Hekeao/Hinds Managed Aquifer Recharge Trial

Year 3 Annual Report

(June 2018 – May 2019)

Mark Trewartha (Environment Canterbury)
Brett Painter (Environment Canterbury)
William Dench (MHV Water)

November 2019

Chairman's Foreword

In Year Three the Managed Aquifer Recharge pilot trial programme has seen significant progress in the construction and commissioning of smaller test sites, completion and operation of the Hekeao Hinds River Near River Recharge site and changes to the long-term scheme governance.

The MAR project "flagship" site at Frazer's Road Timaru Track continues to provide valuable data and vastly improved water quality and quantity down gradient of the site. The ongoing monitoring associated with this site will continue until at least the end of the five-year trial period.

A limiting factor this year has been the interruption of supply due to winter maintenance needed on the MHV Water Valetta pipeline.

Consenting, construction and aquifer testing of 16 small test sites was completed; consequently, two were shut down leaving the rest to operate as fully functioning MAR sites. These sites are proving to be cost effective infiltration methods targeting areas of high groundwater nutrients or as protection for community water supply.

The Hekeao Hinds River Recharge site constructed near the RDR South Hinds River siphon was commissioned in September 2018. This site includes lizard rock piles, a large area of native planting and a wetland that will benefit from the recharge operations.

Governance of the Hekeao/Hinds MAR pilot trial project has transitioned from the MAR Governance Group to a community non-profit trust, the Hekeao/Hinds Water Enhancement Trust (HHWET).

This year has seen significant change in the personnel involved in the governance of MAR and the operational management of the scheme.

I would like to sincerely thank the people that have been involved in the past and those that have now stepped up to be involved in this project going forward.

The MAR trial has enjoyed considerable support from the wider Ashburton community and businesses, Ashburton District Council, Environment Canterbury and Central Government. On behalf of the Hekeao/Hinds Water Enhancement Trust I wish to thank all those involved for their ongoing support.

The ongoing MAR pilot trial is clearly demonstrating that MAR is a viable tool in conjunction with the necessary on farm nutrient reduction to achieve the community agreed water quantity and quality goals in this catchment.

Peter Lowe

Chair
Hekeao/Hinds Water Enhancement Trust

Acknowledgements

The authors wish to thank the Hekeao Hinds MAR Governance Group for project oversight, Mark Webb (Central South Island Fish and Game) for the fish survey and drains enhancement sections, MHV Water, RDRML, Lincoln Agritech and Environment Canterbury field staff for monitoring information.

Executive summary

Background:

Aquifer recharge happens both naturally and artificially every minute of every day and is the reason aquifers and spring-fed waterways exist at all. Recharge from rainfall, rivers, unlined water races and canals, and irrigation activities all act to continually recharge groundwater. These kinds of recharge lead to increased water levels and influence the quality of water in the aquifer. Managed Aquifer Recharge (MAR) is the purposeful recharge of specifically clean water into an aquifer to both complement and mimic these natural processes.

The problem:

The Hekeao Hinds MAR Trial is a response to recommendations from the Hinds Drains Working Party and Ashburton Zone Committee through Plan Change 2 to Canterbury's Land and Water Regional Plan (PC2). These recommendations were based on analysis of historical monitoring information that showed declining water quality and groundwater levels, as well as potential future water quality and quantity levels from a variety of landuse and water management scenarios. Applying a combination of improved on-farm nutrient management, irrigated area constraints and MAR in this region was proposed to address four key objectives:

- Target and protect drinking water supplies;
- Enhance groundwater quality;
- Improve baseflows to spring-fed streams and rivers for ecological, cultural and social values; and
- Improve and sustainably manage groundwater storage (levels).

The Hekeao Hinds MAR Trial was designed to determine proof of concept for this situation. For the Hekeao Hinds MAR Recharge Project, proof of concept is considered achieved if project trials determine that MAR is applicable in the Hinds region to intentionally recharge clean water to aquifers for the purpose of water quantity recovery (rise in groundwater levels) and/or achieve environmental benefits to the aquifer (reduce nitrogen-nitrate concentrations for the protection of human health and the environment).

What we did:

This report summarises Hekeao Hinds MAR Trial results and analysis from the third year of operations (June 2018 – May 2019) and priorities for Year 4. During Year 3 of the Trial, 10 test sites and one near river recharge site became operational to join the Lagmhor Pilot Site. Total recharged volume increased from 2.2 million cubic metres in Year 2 to approximately 5.5 million cubic metres. PC2 analysis estimated that an annual MAR requirement of approximately 125 million cubic metres would be required to fulfil its role (alongside on-farm leaching reduction and irrigated area constraints) in reaching PC2 water quantity and quality goals.

Supply to MAR sites was managed according to inflow water quality and groundwater level consent constraints as well as distribution infrastructure constraints (due to irrigation supply priority or infrastructure shutdown).

What we found:

Key learnings from Year 3 include:

- At the Lagmhor Pilot Site construction of a deep soakage system in combination with sediment removal and higher basin depth operation has increased recharge rates by at least 30%. Monitored groundwater nitrate-nitrogen concentrations down-gradient from the Lagmhor Pilot Site remained low, with a summer increase connected to site shutdown during July – September.
- The Hekeao Hinds River Project (HHRP) near river recharge site performed consistently following its commissioning in late September 2018. Recharge site and Hekeao Hinds River flow monitoring shows some recharged water stays in the groundwater system while other water re-emerges in the Hekeao Hinds River before recharging back to groundwater further down river. Above average river flows and groundwater levels, as well as the 5-6 km distance down gradient to monitoring bores, has made the HHRP influence challenging to identify at this distance. However, the cumulative contribution of clean water to this system is measurable and has been positive.
- Proof of concept was established for the trial test sites design, with direct connection to an irrigation pond preferred over stockwater race supply for water quality (in particular *E. coli*) and sediment management purposes. Analysis for all test sites has involved recharge potential assessments and identifying ways to maximise their clean water recharge volume through distribution and site upgrades. Consent amendments are in process to enable implementation of these improvements.

What does it mean?

Year 3 results provide confidence that proof-of-concept has been established for all MAR designs trialled to date. The test site results also show that their current scale is too small to have a measurable influence on the down-gradient catchment. A key challenge for Year 4 is therefore assessing and up-scaling the high performing test sites as well as progressing additional MAR supply, in particular for parts of the catchment with high nitrate-nitrogen groundwater concentrations in the vicinity of community drinking water supplies.

How we have considered climate change:

Changing patterns of rainfall and evapotranspiration are increasingly affecting groundwater through the timing, quantity and quality of land surface recharge and river recharge. By using long historical datasets where possible and considering climate cycles and trends in analyses, the Managed Aquifer Recharge trial is responding to climate change through site selection and operational decisions.

Table of contents

List of Figures

List of Tables

1 Context

Plan Change 2 to Canterbury's Land and Water Regional Plan (PC2) includes requirements to reduce on-farm nitrogen losses by up to 36% by 2035 and reduce average annual shallow groundwater concentrations of nitrate-nitrogen to a target of <6.9 mg/l by 2035. The 2018 nitrate-nitrogen PC2 update (Figure 1-1) provides sobering viewing, with average annual shallow groundwater concentrations exceeding the New Zealand Drinking Water Maximum Acceptable Value and well above the 6.9 mg/l target for 2035. Historical changes to landuse, water distribution infrastructure, irrigation methods and climate (including the 2014/15 drought) will all influence these groundwater concentrations through complex and difficult to quantify interactions.

PC2 analysis estimated that an annual MAR requirement of approximately 125 million cubic metres would be required to fulfil its role (alongside on-farm leaching reduction and irrigated area constraints) in reaching PC2 water quantity and quality goals. Table 1-1 (below) shows that the total recharged MAR volume in Year 3 was approximately 5.5 million cubic metres. At previous annual recharge rates, the MAR Trial has shown positive localized effects for water quantity and quality. However, because of the relatively limited amount of water available for MAR (compared to what is needed for regional impacts), the effects are localized and not yet measurable on a catchment scale.

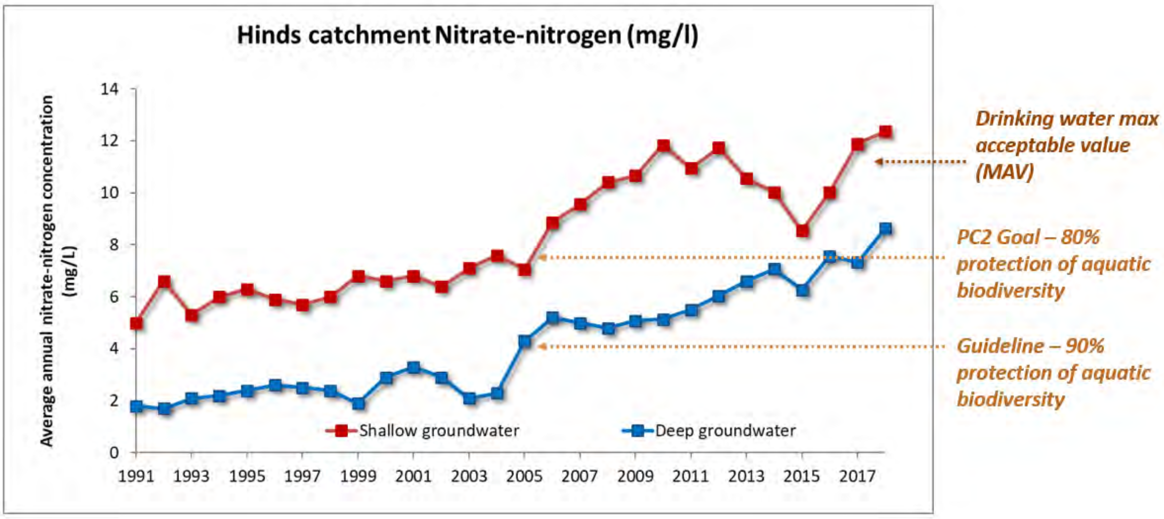

Figure 1-1: Plan Change 2 to Canterbury's Land and Water Regional Plan – Hinds Plains average annual nitrate-nitrogen concentrations

Table 1-1: Year 3 Hekeao/Hinds MAR take and delivery – water budget

	MAR Volume (cubic metres)
Opening balance – Year 2 take not delivered	**73,000**
Year 3 take through RDR	5,124,825
Total Year 3 inflow	**5,197,825**
Delivered to Pilot Site #1	2,160,255
Delivered to HHRP Site #2	1,678,925
Delivered to Test Sites #3-17	1,680,335
Total Year 3 delivered flow	**5,519,515**

2 Lagmhor Pilot Site

The Lagmhor Pilot Site (Site #1) is a 0.9 ha recharge basin inland from Tinwald. Pre-construction modelling and infiltration testing suggested a potential infiltration/recharge rate of approximately 500 l/s, with significant lateral as well as down-gradient influence. The actual infiltration rate during the first two years was approximately 80-100 l/s, with the zone of influence initially limited to a down-gradient paleo-channel before joining nearby groundwater feeding lowland springs. Following further site investigations during Year 2, the necessary consents were confirmed and the site was shut down for construction of a deep soakage system from 4 July to 21 September 2018 (see Figure 2-1). Initial testing showed that recharge rates were similar with the soakage system operating ‘open’ and ‘closed’. This is most likely due to the lack of highly transmissive aquifer material in the core intercepted by the soakage system. The system was therefore left ‘closed’ and the sand filter not constructed. Following construction and testing, accumulated sediment from Year 1 & 2 operations was also removed from the recharge basins and up-gradient delivery channel.

Year 3 monitoring operations continued those undertaken in Year 2, while also monitoring the potential extended influence during Year 3. Monitoring methodologies follow those presented in the Year 2 report, updated as required for current consent conditions (CRC164281, CRC183882 and CRC184617) and monitoring locations. Compliance monitoring results are presented in the Annual Compliance Report 2018-19. Discharge was not required to cease for Hinds Plains Rainfall & Parakanoi Drain flow exceedance or *E. coli* exceedance during Year 3.

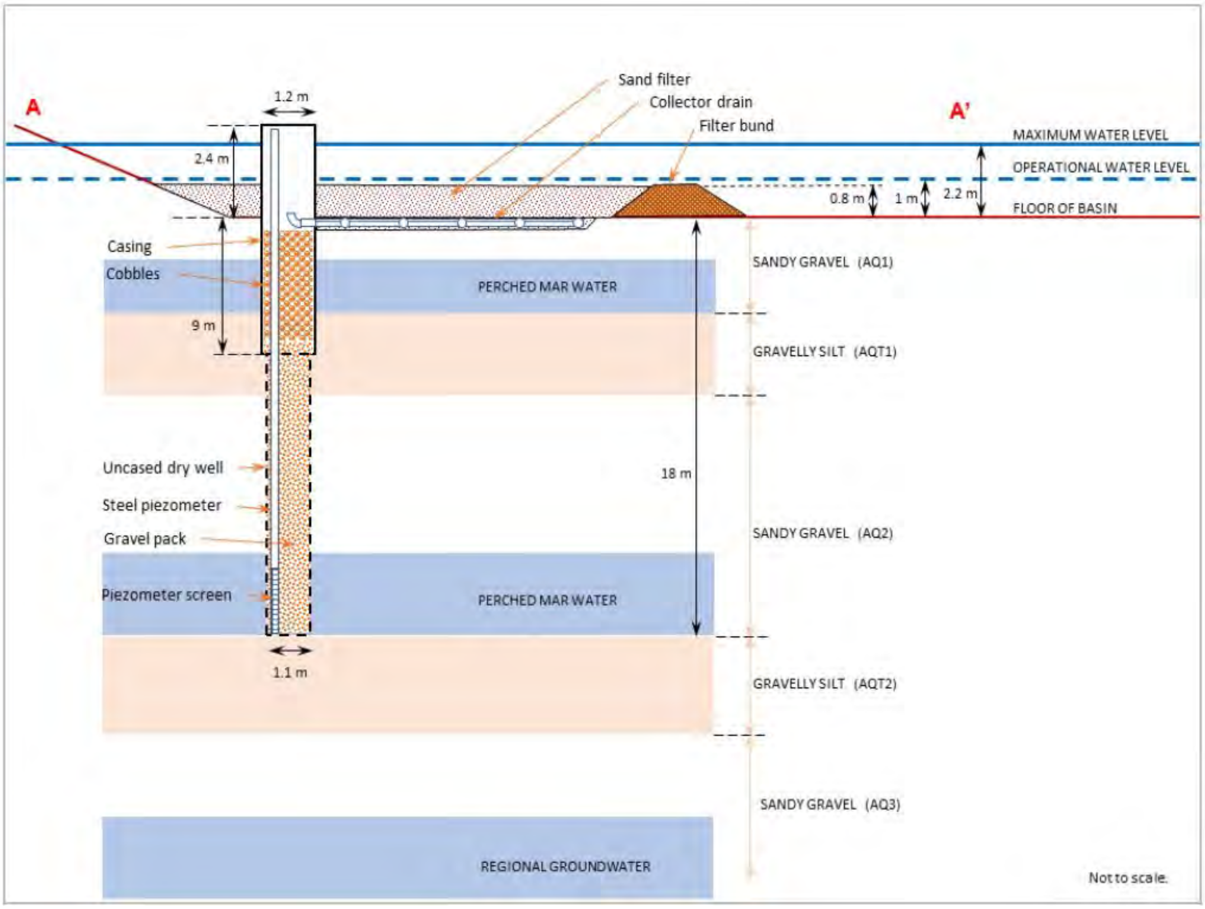

Figure 2-1: Lagmhor Pilot Site “soakage system” upgrade design

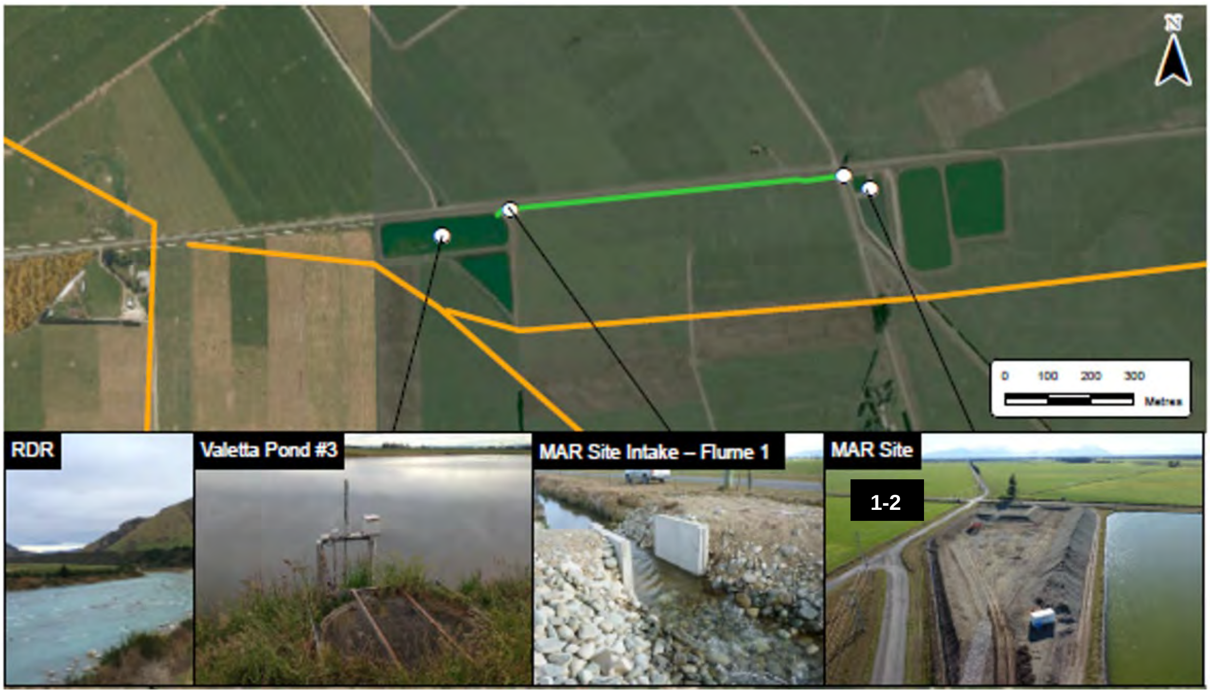

Figure 2-2: Lagmhor Pilot Site infrastructure

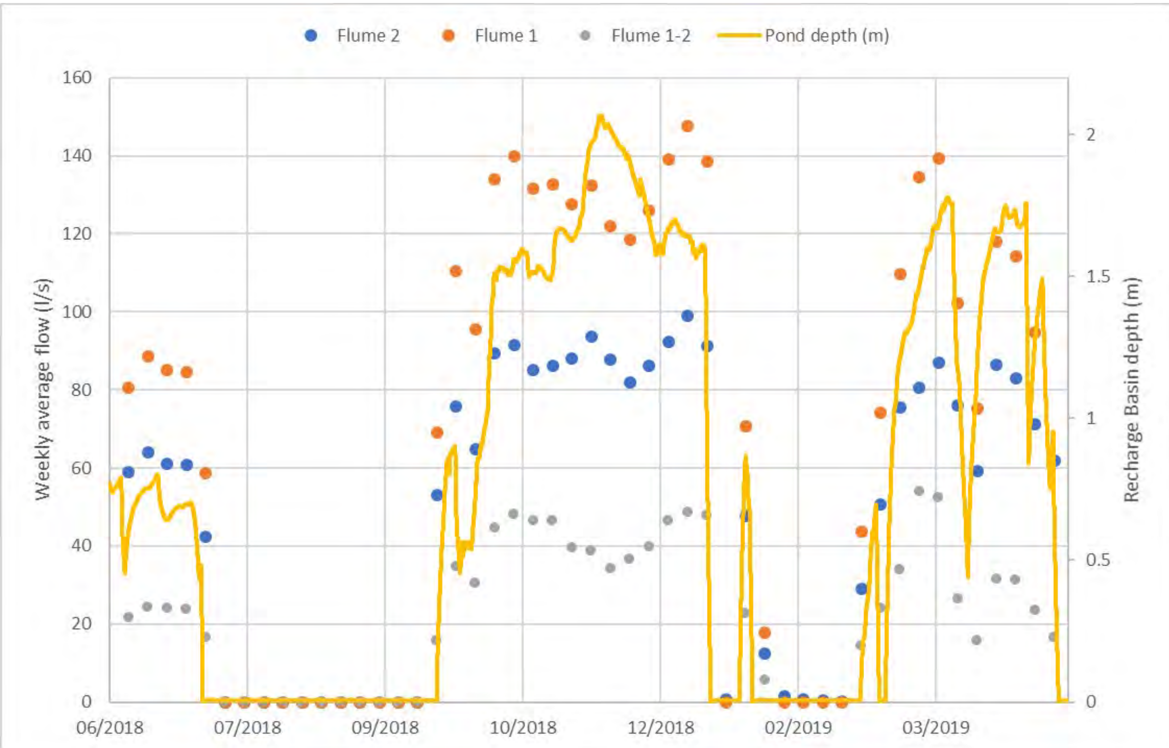

Figure 2-3: Lagmhor Pilot Site operational monitoring

In the Lagmhor Pilot Site operational monitoring (Figures 2-2 and 2-3), Flume 1 shows flows exiting the up-gradient irrigation pond (Pond 3), Flume 2 shows the inflow to the Pilot Site recharge basins, Flume 1-2 shows the calculated recharge / losses from the delivery race, and Pond Depth shows the depth of the main Pilot Site basin. Flows at Flume 1 have previously been overestimated by the flume due to weed growth immediately beneath the flume. In March 2019, Giles Pinfold (MHV Water) noted that Flume 1 (Pond 3 outflow) was reading approximately 30 l/s higher than Pond 3 inflow while pond depth remained constant. Flume 1 readings have therefore been reduced by 30 l/s for the Flume 1 readings from March to June 2019. This brings all Flume flows in line with similar conditions in late 2018. During the winter 2019 shutdown, Flume 1 weeds are being sprayed and checked.

Prior to the Spring 2018 soakage system upgrade total recharge (from Flume 1) was estimated at 80-85 l/s with a main basin depth of approximately 0.7 m. Of this recharge, approximately 20-25 l/s (just under 30%) was estimated to recharge through the delivery race. Following the upgrade, increased basin depths of up to 2 metres were trialled. There are few periods of stable basin depth available to estimate total recharge, but an upper bound of 120-130 l/s (with race recharge still approximately 30% of Flume 1 flow) appears reasonable. Increased basin depth, removal of sediment and the new soakage system are all likely to have contributed to this increase.

During Year 3, the principal down-gradient monitoring site (GWD-04 or BY20/0152) continued to respond to Pilot Site operations in a similar manner to previous years. Groundwater levels rose and fell a few weeks after significant changes in Pilot Site operations, while nitrate-nitrogen concentration response time was a number of weeks longer (Figure 2-4).

In January 2019, the groundwater nitrate tracker in GWD-04 (BY20/0152) was moved to GWD-06 (BY21/0183) to pre-empt any potentially measurable Pilot Site influence. Well water was initially too turbid for the optical sensor in the nitrate tracker, but after repeated maintenance (i.e., cleaning of sensor and well)the sensor began logging nitrate-nitrogen concentrations of 12-13 mg/l in April 2019 (see Figure 2-5). The "non nitrate absorbance" presented in Figure 2.5 is the optical interference primarily provided by the suspended sediment. Monitoring of this well will continue (in comparison with nearby wells) to assess whether any future decreases in nitrate-nitrogen can be attributed to Pilot Site operations.

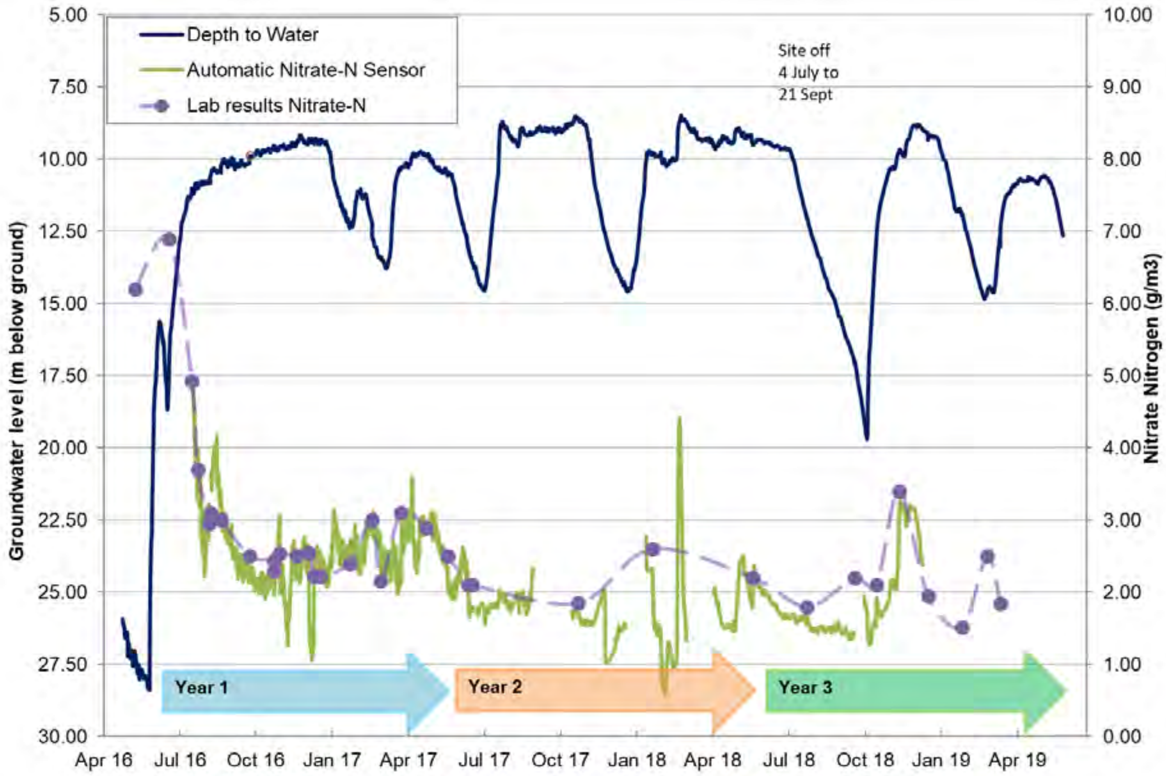

Figure 2-4: Year 1-3 Pilot Site - Water Quantity and Quality Composite Results for GWD-04 (BY20/0152)

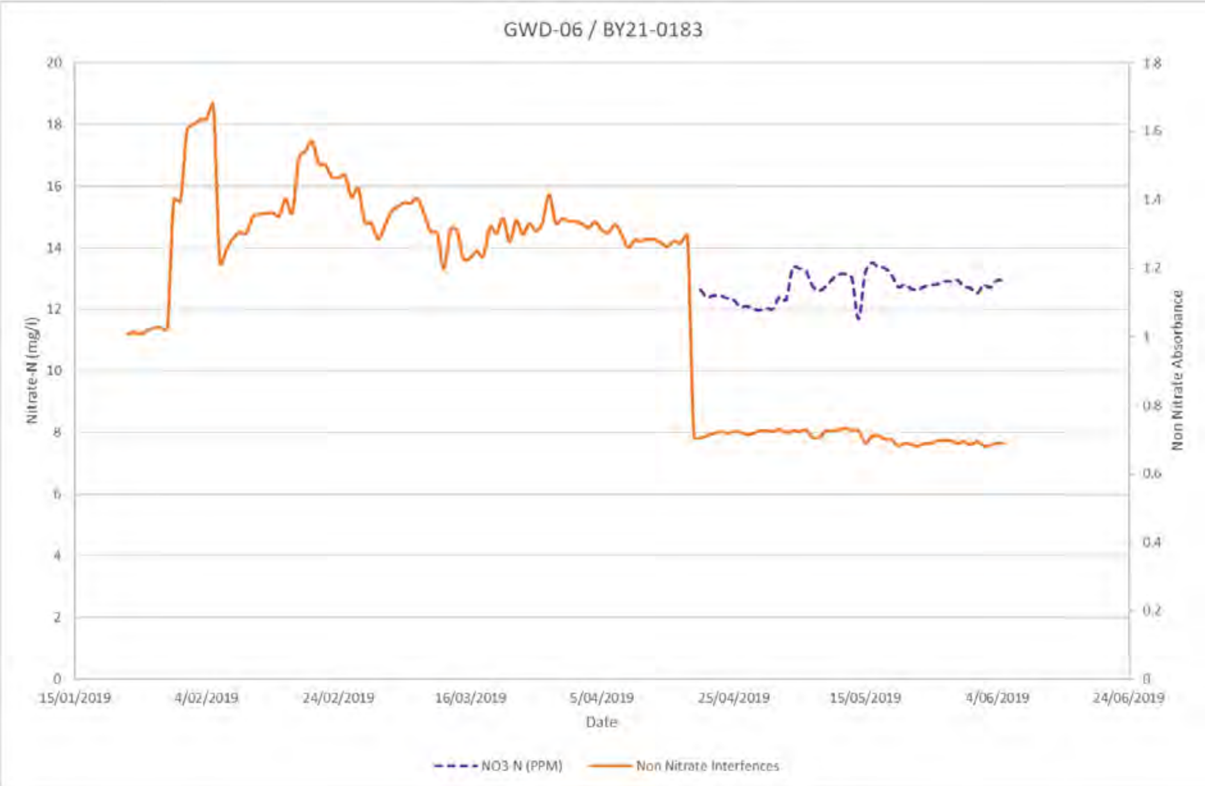

Figure 2-5: Nitrogen tracker commissioning in GWD06 (BY21/0183)

2.1 Groundwater quantity monitoring

Recharge from the Pilot Site causes a groundwater pressure response which increases connected local groundwater levels relatively quickly, with local geology and hydraulic gradient determining the pressure response shape. Land surface recharge from rainfall, irrigation and race losses also increase groundwater levels, while groundwater pumping decreases groundwater levels. The relative proportions of these effects determine the groundwater level changes over time at different locations. To assist in understanding the influence of Pilot Site recharge on groundwater levels, loggers with a 15 minute recording interval were installed in potentially influenced wells, numbered GWD01 to GWD06 in Figure 2-6.

Figure 2-6: Pilot Site groundwater level monitoring

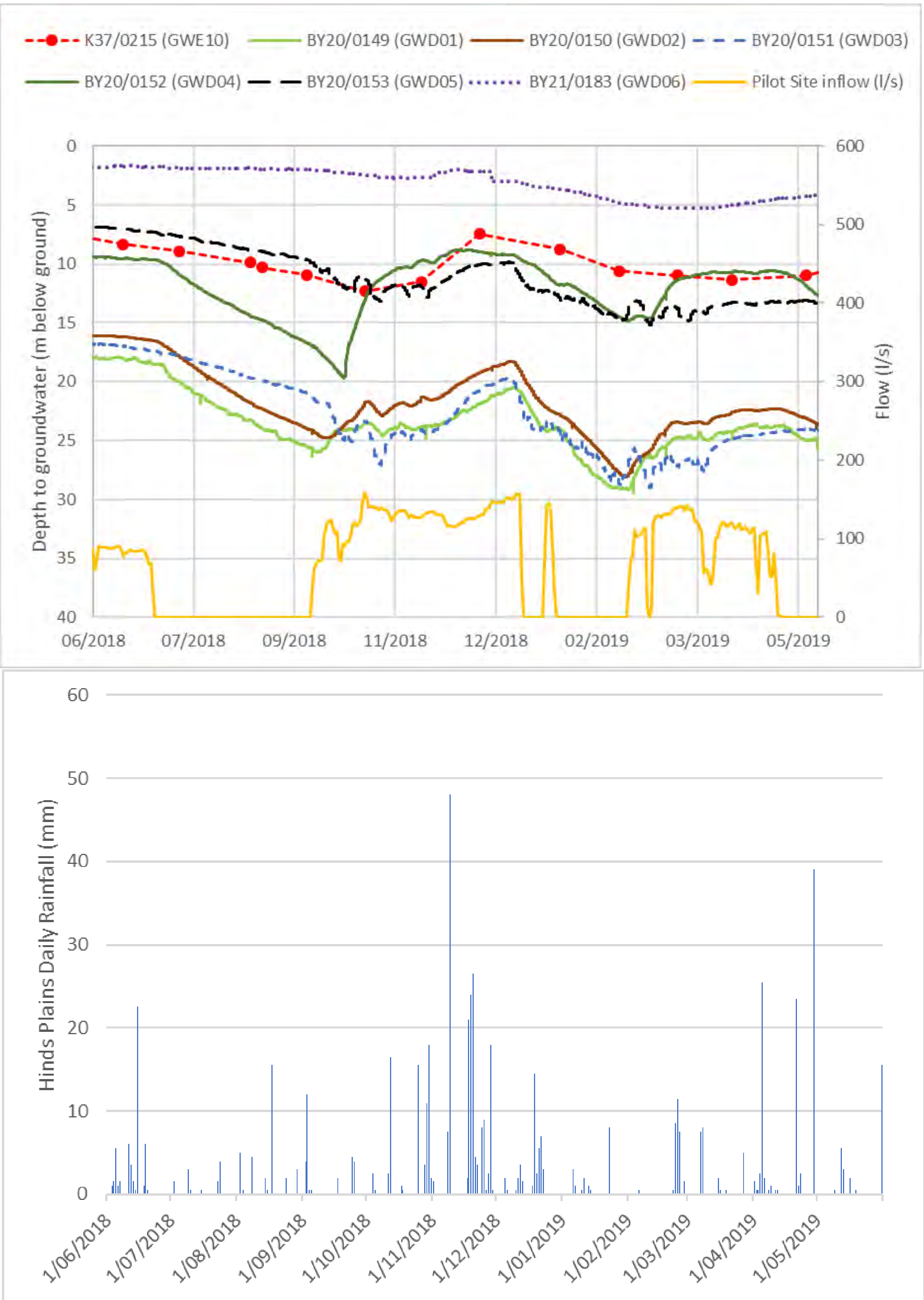

Figure 2-7: Pilot Site groundwater level, inflow and rainfall

Figure 2-7 presents Year 3 monitoring of these groundwater levels alongside an up-gradient well (K37/0215) with daily groundwater levels, daily rainfall (Hinds Plains, CRC Site 319602) and Pilot Site supply flow. Figure 2-7 shows that all well levels rise in response to the significant rainfall periods of November/December 2018 and April 2019. All wells also decrease rapidly in January 2019, most likely due to a combination of low rainfall and increased irrigation abstraction. In addition, wells presented as a solid line (GWD01, 02 and 04) show increasing and decreasing groundwater levels that match the timing of Pilot Site flow increases and decreases. GWD04 response is slightly later than the other two wells due to the increased distance from the Pilot Site.

To understand any potential effects from Pilot Site operations on northern Hinds Drains flow and quality, monitoring is currently focussed on the Flemington and Parakanoi Drains that originate near State Highway 1 (Figure 2-8). Both drains are gauged in their upper reaches and the Parakanoi also has a telemetered recorder in its lower reaches. In Figure 2-9 the Parakanoi recorder shows how drain flows quickly (within days) increase in response to large rain events (see also Figure 2-7). The spot gaugings do not capture the daily variability but do show increased flow down each drain and flow decreases to very low levels during extended dry periods (e.g., February 2019). With the Pilot Site not operational for much of January and February 2019, its potential contribution to drain flow during such a period of high abstraction and low rainfall cannot yet be assessed.

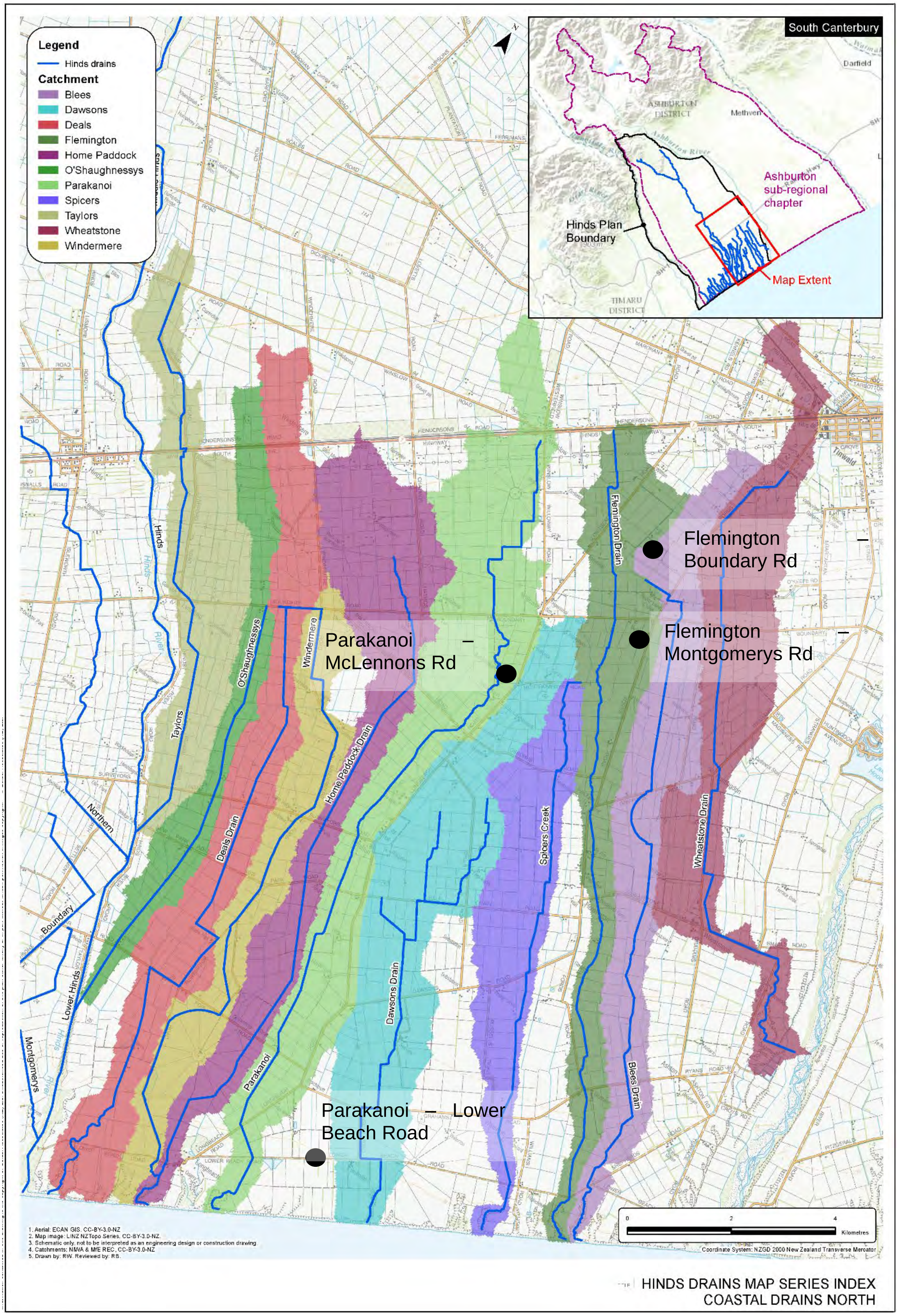

Figure 2-8: Northern Hinds Drains and key monitoring sites

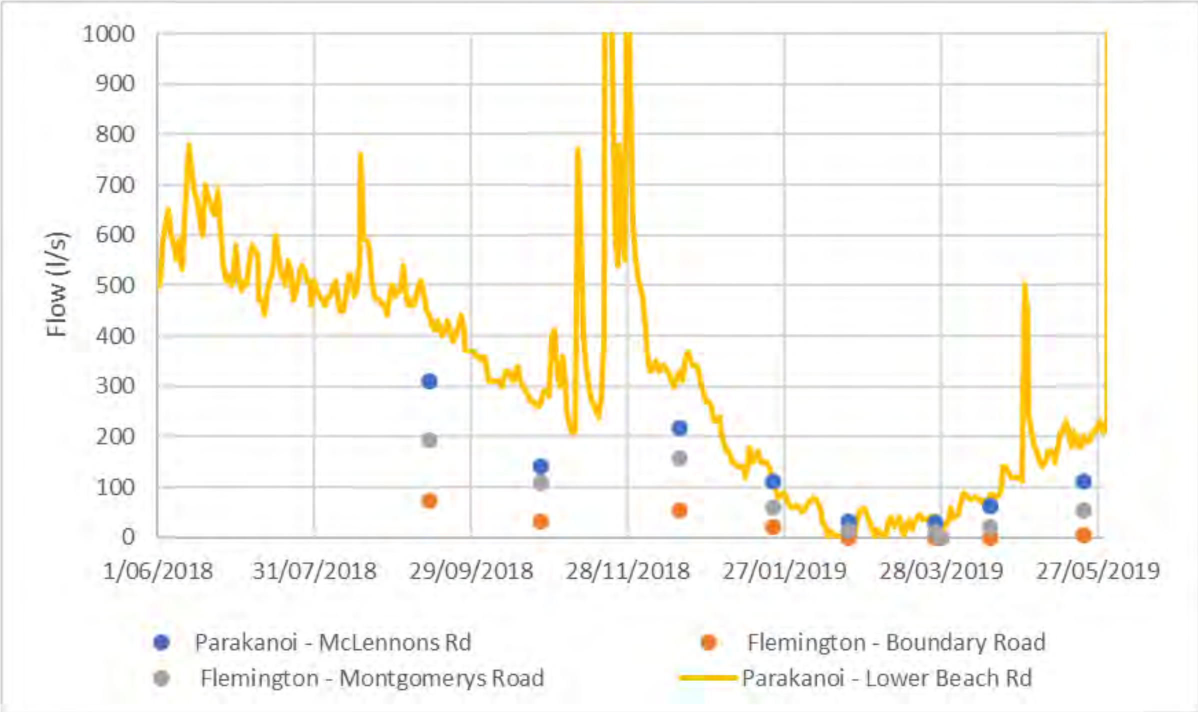

Figure 2-9: Northern Hinds Drain flows

2.2 Groundwater quality monitoring

Testing of source water MAR ensures that it is of high quality. Source water from the Rangitata River remained very low in nitrate-nitrogen (<0.2 mg/l) throughout Year 3 monitoring. Nitrate-nitrogen is the key groundwater quality parameter of interest for MAR monitoring purposes. Figure 2-10 below shows the estimated area of groundwater quality influence from the Lagmhor Pilot Site during Year 2 based on nitrate-nitrogen concentration changes in down-gradient wells and assessed groundwater flow directions (blue arrows, based on light blue piezometric contour lines). Wells coloured green showed a decrease in nitrate-nitrogen concentration and a lag time consistent with expected water particle travel time[1]. It was therefore concluded that these wells were in the Lagmhor Pilot Site zone of influence during Year 2. Wells coloured red showed an increase in nitrate-nitrogen concentration during Year 2 and it was concluded that these wells were outside the Lagmhor Pilot Site zone of influence. Wells coloured yellow showed relatively stable nitrate-nitrogen concentrations during Year 2. Wells near the assessed zone of influence may be receiving some low concentration nitrate water from Lagmhor Pilot Site operations, but the evidence was not as strong as for the green coloured wells. The black wells were monitored during Year 1 but were discontinued for a variety of reasons. The blue wells were not monitored as part of the MAR trial. Year 3 monitoring extended this assessment.

[1] http://apps.canterburymaps.govt.nz/HindsMAR/images/WGA171076_RP_HY_02_6D_Final.pdf

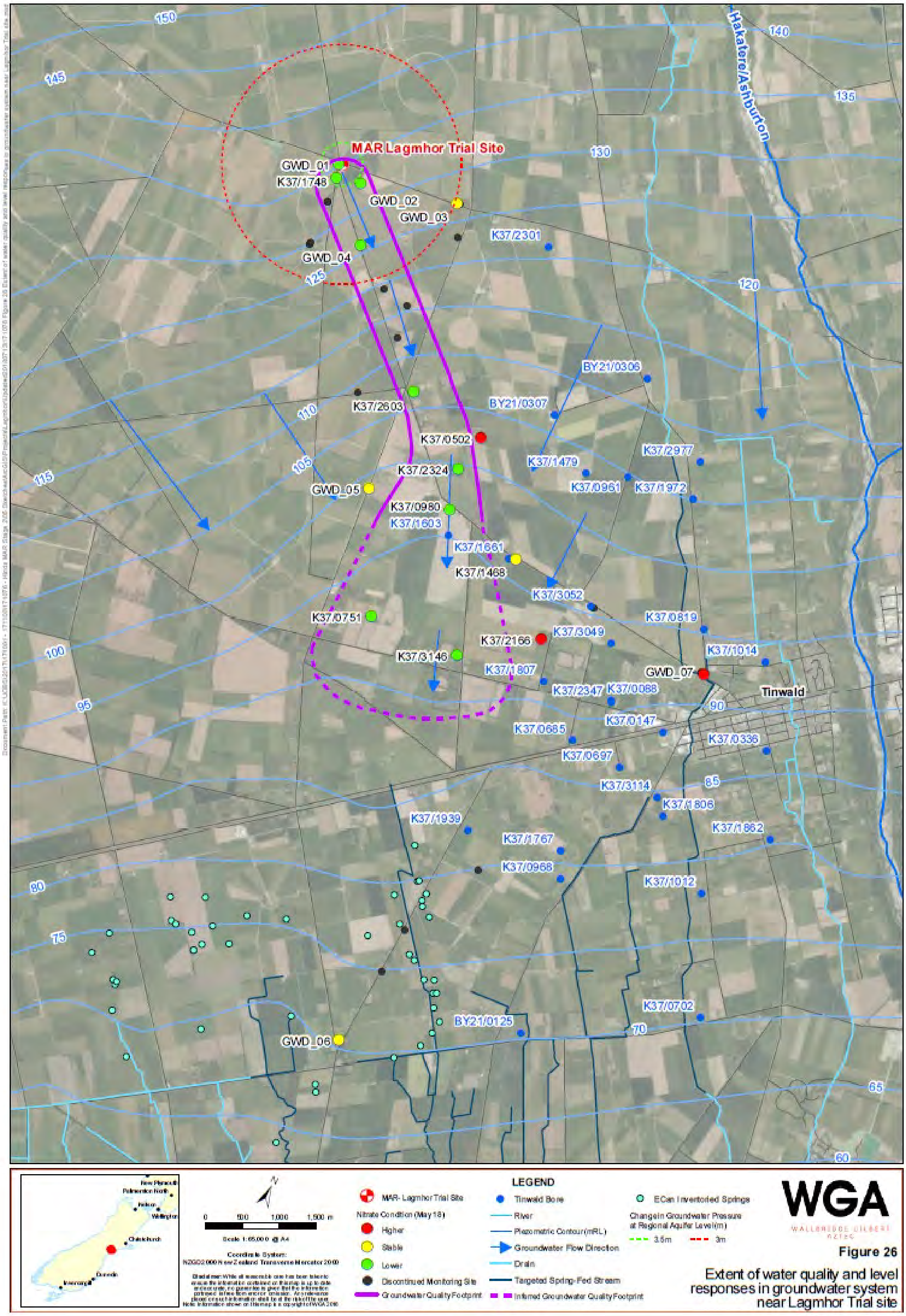

Figure 2-10: Lagmhor Pilot Site monitoring and Year 2 extent (Source: MAR Year 2 report)

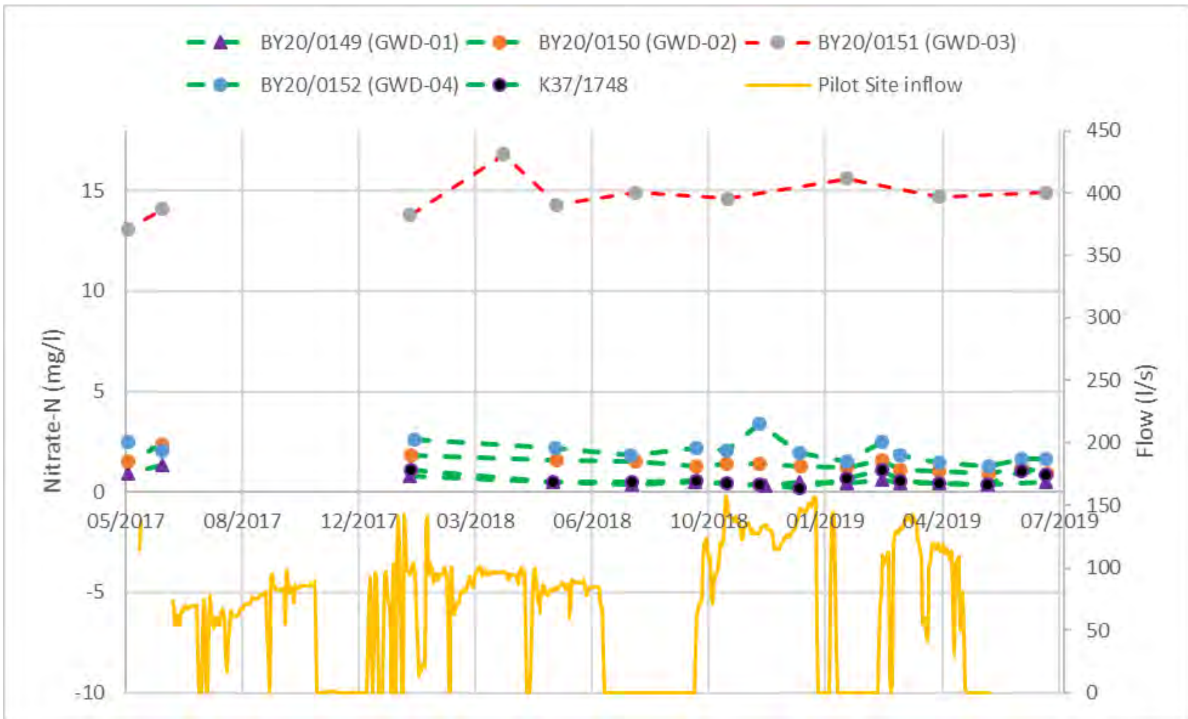

Figure 2-11: Nitrate-N for wells close to the Lagmhor Pilot Site

Ground water quality (nitrate-nitrogen) concentrations in the bores close to the Pilot Site are presented on Figure 2-11 along with Pilot Site inflows. The time period covers Year 2 and 3, with water quality data gaps from July 2017 to January 2018. The colour of the dashed lines between data points matches the colour coding in Figure 2-10. Figure 2-11 shows that GWD-03 nitrate-nitrogen concentrations remain high (unaffected by Pilot Site operations), while the other wells immediately down-gradient continue to be low in nitrate-nitrogen. Concentrations in GWD-04 rose following the July to September 2018 and early 2019 shutdowns but reduced to previous levels once operations re-started.

Figure 2-12 presents the results for monitoring wells approximately 3-5 km down-gradient from the Pilot Site. Monitoring began in January 2018 for most of these wells. As noted in the Year 2 assessment report, the influence of the Pilot Site is expected to decrease with increasing distance away from the site, due to the increasing contribution of land surface recharge and groundwater from the wider catchment. Results of the Year 3 monitoring of nitrate-nitrogen concentrations in these wells draws the same general conclusions as the Year 2 assessment; that being, there is decreasing influence with increasing distance away from the Pilot Site.

K37/0502 concentration varies but remain high, so is assessed to have no measurable water quality benefit from the Pilot Site. The water quality influence of the Pilot Site on GWD-05 remains unclear but unlikely based on lack of clear groundwater level response to Pilot Site activities (Figure 2-7). One reason why we may not be observing a response in this area is groundwater contours indicate that the local groundwater flow direction is coming from south of the Pilot Site (Figure 2-10). Nitrate-nitrogen concentrations in the other three wells decrease following Pilot Site operations and increase following site shutdowns, suggesting positive water quality contributions from the Pilot Site.

Figure 2-13 presents monitoring analysis of potentially influenced bores just up-gradient from SH1. In the Year 2 report K37/0751 and K37/3146 were assumed to be influenced by Pilot Site operations due to nitrate-nitrogen concentration decreases during Autumn 2018. Subsequent concentration increases and decreases in Year 3 follow Pilot Site flow changes in a manner that is distinct from K37/1468 and K37/2166 (as well as BY20/0153). This suggests that up-gradient effects to the north and south of the Pilot Site are unlikely to be driving concentration changes in K37/0751 and K37/3146. On-going monitoring is key to understanding whether Pilot Site recharge does have a measurable influence at this distance. Year 3 results support Year 2 conclusions that Pilot Site operations have no measurable water quality influence on K37/1468 and K37/2166.

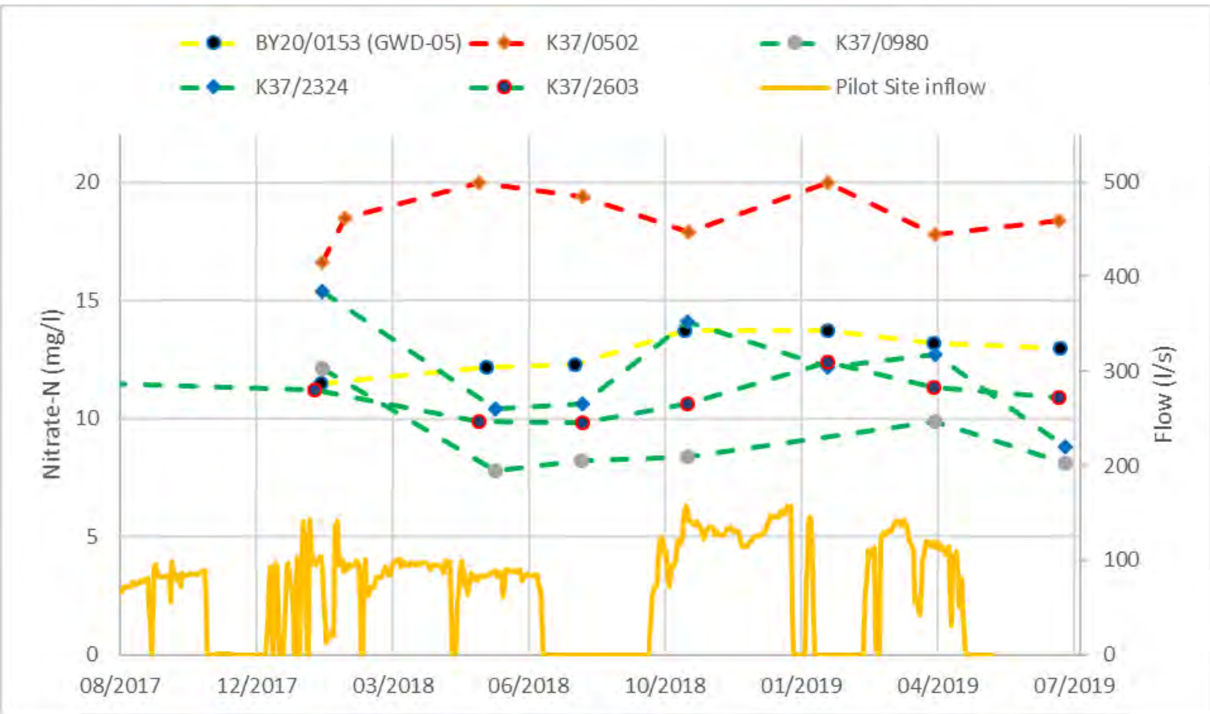

Figure 2-12: Nitrate-N for wells 3-5 km from the Lagmhor Pilot Site

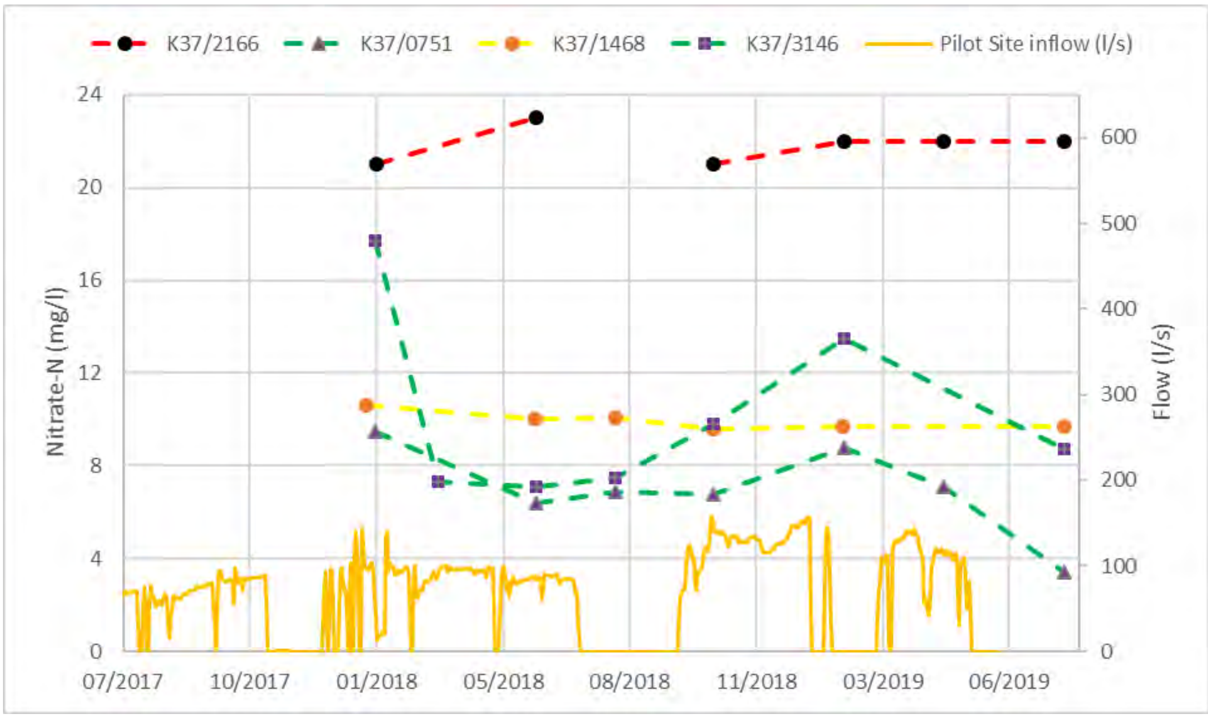

Figure 2-13: Nitrate-N for wells 6-8 km from the Lagmhor Pilot Site

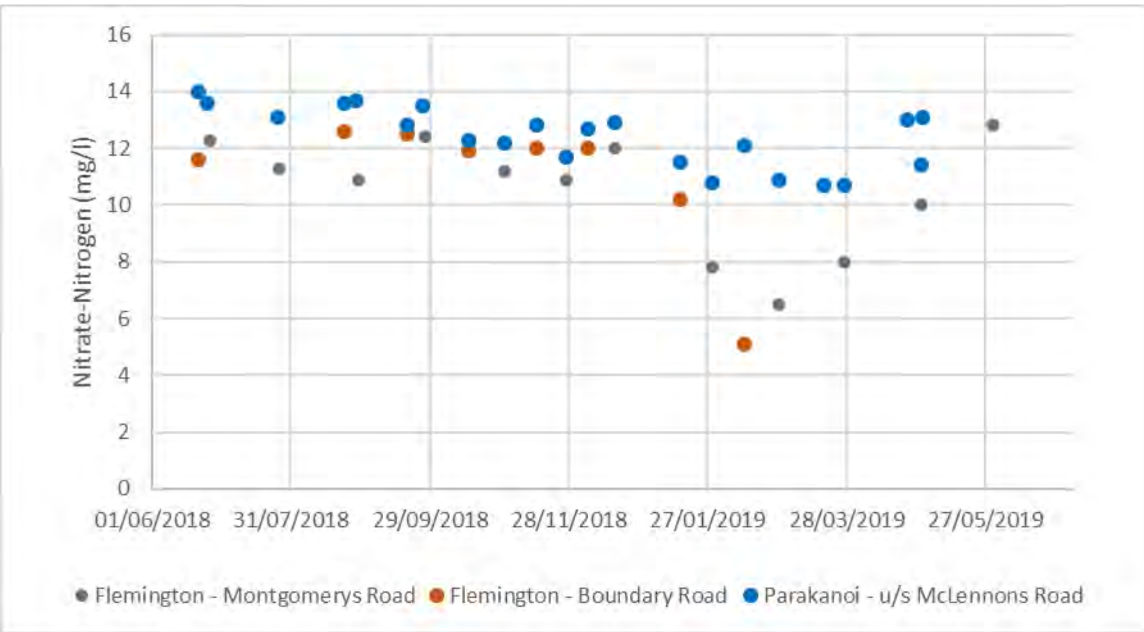

Figure 2-14: Nitrate-N for Hinds Drains of interest to Pilot Site operations

For the Hinds Drains of interest, the available water quality monitoring record extends further back than the gauging record. A comparison of Figure 2-14 with Figure 2-9 shows that Year 3 low nitrate-nitrogen concentrations align with very low flows and show no measurable Pilot Site influence. A comparison of Figure 2-14 with Figure 2-5 shows that nitrate-N concentrations in GWD-06 (situated between Flemington and Parakanoi Drains) aligns well with drain flow concentrations for the period of overlap.

3 Hekeao Hinds River Project

The Hekeao Hinds River Project (HHRP) was opened on 23 September 2018 (Figure 3.1). This site receives MAR Rangitata water via siphon directly from the Rangitata Diversion Race (RDR). Consented supply flow is 210 l/s, but only a maximum flow rate of 170 l/s has been introduced to date. In addition to the recharge channels and basins, lizard habitat has been created away from the flood plain, an oxbow wetland is supported by the raised local groundwater and native plants (wetland and dryland) have been reintroduced.

Figure 3-1: HHRP Site Opening, 23 September 2018

Figure 3-2: HHRP site overview

Figure 3.2 shows a recharge race (in green) supplying two recharge areas (in blue). Groundwater monitoring bores are situated in the clearings. Table 3-1 presents the monitoring requirements for HHRP consent CRC186228.

Table 3-1: HHRP Monitoring (CRC186228)

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

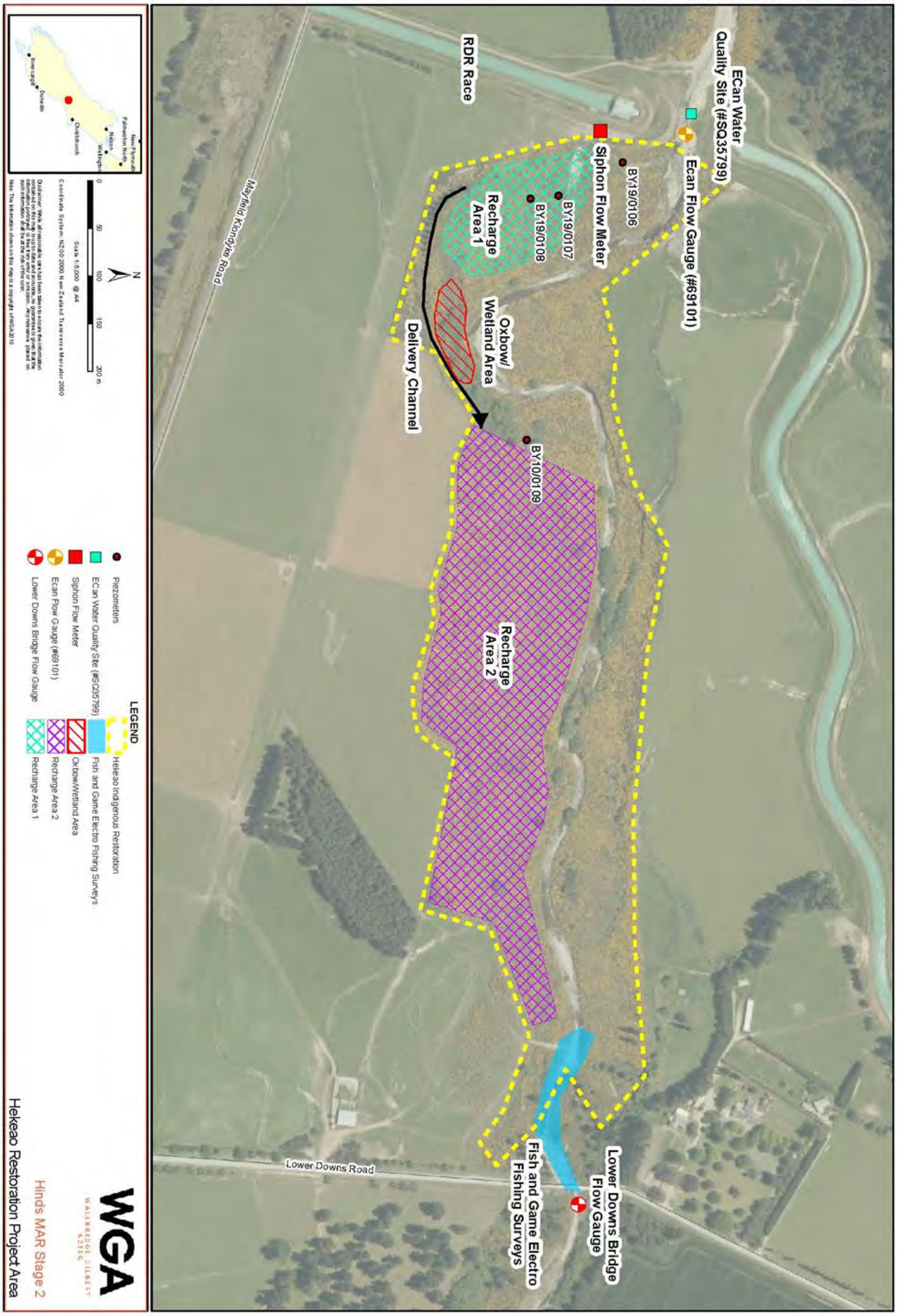

Figure 3-3: Hekeao Hinds River Project (HHRP) site and monitoring points (Source: MAR Year 2 report)

3.1 Water quantity monitoring

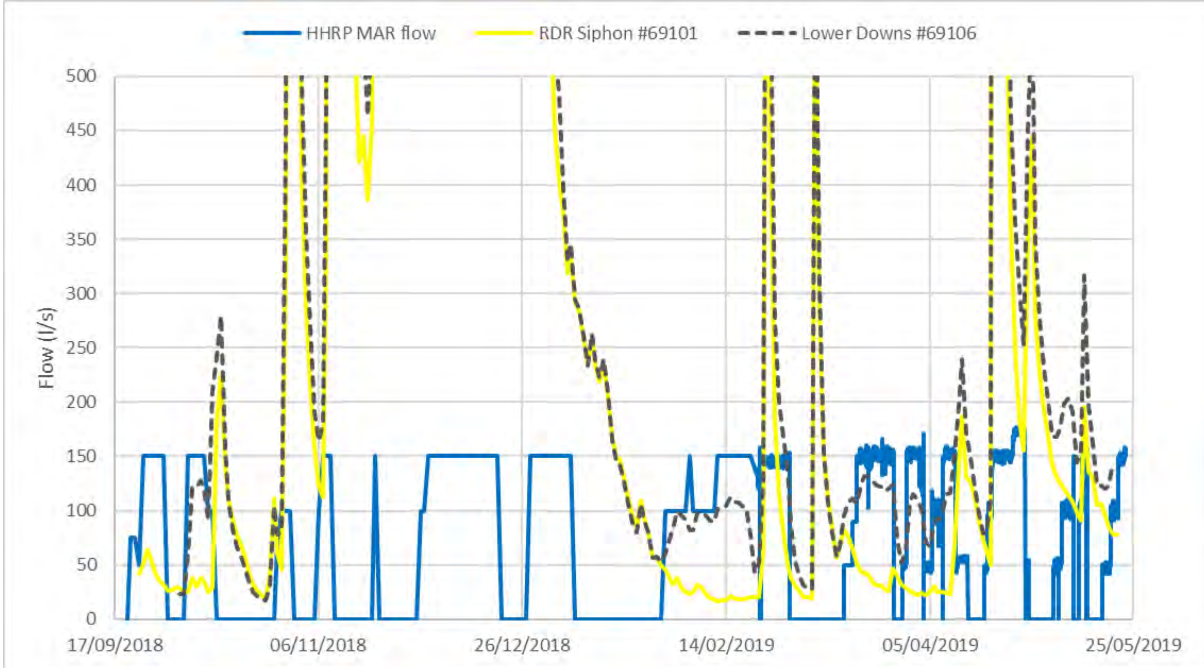

Figure 3-4: HHRP and Hekeao Hinds River flow

Figure 3-4 compares up-gradient Hinds River flow (site #69101) with HHRP flow and down-gradient flow (site #69106). When the HHRP site is turned on site #69106 responds within a day, showing a flow increase less than the supplied HHRP flow. This suggests that HHRP flow is recharging local groundwater as well as the river. Sites #69101 and #69106 produce similar flows when the HHRP recharge site is turned off, thus flow differences can be attributed to HHRP recharge. The median Year 3 flows of 124.5 l/s at Site #69101 and 164.5 at Site #69106 suggest a 32% increase in median flow due to HHRP recharge. The proportion of time the reach is flowing at less than 50 l/s also reduces from 30% to 6%.

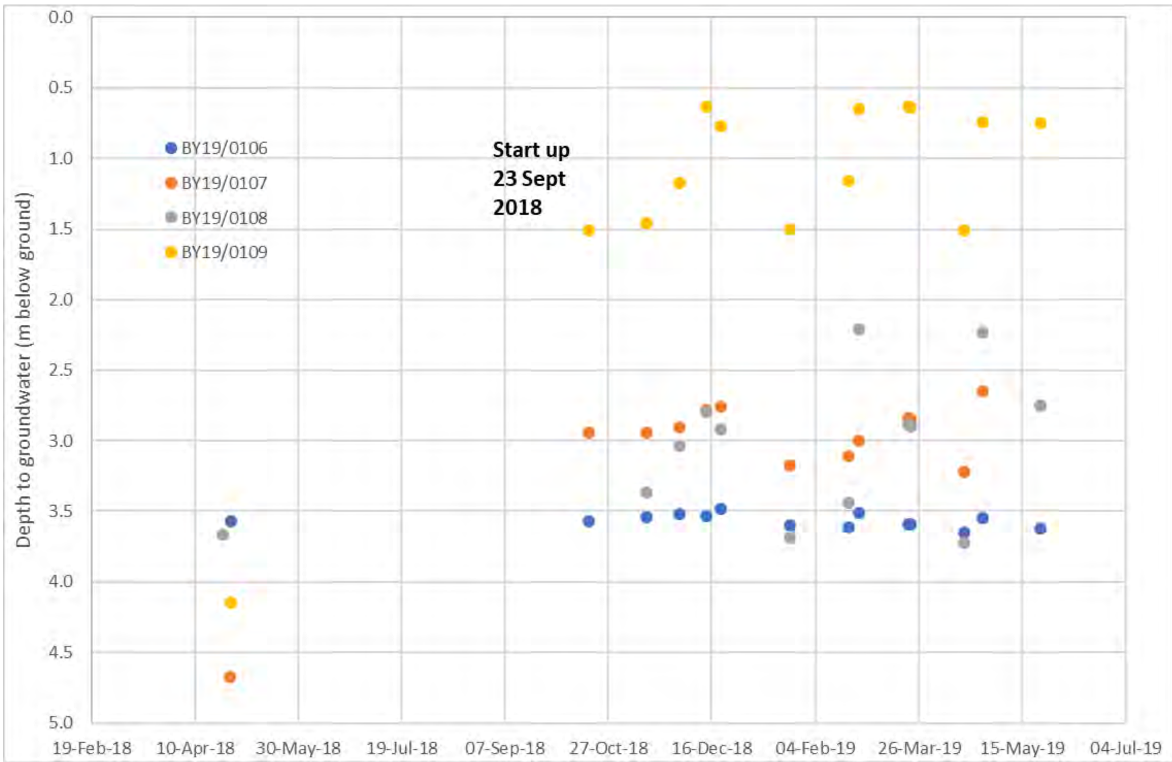

Figure 3-5: Depth to groundwater at HHRP on-site monitoring wells

Figure 3-5 shows the manually gauged depth to groundwater for the four piezometers installed at the HHRP site. BY19/0106 is situated up-gradient from all recharge areas and shows no hydraulic connection to the recharge site. All other piezometers, situated beneath recharge area 1 or 2, respond to recharge operations with the groundwater level change increasing through the site (from BY19/0107 to BY19/0109). 15 minute interval levels are also collected by loggers, but this will only continue long term for BY19/0107 as required by the consent conditions now that the general direction of recharged groundwater flow has been established.

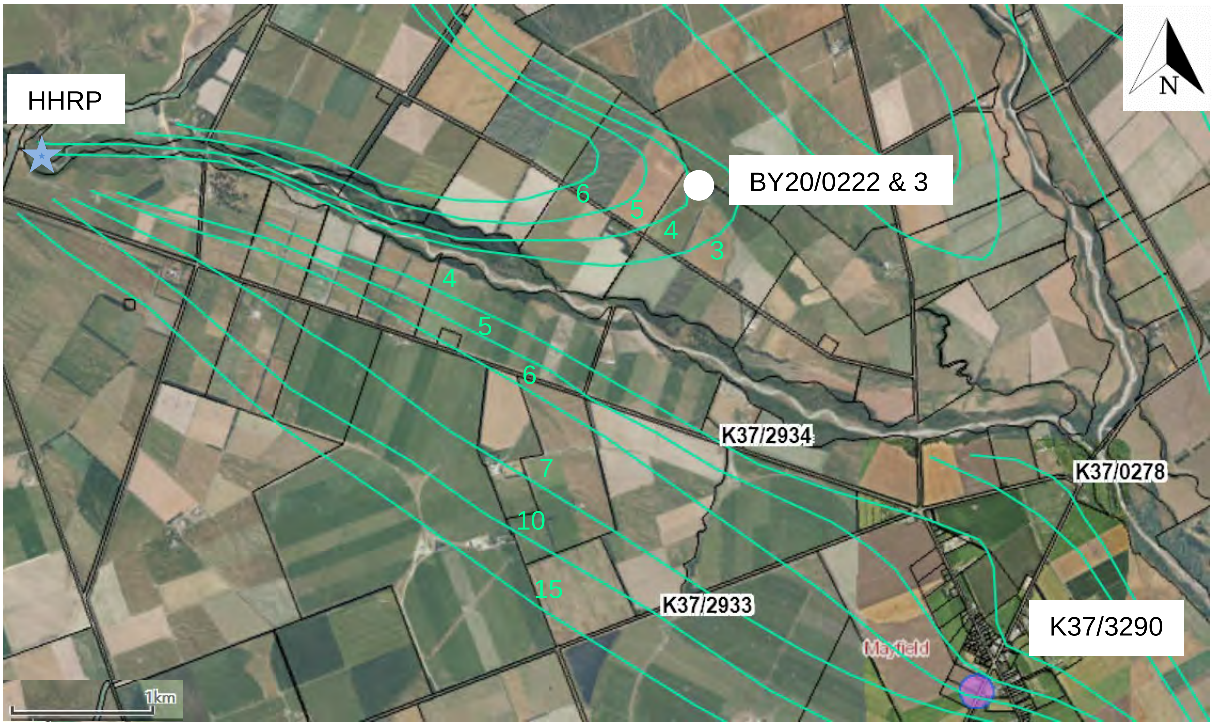

Figure 3-6: HHRP down-gradient monitoring wells and minimum depth to groundwater contours (in m)

Figure 3-6 shows minimum depth to groundwater lines in green (increasing with increasing distance from the river) and four local groundwater level monitoring bores. K37/0278 and K37/2934 log levels every 15 minutes, while K37/3290 logs groundwater level every 60 minutes. K37/2933 is manually measured monthly. Two shallow (2.3 and 2.5 m respectively) piezometers (BY20/0222 and BY20/0223) have been installed on the north side (true left) of the south Hinds early in Year 4 to assist with understanding the relationship between river flows and groundwater between the south and north branches of the Hekeao / Hinds River.

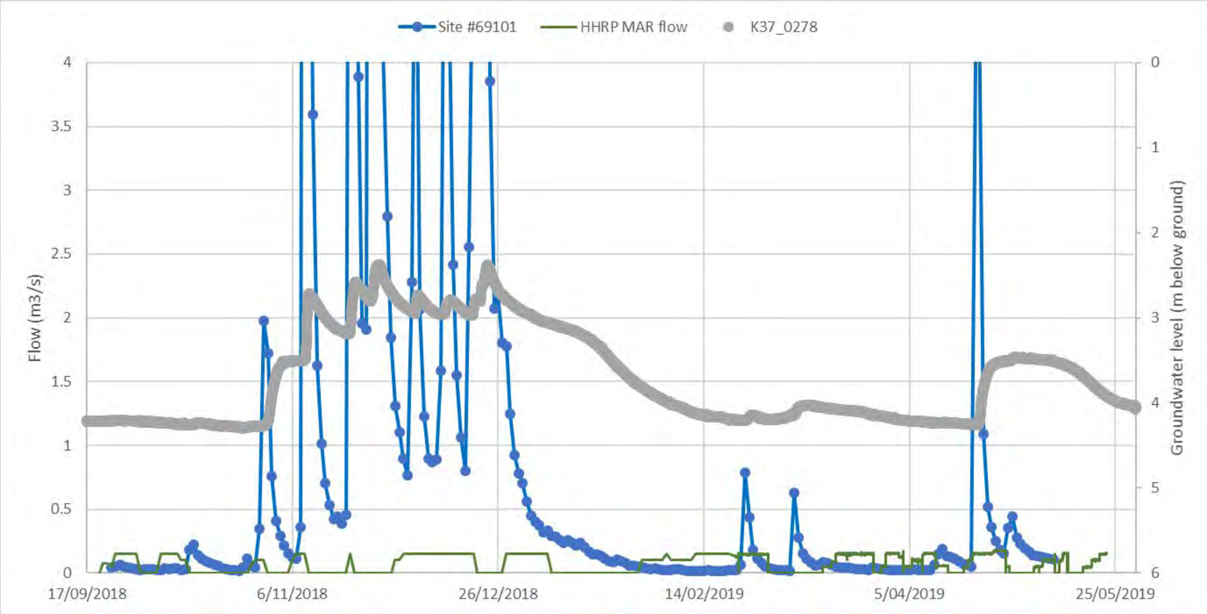

Figure 3-7: HHRP flow, Hinds River flow and K37/0278 groundwater level

Figure 3-7 compares Hinds flow (up to 4 m^3/s) at the RDR Siphon, HHRP flow and depth to groundwater in K37/0278. This shallow bore beside the river responds very quickly (approximately 5 days) to large freshes, but the effect of HHRP flows is small. However, a small benefit from HHRP flow can be inferred in the January – February 2019 period, where the rate of groundwater level decline decreases once the HHRP flow starts. The relatively stable groundwater levels during other low flow periods (e.g., October 2018 and March 2019) can also be partially attributed to HHRP flow. Nearby groundwater pumping records were not available, so their influence could not be considered. The relationship between HHRP flow and depth to groundwater in K37/0278 will be considered further in the coming years.

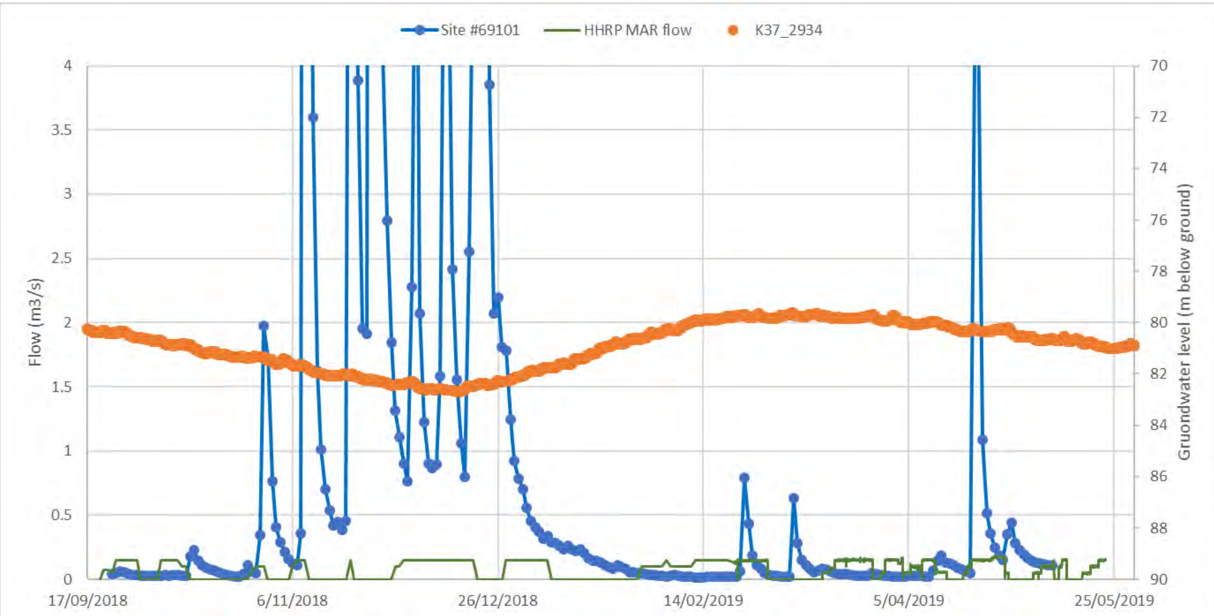

Figure 3-8: HHRP flow, Hinds River flow and K37/2934 groundwater level

Figure 3-8 compares Hinds flow (up to 4 m^3/s) at the RDR Siphon, HHRP flow and depth to groundwater in K37/2934. This deep bore beside the river responds more slowly (approximately 50 days) to large freshes. The effect of HHRP flows is immeasurable but may be clearer during a long period of low flows/groundwater.

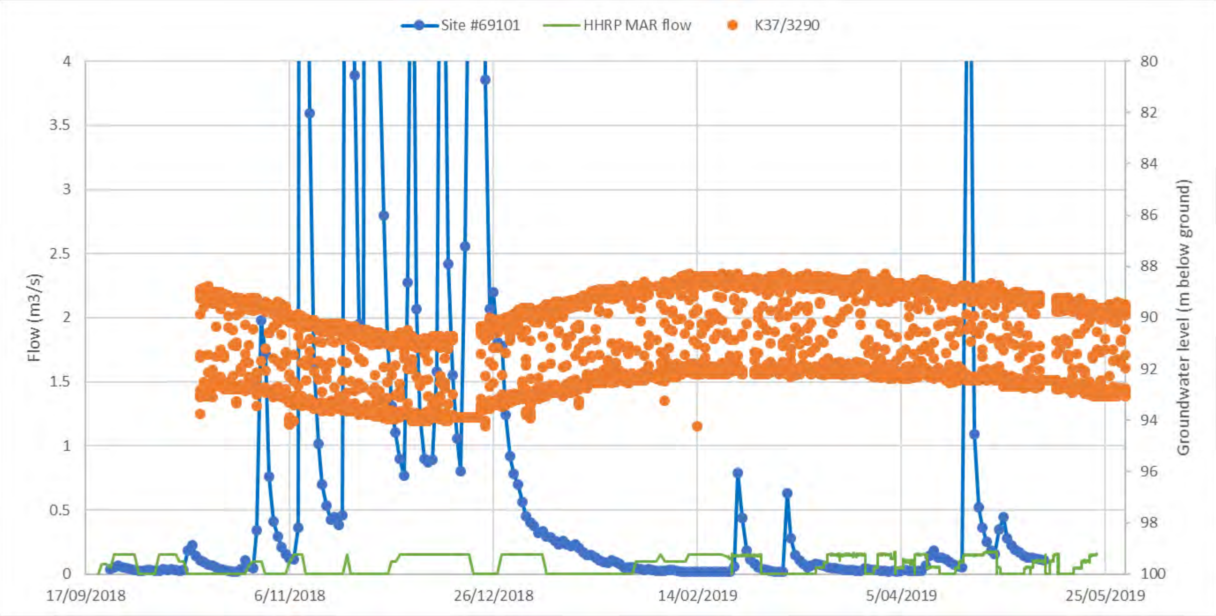

Figure 3-9: HHRP flow, Hinds River flow and K37/3290 groundwater level

Figure 3-9 compares Hinds River flow (up to 4 m^3/s) at the RDR Siphon, HHRP flow and depth to groundwater in the Mayfield community supply bore. This deep bore further away from the river shows significant daily variation in response to pumping requirements. It also shows a slow (approximately 50 days) dampened response to large river freshes. Given the dominating factors of bore pumping and large river freshes, the effects of HHRP flow are unlikely to be measurable. It will continue to be monitored, however, and assessed in more detail if a long period of low flows / groundwater eventuates (e.g., conditions similar to the 2015/16 drought that resulted in this bore dropping approximately 25 m).

3.2 Water quality monitoring

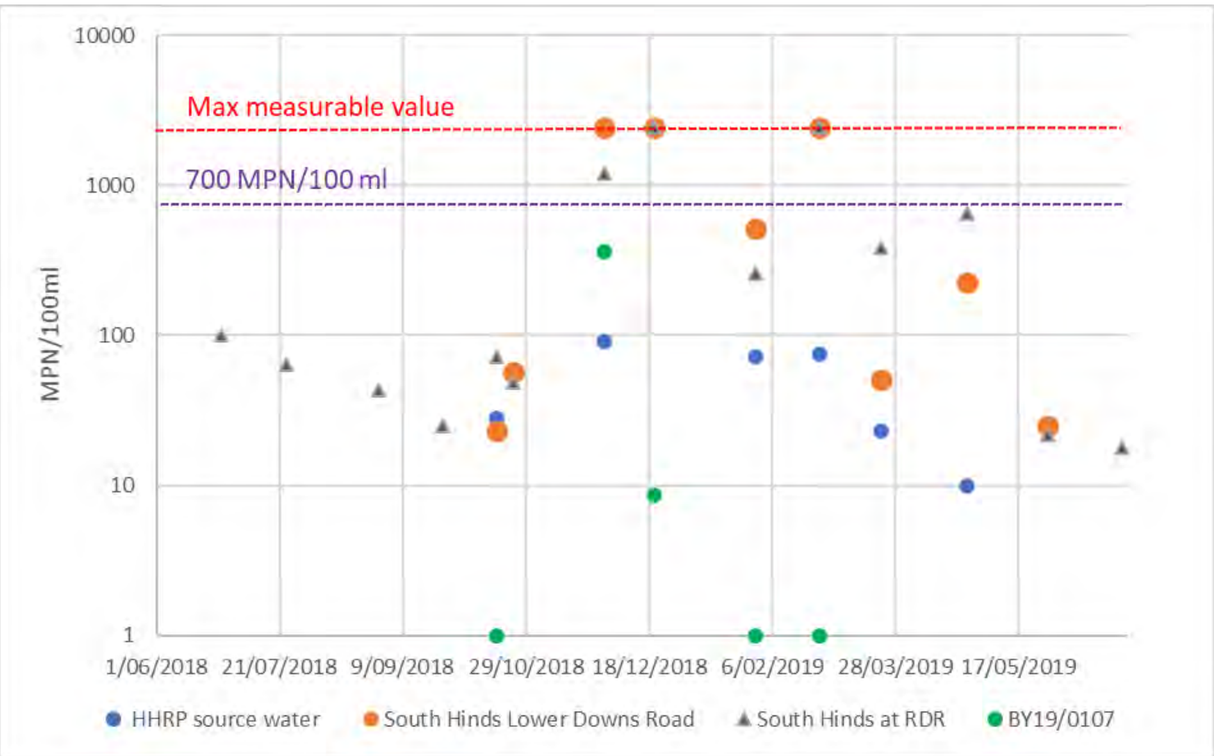

Figure 3-10: HHRP *E. coli* monitoring

The Advice Note for discharge consent CRC186228 requires consideration of an *E. coli* and a nitrate trigger level for site shutdown following its first year of operation. Figure 3-10 presents the HHRP site *E. coli* monitoring information for its first nine months of operation. *E. coli* counts are graphed on a log scale due to the significant monitored variation. The 700 MPN/100 ml level is included for comparison with the consented MAR Test Site shutdown trigger level. The maximum measurable count using existing methods is 2420 MPN/100 ml, so monitoring assigned this value can be significantly greater than this in reality. The key point of interest in Figure 3-10 is whether HHRP source water contributes to increased *E. coli* counts between the up-gradient (South Hinds at RDR) and down-gradient (South Hinds Lower Downs Road) river monitoring points. If this were to occur, then a source water shutoff trigger level would be determined as exists for the MAR Test Sites (currently at 700 MPN/100 ml). With all Year 3 source water *E. coli* counts less than 100 MPN/100 ml, there is no evidence yet for this requirement. The 17 October 2018 reading (above left most green dot) showed a small increase in *E. coli* counts between South Hinds at RDR and South Hinds Lower Downs Road, but *E. coli* counts in the recharged groundwater (well BY19/0107) were negligible, so the additional *E. coli* was more likely to have been sourced from a Hekeao Hinds River tributary between the monitoring points. The two BY19/0107 monitoring results where *E. coli* counts were greater than 1 occurred during high river flow events when the river was carrying very high *E. coli* counts, which will have impacted on connected groundwater.

Figure 3-11 presents the HHRP site Nitrate-N monitoring information for Year 3. Source water Nitrate-N concentrations are very low, though groundwater concentrations (in BY19/0107) are slightly higher as the recharge water mixes with recharged river water and land surface recharge. In the first six months of operation river Nitrate-N concentrations were similar up-gradient and down-gradient from the recharge site. Since late March 2019, concentrations have been consistently lower at the down-gradient site. This is not unexpected given that the HHRP flow has been a significant proportion of Hekeao Hinds River flow at Lower Downs Road for most of this period (see Figure 3.4).

Water quality monitoring of the Mayfield community supply bore K37/3290 is also included in Table 3.1 as background information to check whether a water quality influence from the HHRP site on the bore can be identified. During Year 3 no influence was detected, with monitored *E. coli* counts remaining below detection and nitrate-N concentrations remaining around 2 mg/l.

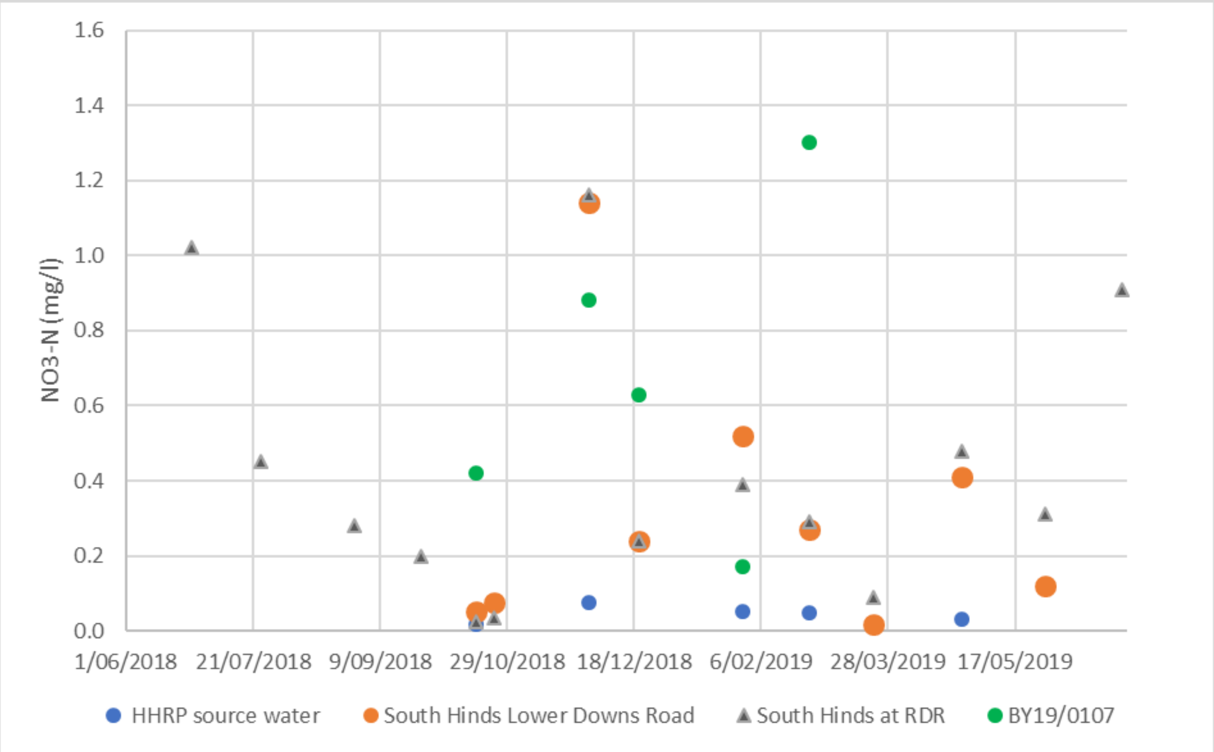

Figure 3-11: HHRP Nitrate-N monitoring

3.3 Turbidity "Trigger Level"

Turbidity relates to the level of suspended sediment in water. This sediment can clog up recharge facilities. HHRP discharge consent CRC186228 contains the following advice note:
"The "trigger level" NTU is calculated over the first 12 months of active recharge operation using the turbidity and Total Suspended Solids (TSS) data from the siphon (Plan CRC186228, Site A), ECan Water Quality Site SQ35799 (Plan CRC186228, Site B), and at the Lower Downs Bridge flow gauge (Plan CRC186228, Site C) to generate a 'real time' trigger for turbidity management for project operations."

The monthly monitoring frequency for the above parameters did not prove to be fit for purpose as turbidity increases in response to rainfall events occurred over hours rather than days to weeks. Real time turbidity monitoring at the HHRP intake was therefore installed. Rangitata River freshes in early April 2019 provided the opportunity to trial high NTU responses (see Figure 3.12). The turbidity monitor has a maximum value of 1304 NTU; actual turbidity could be significantly higher. Figure 3.12 shows short spikes in turbidity of less than 1 hour and longer spikes of greater than 24 hours. Normal turbidity is shown to be less than approximately 100 NTU. Flow reduction experiments in response to high turbidity for greater than 1 hour comprised one stepped reduction (125 then 50 l/s) and two immediate reductions to 50 l/s. On all occasions the deposited sediment in the upper recharge area was unacceptable. The "trigger level" for ceasing discharge was therefore set as 100 NTU at the HHRP intake automatic sensor, with up to 12 hours to cease discharge so that short turbidity spikes could be ignored. Discharge does not recommence until the turbidity level drops to below 60 NTU, though the consented recommencement trigger remains at 100 NTU. This "trigger level" was approved by Environment Canterbury via the Compliance Monitoring Report dated 10 May 2019.

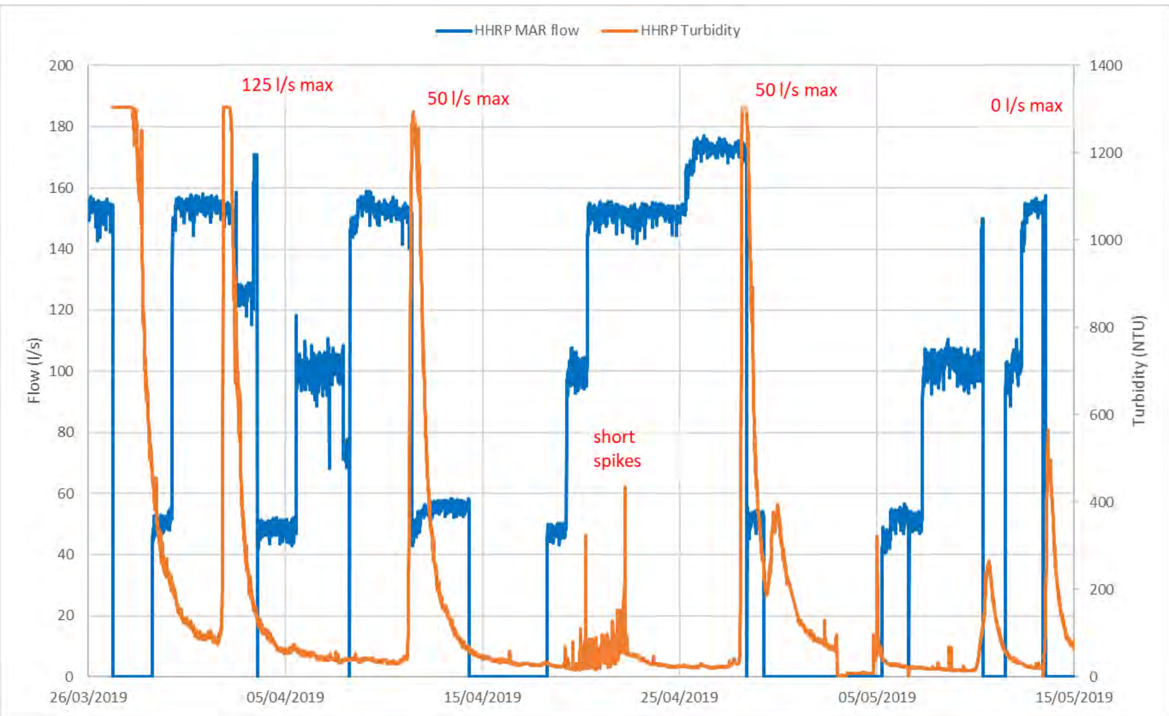

Figure 3-12: HHRP turbidity monitoring

3.4 Hinds River fish species monitoring

The Hinds River is a priority for restoration of ecosystem health and recreation amenity under the Managed Aquifer Recharge (MAR) trial for the Hinds Plains. To monitor long term changes in fish diversity and population sizes in possible response to an improved environmental flow regime in the Hinds River, Fish and Game along with Environment Canterbury implemented monitoring surveys in

2017. Surveys comprise annual assessment of fish diversity and abundance by electric fishing at two sites in the lower river, below SH1, and one upper river site downstream from the HHRP site as per Table 3.1 (aquatic ecology monitoring). All sites are 30 m long and upstream and downstream nets are used to enable diminishing-return population estimates to be calculated. Trout spawning surveys have also been undertaken in sections of the Hinds River between the RDR siphon and the sea in autumn if there is likely to be sufficient flow to enable trout to spawn.

Numbers of most species were quite variable in the two lower river sites over the time of the surveys. These sites are 1 km and 6 km from the coast and their fish assemblage reflects the abundance and distribution of many native fish species that do not penetrate far inland (e.g., inanga and bluegilled bully). At these sites the three bully species (common, upland and bluegilled) comprised between 72% and 97% of all fish present. The other fish present were torrentfish (18% - 25%), longfinned eel (2% to 3%), inanga (1% to 7%) and brown trout (1% to 3%). Four of the seven species caught in the lower river were migrant species requiring passage to and from the sea to complete their life cycles. Their presence suggests the Hinds River mouth was open frequently enough to enable fish migration. In time we will gather information through these surveys to indicate whether the frequency of an open river mouth could be limiting the river population sizes of migrant fish and therefore the contribution MAR may make to addressing this.

At the South Hinds site, 45 km inland from the coast, only three fish species were found in the Year 3 survey – upland bully (66% to 99%), Canterbury galaxiid (34%) and brown trout (1%). This site is approximately 1 km downstream from the Hekeao Hinds River Project that is part of the MAR programme. This project takes water at a rate of about 200 l/s from the RDR canal and discharges it into a disconnected flood channel of the South Hinds River for the purpose of wetland enhancement, groundwater recharge and improving base flow in the South Hinds. The South Hinds electric fishing site was specifically chosen to monitor fish population diversity and abundance in response to the Hekeao Hinds River Project.

Surveys to identify brown trout spawning have been undertaken sporadically since 2011 in up to six river reaches from the RDR siphon on the South Branch down to the river mouth and on two reaches on the North Branch. Total counts are generally low, less than 10 spawning sites in total, and a range of 0 to 2 spawning sites per river reach. The main variable contributing to the distribution and intensity of spawning appears to be flow related. It is expected that the Hekeao Hinds River Project will contribute to improving base flows of the South Hinds River and provide improved conditions for consistent trout spawning.

Annual monitoring of fish diversity and abundance by electric fishing and trout spawning counts remain the preferred methods for assessing long term responses of the fish populations of the Hinds River to the enhanced flow conditions expected to result from MAR. At this time annual surveys since 2017 are contributing to identifying fish diversity and population baselines against which achievement of MAR environmental targets can be measured.

Figure 3-13: Electric fishing at the South Hinds site in April 2019

4 Test sites

4.1 Introduction

As part of the overall Hinds MAR Scoping Study, the Hinds MAR Governance Group (MAR GG) approved an initial testing programme for up to 16 new sites. A consent (CRC182576) to operate these sites was approved by Environment Canterbury, with testing beginning in February 2018. The overall testing programme comprised of two phases:

1. Initial testing programme. This was a short, technically focused phase where the hydraulic behaviour of each site was tested and recorded.
2. On-going testing operations. Following a successful initial testing (Phase 1) process, a 'tested' site then became operational in nature. Each site was then operated to maximise the amount of recharge, collect on-going basic water quality and groundwater level data and observe any longer-term changes in flow rates or general conditions.

4.2 Objectives

The primary outcome for testing of the 16 new sites was to improve understanding of the wider MAR potential across the entire Hinds-Hekeao catchment. The results of these tests were used to support a business case for a Groundwater Replenishment System (GRS) within the Hekeao/Hinds Plains catchment. The following is a list of key programme objectives:

- Methodology: Develop a site-selection and monitoring programme methodology that can be used to roll out the GRS programme under a global consenting approach.
- Scientific Testing: Locate and field test up to 16 new MAR sites across the Hinds catchment, to provide the MAR Governance Group with feasibility and scalability information for the development of a business case to support development of a GRS.
- Utilise up to 500 L/s: Combined with the Lagmhor Trial Site and the Hekeao/Hinds River Project, demonstrate a capacity to utilise 500 L/s of stockwater currently available from ADC.
- Catchment Outcomes: Test MAR sites in different areas from the upper catchment to positions near spring-fed streams/drains.
- Value Added Testing: If a test location is suitable, quantify any additional benefits through either existing or additional monitoring. For example, if the test location is near an area with historically high nitrate levels indicated by existing Environment Canterbury bores. Use this information to demonstrate MAR application to the larger catchment outcomes.
- Cost Effective MAR Tool Development: Evaluate different designs (e.g., small soakage pits).
- Local technical development: Use the testing programme to help upskill staff from the local community in the technical skills required for monitoring and site-evaluation.
- Outreach: Utilise the field testing programme as part of outreach efforts to enable more people to become aware of and participate in the development of the GRS.

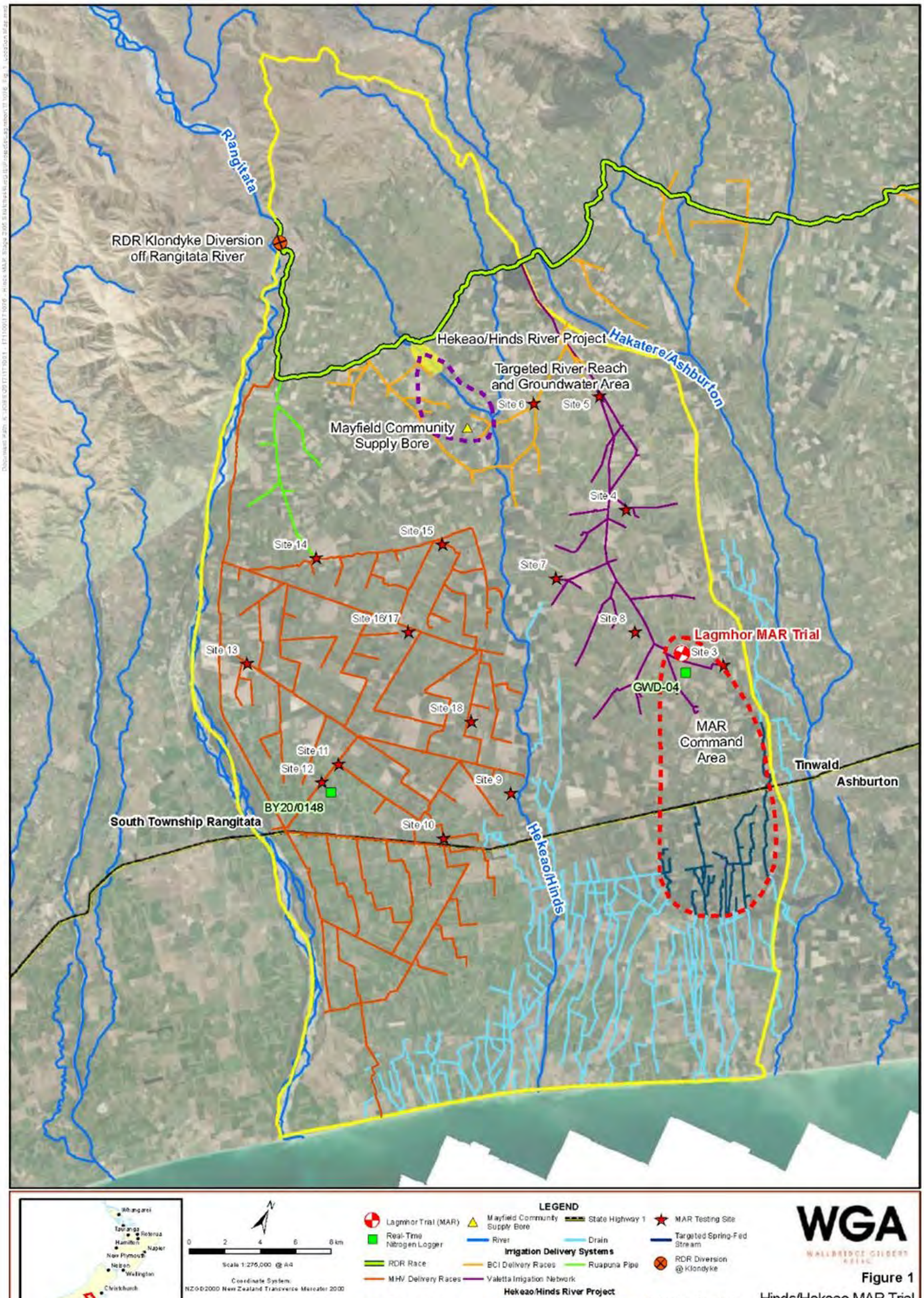

Figure 4-1: Year 3 MAR sites and distribution infrastructure (Source: MAR Year 2 report)

4.3 Hydraulic testing

Hydraulic testing for twelve of the sixteen test sites was conducted between February 2018 and February 2019. Site selection, water delivery infrastructure, and hydraulic testing methods are described in the Year 2 Report. Initial results are presented below in Figure 4-2. Each point combines the tested specific infiltration rate for the site against the potential maximum infiltration rate. The dotted line refers to the relationship between these two variables based on 6.5 metre pit depth minus the 1 metre minimum depth to groundwater requirement. A general conclusion from results to date is that greater infiltration performance can be expected in the upper catchment sites due to a lower chance of shallow groundwater mounding limitations. The location of lower catchment sites is likely to be more critical than upper catchment sites so that their operations can most effectively target priority groundwater quality areas such as community drinking water supplies. Sites 3, 6, 10 and 12 have not been included in Figure 4-2 as their testing did not produce data sets suitable for calculating both performance parameters.

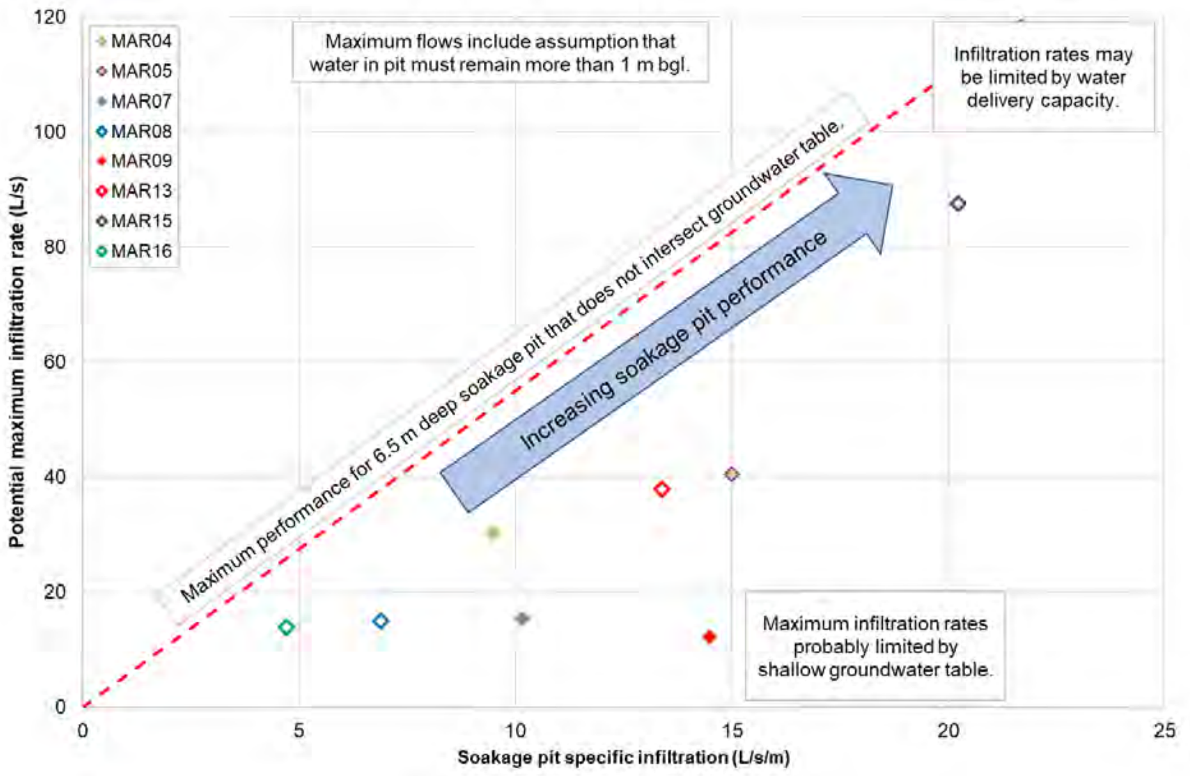

Figure 4-2: MAR test site performance analysis

4.4 Operations

Test site operations are managed by Scheme Operators at MHV Water Ltd, in accordance with a protocol, developed by MHV Water Ltd in consultation with the Hekeao/Hinds MAR Governance Group. Year 3 operational monitoring of test sites is presented in the Year 3 consent compliance report, with a summary in Table 4-1 below. The site numbers in column 1 relate to the MAR site numbers, followed by their location name. Columns 2 and 3 compare the potential maximum infiltration rate (Figure 4.2) to the actual rate for operational weeks. Results are coloured green for good, yellow for average and red for poor. Assessed reasons for poor results are presented in the 'other' column.

Table 4-1: Test site monitoring information for Year 3 (June 2018 – May 2019 inclusive)

June 2018 - May 2019	Tested max potential supply (l/s)	Ave flow for operational weeks (l/s)	TOTAL Volume (m3)	Weeks operational	E. coli shutdowns	Other
3 Mark Walls		20	24,565	2	3	Current infrastructure limits supply to ~30 l/s
4 NZSF	30	16	195,620	20	5	Some clogging likely
5 Pond 2	41	21	217,728	18	10	E. coli from birds on pond
6 BCI/Howden		13	151,777	20	4	Current piping limits supply to ~25 l/s
7 Lobblin	15	15	82,979	9	0	Can't run when irrigating. Requires separate flow meter
8 Lacmor	15	13	197,390	26	2	Some clogging likely
9 Riverbank	12	22	214,039	16	0	High groundwater levels. Siphon from pond added.
10 Low		13	10,584	1	8	Supply and E. coli challenges. Site shut down
12 Slee		13	91,757	11	2	Supply challenges
13 Hills view	38	13	280,346	35	0	Some clogging likely
15 Oakstone	87	14	57,418	7	5	Some clogging likely
16 Broadfields	14	8	156,133	33	2	Some clogging likely. New site constructed

4.4.1 Upgrades and optimisations

Over the third year of operations, a series of upgrades and optimisations were conducted to improve water delivery, water quality and to achieve consenting requirements. A summary of the improvements includes:

- **Site 3 (Smacks)**: The existing metal temporary piping was replaced between the Valetta line off-take and the soakage system. A trench was constructed, and the pipe buried to avoid damage.
- **Site 9 (Riverbank):** The original water delivery system at this site utilised existing farm infrastructure and was limited to delivering either MAR water or irrigation water, but not both simultaneously. A siphon and independent flow meter were installed to better utilise available source water for MAR throughout the irrigation season.
- **Site 16 (Broadfields):** The existing site was decommissioned in July 2019 due to reductions in infiltration rates, likely associated with clogging. A new soakage pit was constructed approximately 20 metres north of the existing location. The new construction uses dimensions of 6.0 x 1.2 x 5.5 m.

4.4.2 Operational challenges and opportunities

Current operational challenges and opportunities are summarised as follows:

- Sites 1-8 are all vulnerable to water supply restrictions if the Valetta pipe scheme is undergoing repairs and if high bird population are present at Pond 1 or 2 (distributing suspected high avian *E. coli* levels to all sites).
- Mayfield Hinds Open Race Scheme allows different distribution options during repairs; however, stock need to be kept out of races to mitigate potential degradation of source water.
- Apart from the Lagmhor Pilot and the South Hinds River sites the remaining sites are recharging less than half their consented flow of 50 l/s. The main reasons for this are distribution infrastructure limitations and recharge areas clogged by sediment.

- Changing pond levels result in varying flow rates to test sites, which increase the workload to keep flows consistent.
- Replacement Site 16 was constructed during winter 2019, with initial recharge flows of 24 l/s.
- Replacement Sites 17 & 18 have been identified for development once they have been included in the discharge consent via a consent amendment process.
- The automation of the Mayfield Hinds Scheme will provide more accurate monitoring of current distribution system losses and related information for MAR assessments.

4.5 Monitoring

Water quality data is collected from the outflow pipe at each operational MAR site on a weekly basis as per consent CRC182576. Water quality data is also collected prior to MAR operation from either the supplying pond or in the open race. The consent outlines two water quality trigger values related to *E. coli*:

1. Values exceeding 500 MPN/100 ml require immediate resampling to determine the cause, and
2. Values exceeding 700 MPN/100 ml require discharge to cease immediately and sampling of nearby shallow bores.

4.5.1 Source water quality

Source water quality data collected over the third year of operation is summarised below (Figure 4-3). The results show median source water *E. coli* values collected over this period was under 100 MPN/100 ml. Generally, higher *E. coli* values were observed during the summer than winter period. The majority of the *E. coli* values exceeding 700 MPN/100 ml were observed at Sites 4, 5, 10, and 15. Site 10 is connected to a stockwater race, but Sites 4, 5, and 15 are supplied from irrigation/scheme ponds.

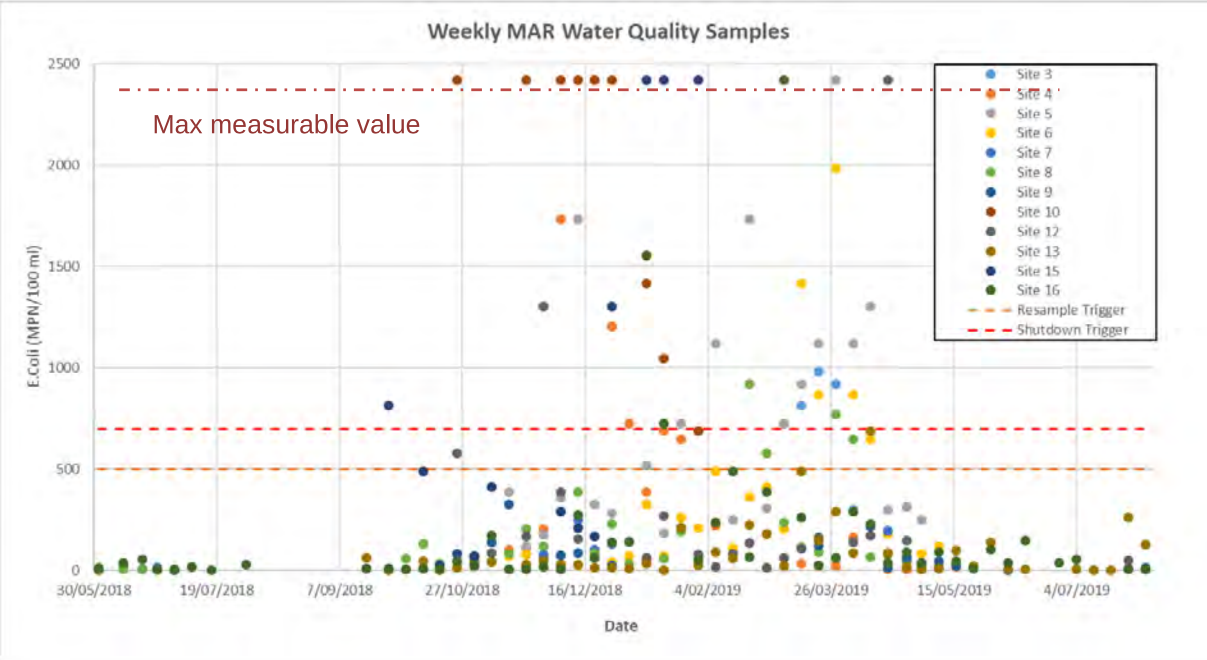

Figure 4-3: Weekly samples collected from MAR source water during the third year of operations[2]

A number of additional samples were collected during Year 3 operations to determine possible contamination of source water. On the Valetta side, eight samples were collected between the RDR/Valetta inlet and Pond #2. Samples were collected for the testing of *E. coli* and total coliforms. All samples were delivered chilled to Hills Laboratory within six hours of collection. At each pond a

[2] 2420 MPN/100 ml is the maximum measurable E. coli count in this analysis.

sample was collected from the supplying water (i.e., inlet), at the bank of the centre of the pond, and at the pond outlet, both at the surface and ~3 m depth.

Results show *E. coli* counts of source water entering the Valetta piping network at 172 MPN/100 ml. Historical, water delivered by the RDR is thought to have *E. coli* counts ~30 MPN/100 ml. At Pond #1, the *E. coli* count increased to between 1414 and 1986 MPN/100 ml. At Pond #2 the *E. coli* count remained elevated, ranging from 1300 and 1986 MPN/100 ml (see Figure 4-4 below). During the investigation, substantial birdlife was observed at both Pond #1 and Pond #2. Images were taken at both ponds, though many birds have been scattered upon arrival and are missing from the images (see Figure 4-5 below).

On the open race side, samples were collected upstream of junctions periodically to determine where points of contamination might occur. No recognisable pattern could be found other than a broader conclusion that race water quality appeared to decrease with greater distance from the RDR.

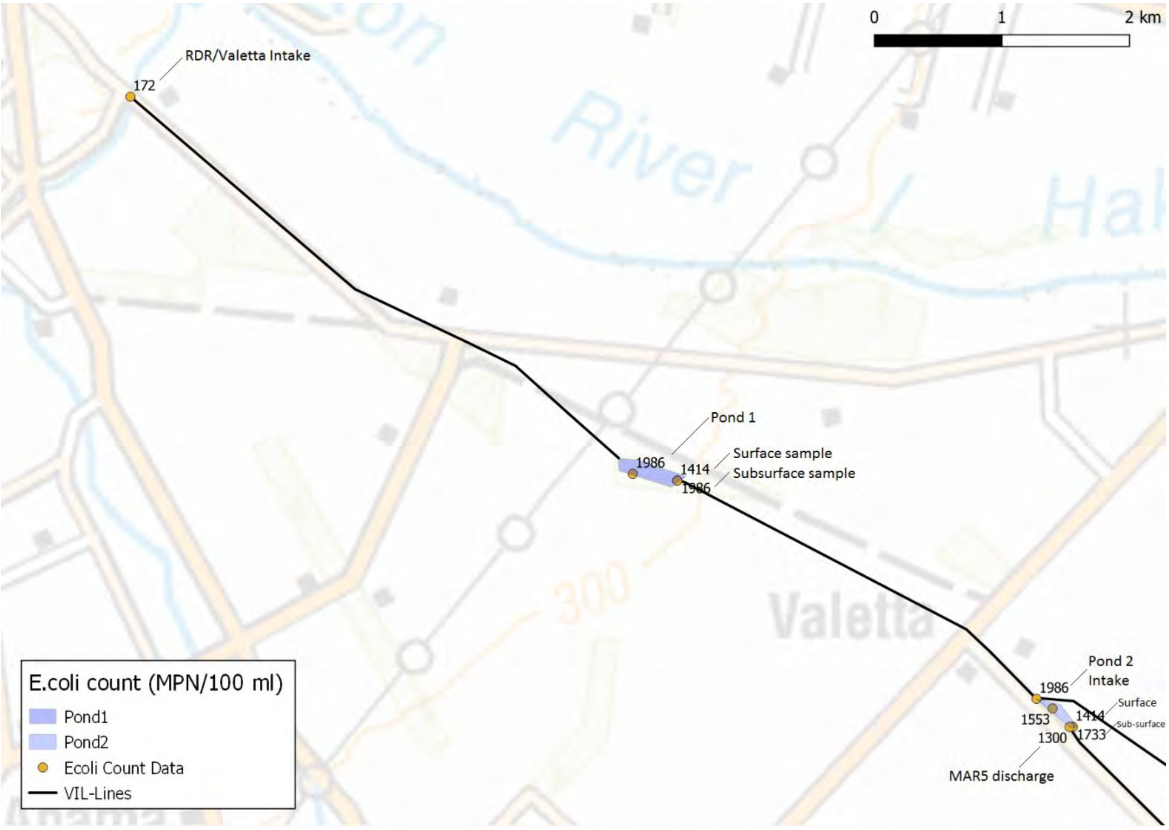

Figure 4-4: Map showing the locations of samples collected along the Valetta pipeline

Figure 4-5: Pond #2 photograph showing presence of birdlife. Larger numbers are out of frame, having been disturbed

4.5.2 Groundwater quantity and quality

Figure 4-6: Site 4 location and nearby monitoring information

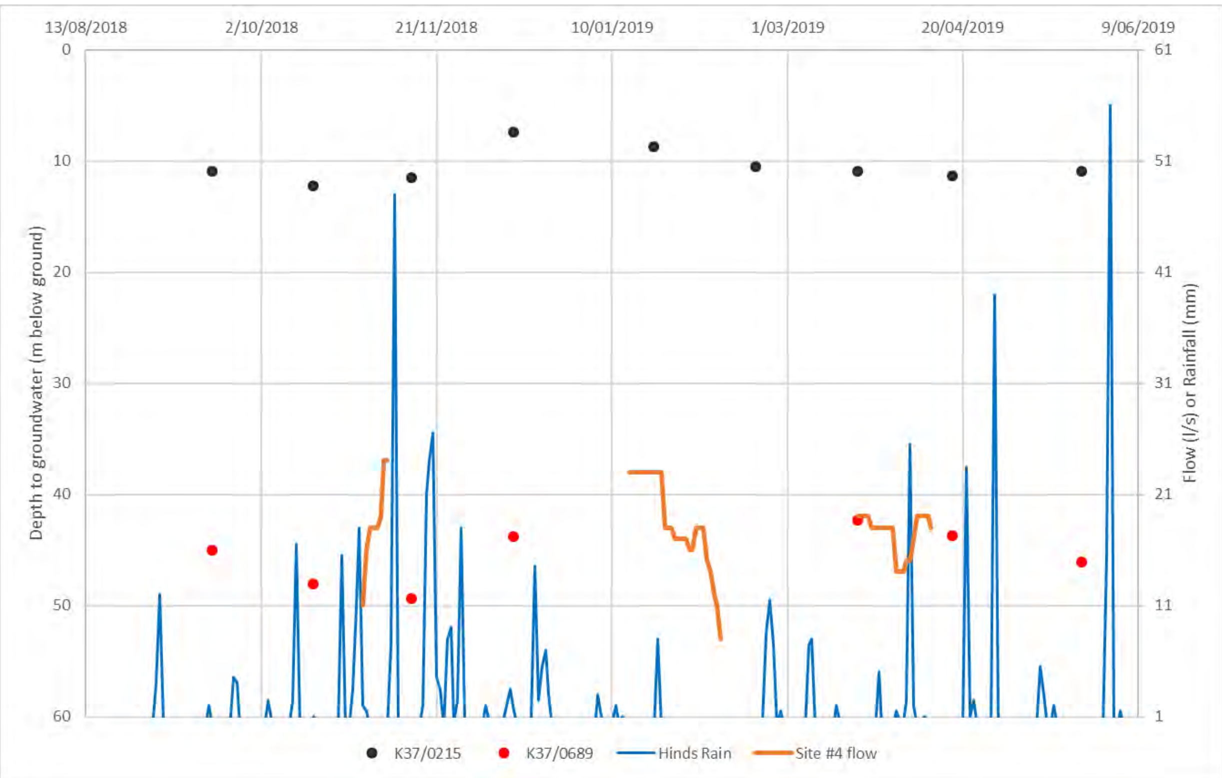

Figure 4-7: Site 4 Year 3 monitoring

Only two test sites with Year 3 annual volumes in excess of 150,000 m^3 currently have regular groundwater level monitoring down-gradient. Site #4 is near three groundwater level bores sampled most months (Figure 4-6). K37/1998 is a deep bore, so is not included in Figure 4-7. Figure 4-7 above compares Site #4 recharge flow, Hinds Plains rainfall and groundwater levels in the two nearby monitoring bores. Groundwater levels in both bores respond to large rainfall events but show no measurable response to the three recharge flow periods. Groundwater levels in the piezometer beside Site #4 fluctuated by approximately 3 m during testing, but this level of influence is likely (and expected) to reduce quite quickly down-gradient (and especially sideways where the wells are situated) from the site due to a number of site factors (e.g., infiltration rates, high transmissivity of aquifer material, porosity) and the relatively low recharge flows (up to 24 l/s). Recent shallow groundwater nitrate-N concentration near this site is understood to be approximately 12 mg/l, but further detail is not currently publicly available.

Figure 4-8: Site 9 location and nearby monitoring information

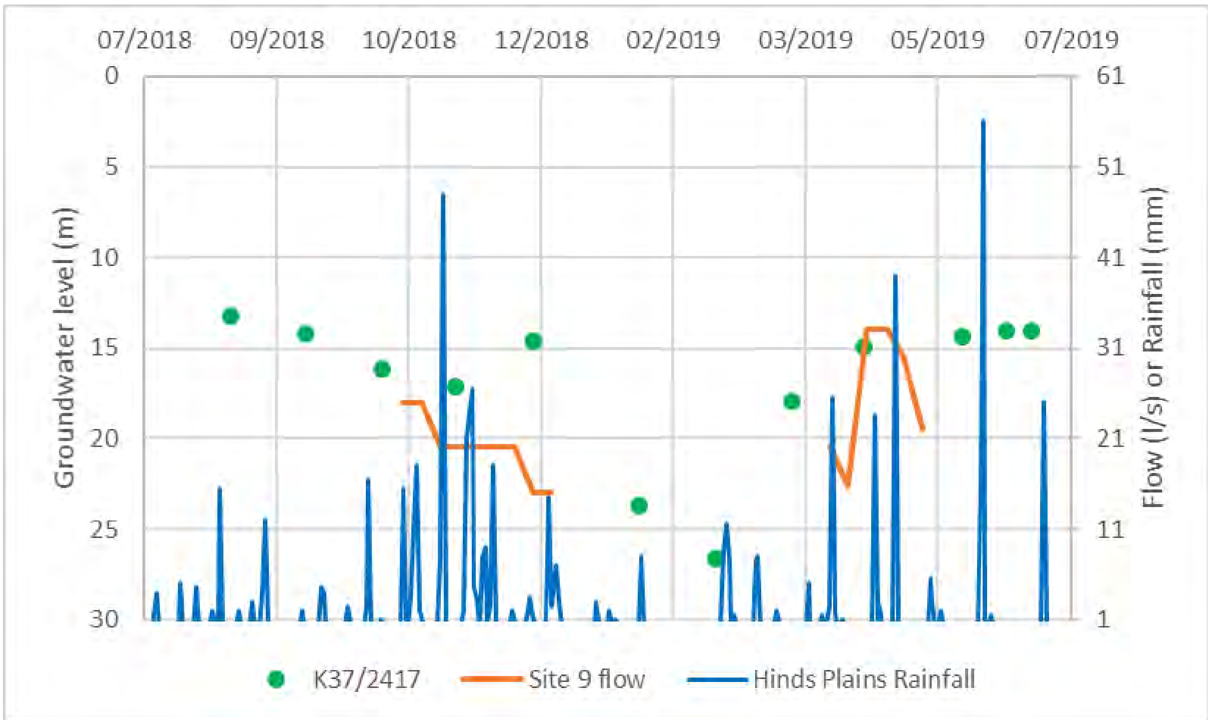

Figure 4-9: Site 9 Year 3 monitoring

Site #9 is up-gradient from one groundwater level bore (K37/2417) sampled most months. Figure 4-9 above compares Site #9 recharge flow, Hinds Plains rainfall and groundwater levels in K37/2417. Groundwater levels clearly respond to large rainfall events and seasonal cumulative groundwater pumping. To understand whether there is also a measurable contribution from Site #9, a reasonable period of recharge without significant rainfall or pumping effects would be necessary. Recent moderate depth groundwater nitrate-N concentration near this site is understood to be approximately 11 mg/l, but further detail is not currently publicly available.

Figure 4-10: Site 12 location and nearby monitoring information

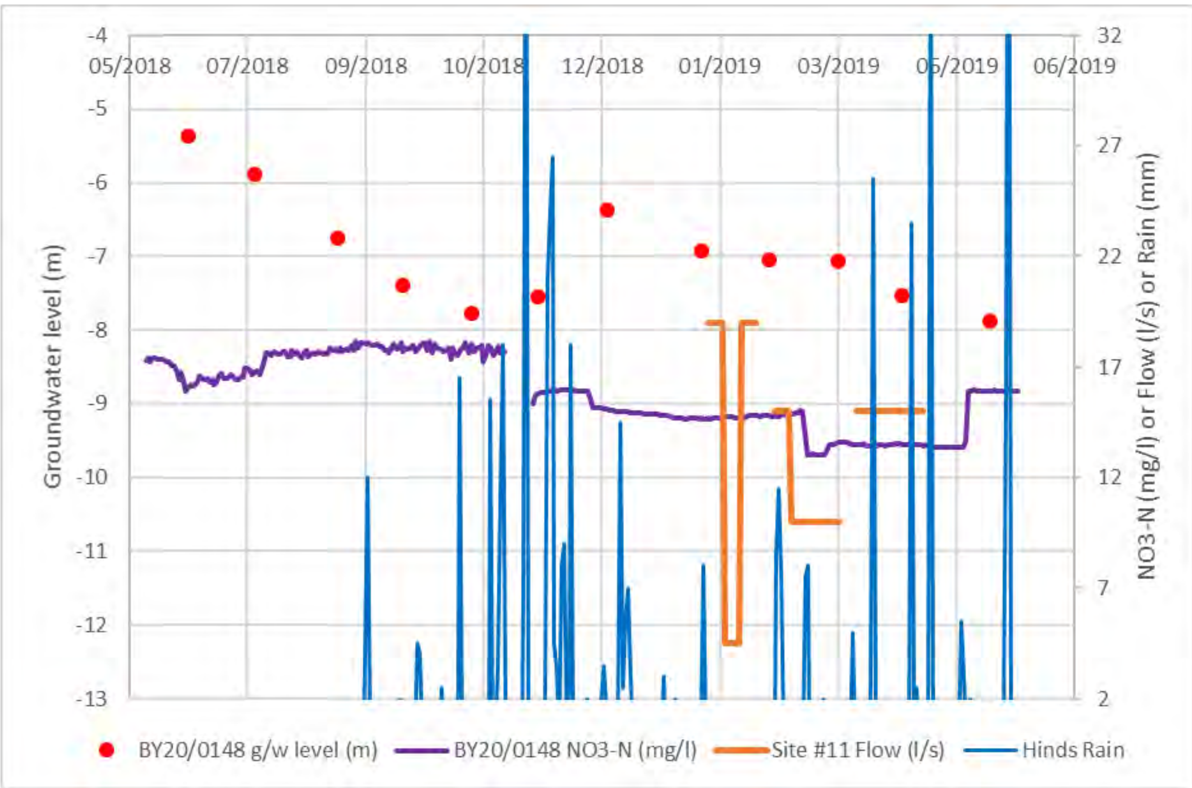

Figure 4-11: Site 12 Year 3 monitoring

Despite recharging less than 100,000 m^3 in Year 3, Site #12 is included for analysis (see Figures 4-10 and 4-11) as it has a nearby down-gradient bore (BY20/0148) with the second nitrate logger installed as well as regular groundwater level measurements. As with the other assessed test sites, groundwater levels respond positively to the November 2018 rainfall. Nitrate concentrations also drop at this time. The beginning of the late January – April 2019 operational period for Site #12 is followed closely by a slowing in groundwater level decline without a contribution from rainfall. After approximately 5 weeks, the nitrate-N concentration drops from approximately 15 to 13 mg/l. Approximately 2 weeks after operations cease, the nitrate-N concentration jumps back up to 16 mg/l. These results could be an indication that Site #12 recharge is influencing BY20/0148 level and quality, however additional land use information and monitoring during this period is required to substantiate this conclusion.

5 Hinds Drains enhancements

5.1 Windermere and Taylors Drains

Extensive ground surveys by Central South Island Fish and Game staff of many of the Lower Hinds Plains drains in winter and spring of 2014 found conditions that made poor habitat for most fish species, particularly for eels and trout. The physical habitat for fish was constrained by the lack of habitat diversity that in natural waterways is provided by a range of water depths, bed gradients, substrate sizes and instream and bank cover types.

The Hinds Drains (in common with most drains throughout Canterbury and New Zealand) lacked habitat diversity to support abundant and varied instream ecosystems. Improvement of fish habitat complexity would improve the habitat of longfinned and shortfinned eel, native bullies and galaxiids, and brown trout. In some drains specific habitat needs for a particular species could be targeted.

The Hinds Drains Working Party recommended to the Ashburton Zone Committee in November 2014, that a trial fish habitat enhancement project be undertaken in approximately 900 m of Windermere Drain and approximately 800 m of Taylors Drain (see Figure 2-7). The project would also involve monitoring of fish population response to the habitat change through annual survey of fish diversity and abundance at randomly selected sites on these two drains and on nearby Deals Drain where no works were undertaken.

On 8/9 June 2015 approximately 92 m^3 of boulders of 0.25 m to 0.6 m diameter were used to create 22 weirs in Windermere Drain and 19 weirs in Taylors Drain. While boulders were mechanically deposited in the drains they were then placed by hand to create the preferred weir height, porosity and water velocity. The purpose of the weir was to recreate the natural pool-run-riffle sequence that is a cornerstone of natural river habitat diversity. The project was approved with funding for creation of boulder weirs by an Environment Canterbury Immediate Steps grant in June 2015. In-kind contribution in the form of project oversight and on-going monitoring would be provided by Central South Island Fish and Game.

Annually, multiple electric fishing runs through five randomly selected sites on each drain enables population estimates to be made for each fish species caught that can be summed for each drain. Changes in fish population size and species composition over time may indicate a change in habitat quality due to enhancement activities and also the influence of other environmental factors such as floods and droughts.

In all drains the most abundant fish is the upland bully and its numbers have increased in Deals and Taylors drains with time. Upland bullies are a non-migratory species that do not need access to the sea to complete their life cycle. They are very hardy, quick colonisers, can mature at one year of age, and occupy a wide range of habitats. Their increased abundance at these sites, both enhanced and control, is likely to reflect their generalist habitat abilities, low density of other competing and predatory fish species, and their tolerance to midsummer low flows. Four other species have also been caught – shortfinned and longfinned eel, Canterbury mudfish and brown trout. Estimated population sizes for these fish in all years were low and there are no definitive population trends.

The habitat created by the weirs was a simple attempt to simulate the complex interactions of flow, depth, velocity, gradient and substrate that occur naturally in streams and provide a wide range of niches for a wide range of stream life. The make or break point of the enhancement was not going to be the immediate reaction of fish to creation of habitat directly attributable to introduction of the weirs but rather what long-term changes were naturally created in the drains from the interaction of flow and boulder substrate. The first evidence of this interaction did not occur until two years after weir creation with the flood flows of July 2017, estimated to be a 1 in 40-year event. In reality this flood reset the natural environment inclusive of the boulders and monitoring the true impact of the boulder induced habitat on fish populations effectively began after July 2017 (see Figures 5-1 and 5-2).

Figure 5-1: Monitoring site 1 on Windermere Drain prior to boulder weir placement, May 2015

Figure 5-2: New pool below the weir in Site 1 of Windermere Drain, September 2017

5.2 Boundary Drain

To monitor long term changes in fish diversity and population sizes in possible response to a revised environmental flow regime in Boundary Drain implemented in 2016, fish diversity and abundance surveys (including electric fishing and ecological health assessments) have been undertaken at four sites twice annually. Trout spawning surveys have also been undertaken in the last three years over the length of Boundary Drain.

Numbers of most species were found to be variable between sites and over the time of the surveys. Upland bullies were numerically dominant at the three upstream sites, with common bullies more common at the lower site. On average bully numbers were highest 3 km above the coastal lagoon while total bully numbers increased in the lower reaches and decreased in the upper reaches. The two eel species were common at all sites and there were no obvious population trends over time. Bluegilled bullies have been found only in the lagoon and 200 m upstream. Inanga have been found in the lagoon and up to 1 km upstream and their upstream presence appears to be a recent event. In the annual report for 2018 it was noted that with good flows over 2017/18, inanga along with torrentfish and smelt may begin to appear in Boundary Drain.

Good numbers of brown trout were captured by electric fishing in November 2018; all were fry that had hatched in the previous winter and ranged from 32 mm to 69 mm. The presence of fry confirmed the success of the two trout redds (nests) counted in the spawning survey of July 2018. Two of the three trout caught in July 2019 were around 150 mm long and likely to be the same cohort captured in November 2018 (with another 7 months summer growth). This indicated very good conditions for trout growth over the 2018/19 summer.

A survey to identify brown trout spawning was completed on 10 July 2019. Four trout redds (nests) were identified compared to two in 2018 and none in 2016. These numbers are encouraging and provide the necessary foundation for a good trout population. I believe the spawning numbers, which are indicative of adult trout presence, show the benefit of sustained flows in Boundary Drain. If adult trout are lost during prolonged low flows it takes at least three years before any surviving juveniles grow to maturity and spawn.

Annual monitoring of fish diversity and abundance by electric fishing remains the preferred method for assessing long term responses of the fish population in Boundary Drain. Consistent flows well above the minimums in the last two years appear to have benefitted the trout population with redds being observed and juvenile trout produced from these, tracked to two years of age. The presence of Inanga and bluegilled bullies, wide size ranges of longfinned and shortfinned eels, and the presence of good numbers of small eels suggests periodical access to and from the sea, probably on a near-annual basis.

Figure 5-3: Trout redd (clear gravel patch mid-stream) in Boundary Drain downstream of Trig Pole Road, 10 July 2019

6 Next steps

With proof of concept established for existing MAR designs, current MAR Trial consents expiring in February 2021 and with shallow groundwater nitrate concentrations continuing to rise, the following workstreams are proposed for prioritisation in Year 4:

- Increased MAR supply by arrangement with relevant water take consent holders.
- MAR site optimisation to increase recharge rates, in particular for the MAR sites situated up-gradient from the community water supplies of Tinwald, Hinds and Mayfield. Site specific recommendations are:
    - Site 14 (Portabello) should be constructed due to high nitrate concentrations down-gradient, even though there is currently a distribution infrastructure limitation of 20 l/s. Scoping of additional infrastructure is required to increase supply rate.
    - Scoping of additional infrastructure is required to increase supply rate to Site 3.
    - Site 7 (Lobbin) requires a flow meter so that it can run while farmer is irrigating. This site is situated in a disused irrigation pond, which is recommended as a recharge basin following sediment removal.
    - A replacement site for Site 10 (Low) should be investigated.
    - Sites 4, 8, 13 and 15 have declined in their ability to take water, likely due to sediment clogging. They would benefit from site upgrades such as digging a larger recharge basin or digging a dispersal drain away from the existing site.
- New MAR site prioritisation. This assessment includes:
    - New MAR sites (including gravel pits), stockwater and currently redundant Mayfield Hinds Scheme races that could be connected to RDRML/MHV Water/BCI distribution. In particular:
        - Identify a MAR site up-gradient from Carew School as it has a water protection zone.
        - Progress the Winslow Road Near River Recharge (Hinds River) and scope South Ashburton Near River Recharge as an upper catchment basin with direct connection to the RDR.
        - Progress an upper catchment pilot Aquifer Storage Transfer and Recovery Bore (ASTR).
    - Supply rate potential (in collaboration with RDRML/MHV Water/BCI);
    - Learnings to date from test sites including soil profile, depth to water and recharge potential;
    - Potential to influence drinking water supplies (community and individual);
    - Catchment spread of MAR sites and current nitrate concentration spread.
- Assessment to support the development of a catchment-wide MAR monitoring network, starting with current public and private bores. This workstream will enable collection of baseline monitoring information as well as improve catchment wide understanding of drinking water nitrate risk.
- Assessment of long term consenting requirements, collection of relevant technical information and drafting of consent application documentation.

7 References

Environment Canterbury, 2019, Annual Compliance Report – CRC182576, CRC183882, CRC184617, CRC164281 Hekeao Hinds Managed Aquifer Recharge (MAR) Project.

Hinds MAR Governance Group, 2017, Hinds Managed Aquifer Recharge Pilot Trial: Phase 1 Report, Available at:

https://ecanmaps.ecan.govt.nz/portal/apps/MapJournal/index.html?appid=19283c16a6464eda8f30c8b2dab197ab#

Hinds/ Hekeao MAR Governance Group, 2018, Hinds/Hekeao Managed Aquifer Recharge Trial - Year 2 Final Report, Available at:

https://apps.canterburymaps.govt.nz/HindsMAR/images/WGA171076_RP_HY_02_6D_Final.pdf