
 - c. Wider communications were achieved through 9 presentations/articles relevant to the wider community, 6 presentations/articles relevant to the farming community, and an article in the Lincoln Agritech Annual Report.
 - d. Enabling Regulatory Environment
 - e. CRC233041, for use of up to 3200 l/s surface water for MAR purposes, supplementary to RDRML consent CRC182542 was lodged on behalf of RDRML in December 2022.
 - f. 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 lodged in December 2022.
 - g. CRC233851, to discharge up to 410 l/s at Near River Recharge Site #1 (NRR1) was lodged in March 2023.
 - h. CRC233852, to undertake works in the bed of the Hekeao/Hinds River (for NRR site construction) was lodged in March 2023.
 - i. CRC233853, to discharge up to 200 l/s in total at NRR2 and NRR3 was lodged in March 2023.
 - j. CRC234782 and CRC234783 for eClean Bioreactor take, use and discharge was lodged on behalf of Ortoongreen farm in May 2023 and granted in June 2024.
3. Access to water
- a. HHWET-RDRML Water Supply Agreement for the generation season was finalised.
4. Proof of concept
- a. Prioritisation of new MAR/NRR site construction in the Hekeao/Hinds Environmental Enhancement Scheme was completed.
 - b. HHWET are a project partner in the trialling of the eClean bioreactor in Hekeao/Hinds. During 2023/24, the required consents were granted, and the site was prepared for operations.
 - c. The Windermere Drain TSA Enhancement project with ECGIS began in May 2024.
 - d. Monitoring equipment for the first Irrigation Nutrient Recycling trial was installed and background monitoring begun.
 - e. MSc support for Madeleine Inglis (Microbial pathogen risk from MAR) continued via background monitoring. Her primary MAR01 *E. coli* trial is timed for July 2024.
 - f. Preliminary design and assessments of effects were undertaken for potential lower catchment constructed wetland sites to inform consent applications. The operating constructed wetland pilot site was monitored, with promising nitrate monitoring results.

- g. Potential existing groundwater consents were identified for a shadow TSA consent application targeting the lower Hinds River, O'Shaughnessy's Drain and Parakanoi Drain.
5. Collaboration
- a. Oversight of the Hekeao/Hinds Science Collaboration Group continued, with development of a Vadose zone Monitoring System (VMS) project the key focus.
 - b. Master of Water Resource Management (MWRM) supervision of Sidinei Teixeira was completed following thesis lodgement (*Hydrological drivers influencing nitrate nitrogen changes in an alluvial aquifer*).
 - c. PhD supervision of Justin Legg was started (*Hekeao/Hinds nitrogen drivers and solutions*).
 - d. Maintenance of 17,500 new 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 2024 by confirming the following objectives through to 30 June 2025, along with a commitment to continue the ICM approach presented in Figure ES-1 (Executive Summary) for the achievement of the Hekeao/Hinds Environmental Enhancement Scheme presented in Figure ES-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 m³/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 (equivalent to a maximum of 117 million m³/year).

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 m³/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.
- 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.

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