Central Plains Water Trust

Annual Sustainability Report 2021-22

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- December 2022

Report prepared by

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List of Abbreviations

CCC	Christchurch City Council
CLG	CPW Community Liaison Group
CWMS	Canterbury Water Management Strategy
CPW	Collective reference to CPWL and CPWT
CPWL	Central Plains Water Limited
CPWT	Central Plains Water Trust
ECan	Environment Canterbury
EMF	CPW Environmental Management Fund
EMS	CPW Environmental Monitoring Strategy
FEP	Farm Environmental Plan
GSWERP	Ground and Surface Water Expert Review Panel
GSWMP	Ground and Surface Water Monitoring Plan
LWRP	Canterbury Land and Water Regional Plan
SDC	Selwyn District Council
TWEMF	Te Waihora Environmental Management Fund
TLI_3	Trophic Level Index
ZIP	CWMS Selwyn Waihora Zone Implementation Plan

Executive Summary

The Central Plains irrigation scheme (the Scheme) supplies water to a command area of approximately 71,000 hectares between the Waimakariri and Rakaia rivers. The initial stage of the Scheme (Stage 1) of the commenced operations in 2015, with the final stage (Stage 2) being commissioned in October 2018.

Stage 1 of the Scheme covers an area of approximately 30,300 hectares between the Rakaia and Selwyn rivers, approximately 22,500 hectares of which is irrigated using CPW water. Stage 1 incorporates a 17km long headrace canal to supply water from the Rakaia River intake to 133 farm turnouts via a 130 km distribution network comprising pressurised underground pipes. Stage 2 of the CPW Scheme covers an area of approximately 32,000 hectares between the Selwyn and Waimakariri Rivers, 18,200 hectares of which is irrigated using CPW water. Stage 2 extends from the end of the Stage 1 headrace canal and supplies 135 farm turnouts via a pressurised distribution network approximately 200 kilometres long. The 7,000 ha Sheffield Scheme is a stand-alone project along the northern margin of the Central Plains area that commenced operations in November 2017 utilising water from the Kowai and Waimakariri Rivers in combination with a 2 million m^3 storage pond constructed near Springfield. Approximately 4,200 hectares of the Sheffield Scheme area is irrigated using CPW water.

Cumulative rainfall during the 1 September 2021 to 23 May 2022 irrigation season was generally between 10 to 20 percent above average across the Central Plains area. However, this rainfall was unevenly distributed through the season with large rainfall events occurring in mid-December 2021 and early February 2022. These rainfall events moderated accumulated soil moisture deficits during the summer and autumn period, reducing cumulative irrigation demand over 2021-22 irrigation season. Following wetter than normal conditions during winter 2021, groundwater levels and surface water flows were generally above average during the early part of the season. Following the December 2021 and February rainfall events, this recovery was maintained through the remainder of the year.

During the 2021-22 season the CPW scheme supplied 111.3 million m^3 of water to 259 shareholder properties. A combined total of 104.1 million m^3 of water was supplied to 228 properties in the Stage 1 and Stage 2 areas of which 69.4 million m^3 (66.7%) was sourced from run-of-river abstraction from the Rakaia River, with an additional 34.7 million m^3 (33%) of stored water sourced from Lake Coleridge. A total volume of 7.2 million m^3 was supplied to 31 properties in the Sheffield Scheme area during 2021-22, comprising 5.3 million m^3 (77%) pumped from the Waimakariri River and 1.6 million m^3 (23%) gravity fed from the Kowai River.

During the 2021-22 season direct run-of-river abstraction by the Scheme totalled 26 and 7 percent of the volume potentially available under resource consents held by CPW for abstraction from the Rakaia and Waimakariri Rivers respectively. Groundwater usage by CPW shareholders during 2021-22 totalled 13% of the total volume authorised by existing water permits across the Scheme area.

Water quality monitoring results recorded by the CPW monitoring programme during the 2021-22 year show surface water quality, groundwater quality and lake water quality trigger levels established for the CPW Scheme[1] were exceeded at a number of monitoring sites located both up-stream, within and down-stream of the CPW Scheme area. The recorded trigger level exceedances are either within the historical range and/or consistent with background trends observed prior to commencement of CPW operations. Although influenced by medium-term variation in climate and land use, historical increasing trends in Nitrate-Nitrogen appear to have levelled-off in several lowland streams. Similarly, in-Scheme groundwater levels have recovered significantly compared to those prior to commissioning of the Scheme, particularly in the Stage 1 area where the magnitude of seasonal variation has decreased in response to the substitution of deep groundwater abstraction with water supplied by CPW Scheme.

Implementation of Farm Environment Plans (FEPs) for all CPW Shareholder properties, combined with ongoing improvements in farm management practices, has resulted in significant reductions in nutrient losses across the Scheme. Based on farm nutrient budgets, 2021-22 nutrient losses were approximately 22% below the 2017 baseline across properties in the CPW Scheme, exceeding the 2022 nutrient reduction target for agricultural land use in the Selwyn-Te Waihora zone specified in the Land and Water Regional Plan (LWRP).

Key Statistics for the CPW 2021-22 Irrigation Season

	Stage 1	Stage 2	Sheffield
Number of Properties Supplied	98	130	31
Number of Turnouts Supplied	133	135	37
Farm Enterprise Property Area	30,300 Ha	32,000 Ha	7,000 Ha
Irrigated area	22,500 Ha	18,200 Ha	4,200 Ha
Total Volume of Water Delivered	104.1 million m^3		7.2 million m^3
Total Volume of Run-of River Take	69.4 million m^3		6.3 million m^3
Total Volume of Water from Storage	34.7 million m^3		0.9 million m^3
Total Volume of Groundwater Used	11.2 million m^3	14.8 million m^3	0.02 million m^3
Length of 2021-22 Irrigation Season	265 days		260 days
Available Surface Water Allocation Taken	26%		7%
Days with Partial or Full Restriction on Abstraction	105 days		97 days

[1] These trigger levels are consistent with equivalent environmental limits established in the Canterbury Land and Water Regional Plan

1. Scheme Background

1.1. History

The Central Plains Water Trust (CPWT) was established jointly in 2003 by Christchurch City Council (CCC) and Selwyn District Council (SDC) to implement the Central Plains Water Enhancement Scheme (the Scheme) which was intended to supply irrigation water to an area of approximately 60,000 hectares between the Waimakariri and Rakaia Rivers.

In July 2012, the CPWT was granted resource consents by Environment Canterbury (ECan) and SDC to take and use water for irrigation purposes, as well as to construct and operate the Scheme. Central Plains Water Limited (CPWL) was subsequently established to implement the Scheme, and CPWT has licensed the use of the Scheme consents to CPWL. CPWL is responsible for the construction and operation of the Scheme, and for all consent compliance and reporting. For the purposes of this report, CPWT and CPWL are referred to collectively as CPW.

1.2. Scheme Development

As illustrated on Figure 1 development of the Scheme was completed in three stages.

Stage 1 provides irrigation water to an area of approximately 30,300 hectares between the Rakaia and Selwyn rivers and was completed in September 2015. Stage 1 is supplied from the Rakaia River via a 17km headrace that extends from the river intake as far as Leeches Road. From the end of the headrace, water is conveyed to individual shareholder properties via a pressurised pipe network approximately 130 kilometres in length. Construction of the Rakaia River intake and distribution network for Stage 1 was undertaken between early 2014 and mid-2015, with the first irrigation water supplied on 1 September 2015.

Stage 2 supplies a command area of approximately 32,000 hectares between the Selwyn and Waimakariri rivers. Construction of Stage 2 commenced in early 2017, with the scheme becoming operational on 2 October 2018. This component of the Scheme is a fully piped network that is integrated with the Stage 1 reticulation, utilising water from the Rakaia River intake (including Lake Coleridge storage). Stage 2 is supplied by a 23-kilometre, large diameter (2.5 m) Glass Reinforced Plastic (GRP) pipe which extends from the end of the Stage 1 headrace canal and feeds a pressurised distribution network approximately 200 kilometres long.

The Sheffield scheme, covering approximately 7,000 Ha commenced operations in November 2017. This component of the scheme is physically separate from Stages 1 and 2, supplying irrigation water, stock water, firefighting water and supplementary town supply water for Springfield and Sheffield from the Waimakariri and Kowai Rivers. The Sheffield scheme includes a 2 million m^3 pond constructed near Springfield to provide storage during periods of low flow when run-of-river abstraction is restricted.

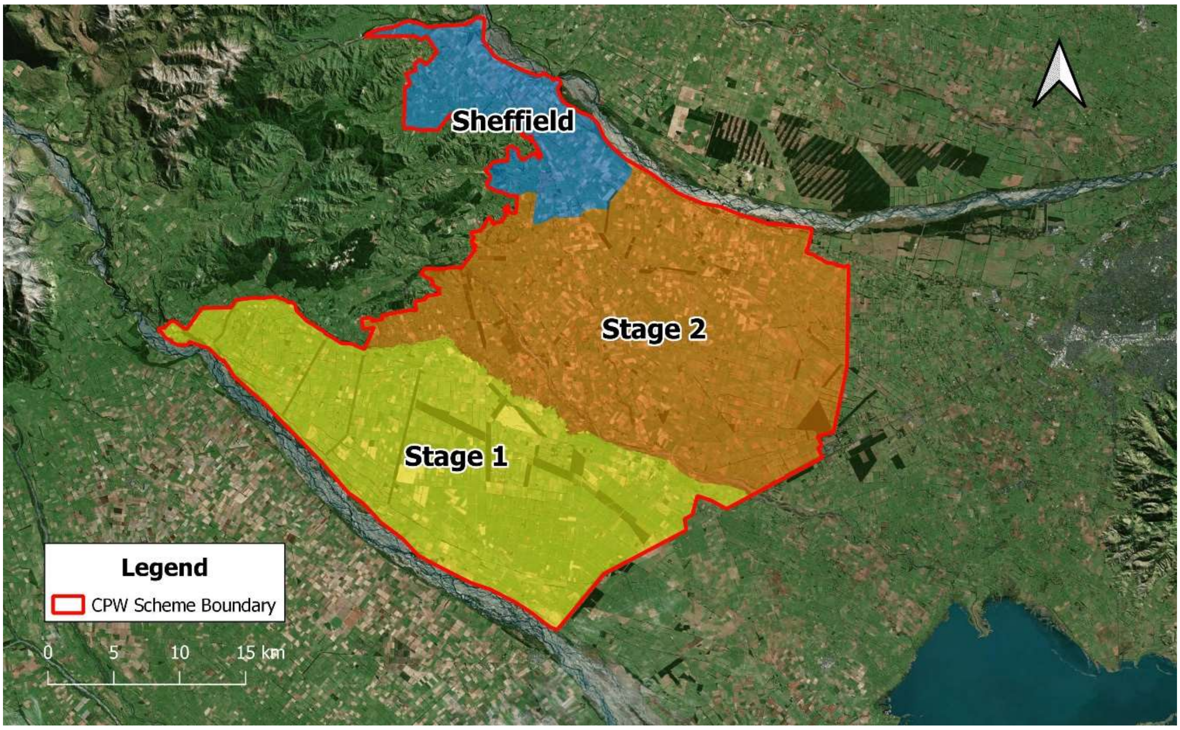

Figure 1. *Layout of the CPW scheme showing the extent of individual Scheme stages.*

1.3. Water Sources

Stage 1 and Stage 2 of the Scheme derive water from the Rakaia River via an intake constructed approximately 8 kilometres downstream of the Rakaia Gorge (SH77) bridge. Conditions of resource consents authorising the taking of water from the river are subject to minimum flow conditions which require the rate of abstraction to progressively reduce as river flows decline.

The Rakaia River Water Conservation Order establishes a minimum flow at Rakaia Gorge which varies depending on the month between 90 cubic metres per second (cumecs) in September and 139 cumecs in December. When flows are below the minimum flow, no water can be taken from the river. When flows are higher than the minimum flow, water can be taken from the river by resource consents assigned to multiple allocation 'Bands' which have varying minimum flow restrictions. Water permits assigned to individual Bands can take water on a 1:1 basis above the specified minimum flow (i.e., for every 2 m^3/s of flow above the specified minimum, 1 m^3/s can be taken from the river).

The bulk of allocation held by CPW is assigned to flow Bands which require abstraction to cease when river flow falls to less than 70 cumecs above the WCO minimum flow, resulting in relatively modest supply reliability (i.e., it is cut-off first as river flows decline). Due to constraints imposed by the minimum flow restrictions, the full volume of allocation held by CPW can only be taken on average for around 63 percent of the time during the irrigation season. To provide an adequate reliability of supply for irrigation, CPW have an agreement with Trust Power Ltd to access water stored in Lake Coleridge. Under this agreement, water is released from Lake Coleridge as river flows decline. This enables CPW to continue to take water from the river without having any adverse effect on natural flows in the river. The use of stored water increases the reliability of supply for Stage 1 and 2 to approximately 98 percent.

The Sheffield Scheme utilises water from the Kowai and Waimakariri Rivers which are subject to similar low flow restrictions to those applying on the Rakaia River. The storage pond constructed for the Sheffield Scheme holds sufficient water to maintain reliability of supply at a similar level to Stages 1 and 2. It is noted that the maximum rate of take possible from the Waimakariri River intake under the current Scheme configuration is significantly lower than that authorised by existing resource consents.

Table 1 below provides a summary of the average utilisation of water available to CPW under existing resource consents via the Rakaia River and Waimakariri River intakes since the Scheme commenced operation. The proportion of total river flow available for abstraction by CPW varies from year-to-year reflecting temporal variation in river flows and the resulting effect of minimum flow cut-offs on water available for abstraction by CPW. The figures show that, to date, CPW has utilised less than 40% of the total allocation available to it from the Rakaia River and less than 12% of the water available from the Waimakariri River.

Table 1. *Average water availability and utilisation by CPW consents, 2016-17 to 2021-22.*

Source		2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
Rakaia River	Percentage of river flow available for CPW abstraction	6.2%	9.1%	4.8%	6.1%	7.2%	7.2%
	Percentage of river flow used by CPW	1.5%	1.5%	1.6%	2.3%	2.9%	2.0%
	Percentage of CPW allocation utilised	24%	17%	33%	38%	40%	26%
Waimakariri River	Percentage of river flow available for CPW abstraction	n/a	2.2%	3.1%	2.8%	2.5%	2.8%
	Percentage of river flow used by CPW	n/a	0.25%	0.14%	0.31%	0.25%	0.20%
	Percentage of CPW allocation utilised	n/a	11%	5%	11%	9.9%	6.6%

1.4. Regulatory Environment

The Canterbury Land and Water Regional Plan (LWRP) establishes objectives, policies and rules relating to the management of land and water resources across the Canterbury region. The plan divides the region into ten geographic zones and establishes a set of objectives, policies and rules which apply uniformly across the entire region. In addition, each Zone has a set of specific policies, rules and limits which address localised or sub-regional resource management issues particular to that Zone, which either over-ride or add to the region-wide rules.

The specific management provisions for each Zone are developed and overseen by a Zone Committee comprising a range of community representatives. The Zone Committee is responsible for developing strategies, targets and activities outlined in a Zone Implementation Plan (ZIP) that outlines recommendations for short and long-term water management in each Zone.

The Scheme is located in the Selwyn - Te Waihora Zone and forms an integral part of measures outlined in the ZIP (also referred to as the "Solutions Package") for delivering the Canterbury Water Management Strategy (CWMS) outcomes adopted by the Selwyn - Te Waihora Zone Committee in October 2013. These measures anticipate that the Scheme will provide additional recharge to the catchment from alpine water, a reduction in the volume of groundwater used for irrigation and provide opportunities for targeted stream augmentation. This is expected to result in increased volumes of water in aquifers and flows in lowland streams, as well as dilution of nitrogen concentrations in Lake Ellesmere/Te Waihora, thereby improving water quality and quantity across the wider Zone.

Recommendations in the Selwyn - Te Waihora Solutions Package were formally adopted by ECan via Plan Change 1 to the Canterbury Land and Water Regional Plan (LWRP) in February 2016. Updated provisions for the Selwyn - Te Waihora zone in the LWRP include:

- Prohibiting new groundwater takes in over-allocated water management zones and reducing the total volume of water allocated within the Zone
- Revised surface water allocation limits to deliver ecological and cultural flows, particularly in lowland streams
- Introduction of a fixed allocation or "cap" on nitrogen losses in the catchment (including the Scheme). Progressive reductions in cumulative nitrogen losses are required over time
- A requirement for all farming properties to prepare a farm environment plan (FEP) and implement a range of good management practices. This includes specific requirements for individual landholdings to reduce nitrogen leaching losses by specific amounts (depending on land use type) by 2022
- A reduction in legacy phosphorus in Lake Ellesmere/Te Waihora by 50 percent and improved management of lake-level and opening.

The Selwyn-Waihora provisions of the LWRP make specific provision for nitrogen losses from the Scheme. These provisions set a threshold for cumulative losses from the land irrigated from the Scheme which enables conversion of some existing dryland farms to irrigation, while requiring land uses within the scheme to implement good management practice to achieve the overall reduction in nitrogen losses required by 2022.

2. 2021-22 Annual Summary

2.1. Climate

During the 2021-22 year cumulative rainfall totals were above the long-term average across the Central Plains area. Figure 2 shows a total of 942 mm of rainfall was recorded at NIWA weather station 4702 (located approximately 4km west of Hororata) between July 2021 and June 2022, 115 mm (14%) above the long-term average of 827 mm. The figure also illustrates cyclical variations in medium-term (5-year moving average) rainfall, with multi-year periods of above and below-average rainfall observed in the historical record. Since 2000, despite individual dry seasons (e.g., 2014-15 and 2015-16), medium-term average rainfall totals at Hororata have remained close to, or slightly above, the long-term average.

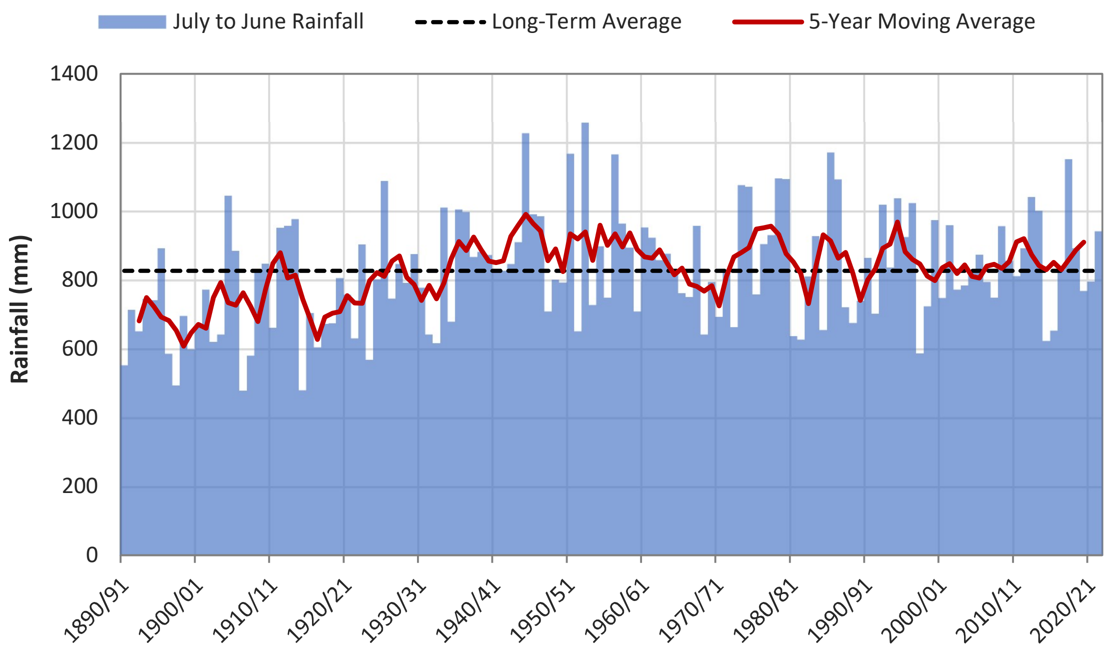

Figure 2. *Historical July to June rainfall at Hororata (4702), 1890-91 to 2020-22 (Data from NIWA CliFlo database).*

Although above the long-term average, rainfall was unevenly distributed through the 2021-22 year. Of particular note was a 10-day period between 4th and 14th February 2022 when between 130 and 140mm of rain was recorded across much of the Central Plains, approximately twice the average annual rainfall for February. A significant rainfall event of 60 to 70mm was also recorded over a 3-day period in mid-December 2021. As shown on Figure 3 below, with the exception of December 2021 and February 2022, monthly rainfall was generally below average across the Central Plains area during the remainder of the 2021-22 season.

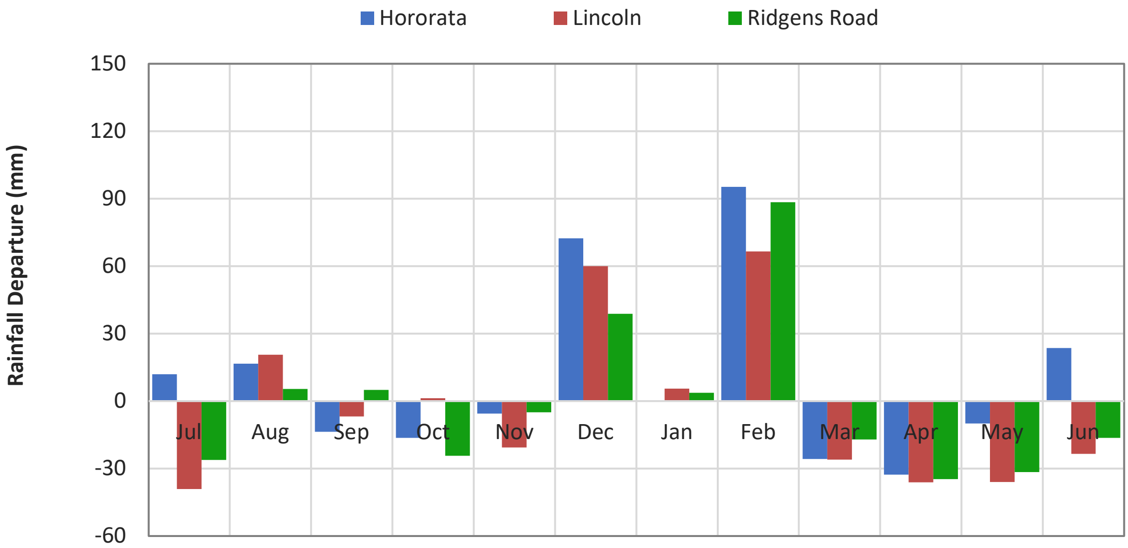

Figure 3. *Departure from average monthly rainfall at Hororata, Lincoln and Rigdens Road during the 2021-22 year (Data from NIWA CliFlo database and Environment Canterbury).*

Temporal variation in rainfall during the 2021-22 year was reflected in the accumulated soil moisture deficit across the Central Plains. As shown on Figure 4, soil moisture deficit was generally average to slightly below average from July to mid-December 2021 before declining appreciably in response to the December 2021 and February 2022 rainfall events. Following the February 2022 rainfall soil moisture deficit generally remained below average for the remainder of the season. Due to the summer rainfall, soil moisture deficits during the 2021-22 season were appreciably lower than those recorded during the 2019-20 and 2020-21 seasons, partially over the summer and autumn months. Such differences in the timing and magnitudes of soil moisture deficit between individual irrigation seasons significantly influence the seasonal pattern and volume of water demand in the CPW Scheme.

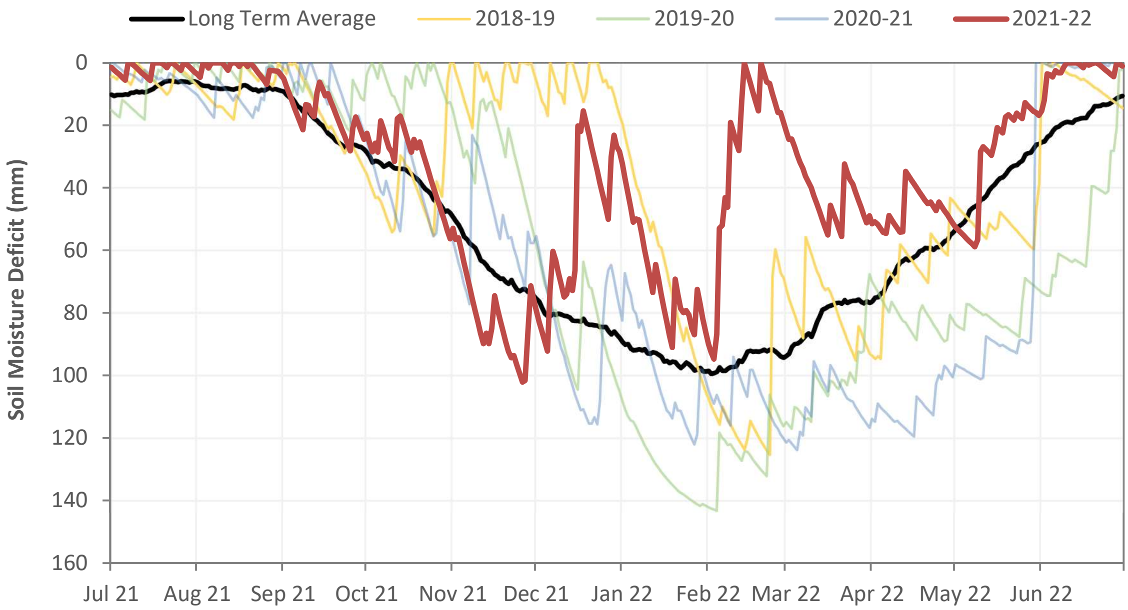

Figure 4. *Soil moisture deficit at Hororata during 2018-19, 2019-20, 2020-21 and 2021-22 compared to the long-term average (Data from NIWA CliFlo database, Station No. 4702).*

While requirements for irrigation reflect short-term variation in rainfall, the overall quantity of groundwater and surface water resources in the Central Plains area generally reflect longer-term trends in climate. As illustrated on Figure 5, cumulative rainfall during the 2021-22 year was close to average from July to mid-October 2021, declining to slightly below average during November and early December 2021. Following the December 2021 and February 2022 rainfall events, cumulative rainfall remained above average for the remainder of the season.

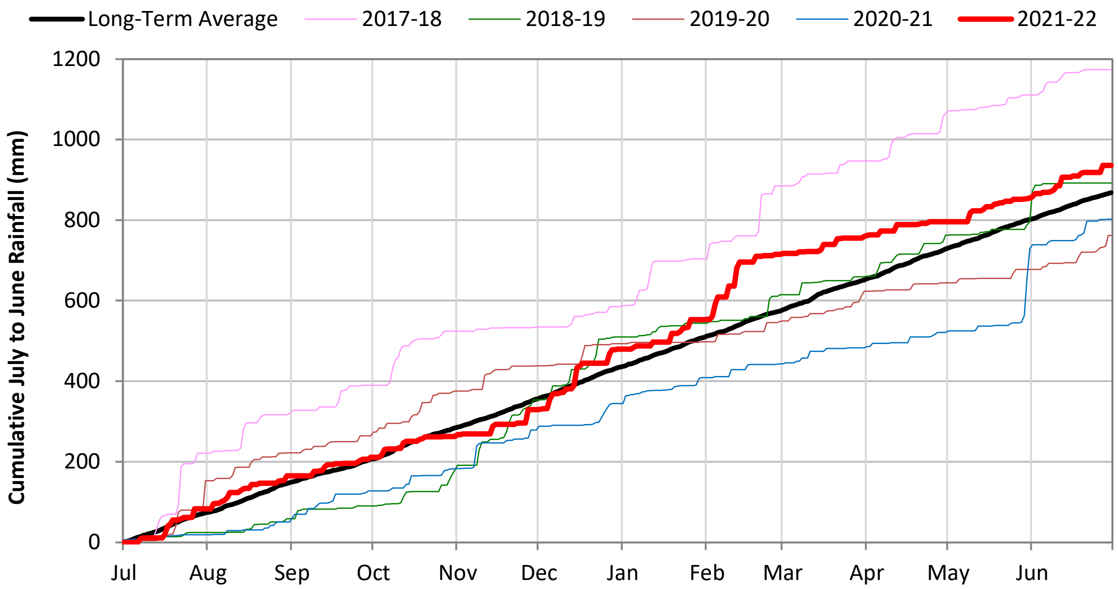

Figure 5. *Cumulative (July to June) rainfall at Hororata, 2017-18 to 2021-22.*

Both short and medium-term variations in rainfall departure from average were reflected in groundwater levels and stream flows across the wider Central Plains area during the 2021-22 year. While surface water flows are generally influenced by individual rainfall events over the short-term, variations in groundwater levels and discharge in lowland streams are more strongly influenced by seasonal to inter-annual variations in rainfall.

Figure 6 shows a plot of groundwater levels in representative long-term ECan monitoring wells located in the Central Plains area. During 2021-22 groundwater levels recovered from their seasonal minimum in winter 2021 and remained above for the average for the remainder of the year. The above average rainfall in December 2021 and February 2022 offset the seasonal decline typically observed during the summer and autumn period due to increased recharge and reduced abstractive demand.

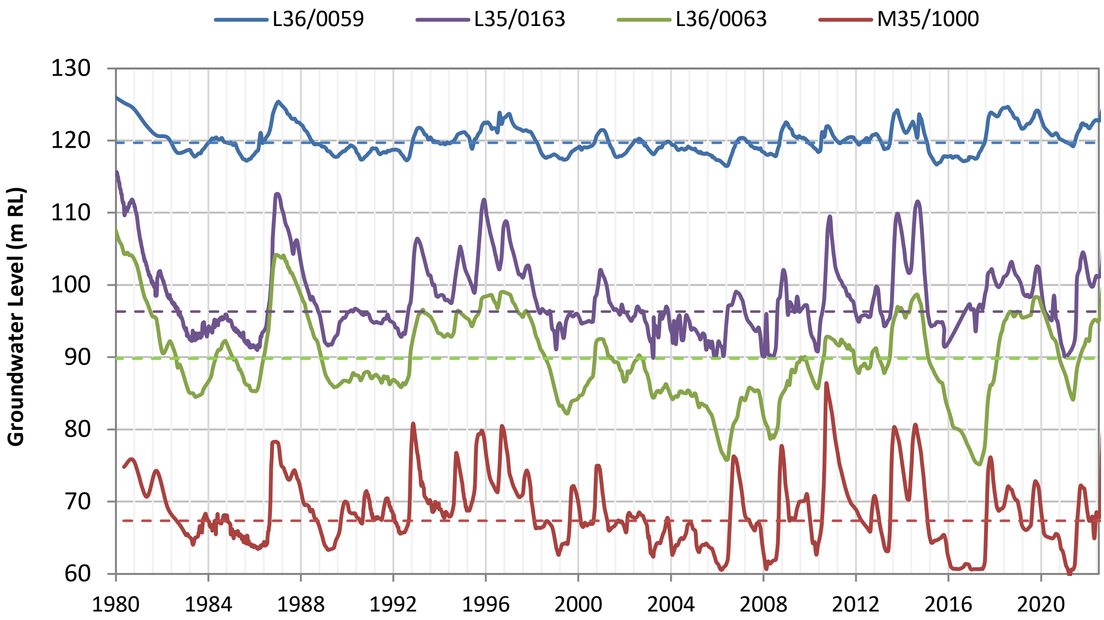

Figure 6. *Long-term groundwater levels recorded in L36/0059 (Hororata), L35/0163 (Kirwee), L36/0063 (Greendale) and M35/1000 (West Melton) from 1980 to 2021. Dotted lines indicate long-term median groundwater levels at each site. (Data from Environment Canterbury).*

Flows in rivers and streams draining the Central Plains area are influenced by both rainfall and groundwater levels (particularly during periods of limited rainfall). Figure 7 compares flow in the Selwyn River at Coes Ford during the 2021-22 year with the long-term average for this site. The figure shows flows remained well below average during summer and autumn 2021 before recovering close to normal during the 2021 winter (May to July). During spring 2021 flows declined slightly faster than normal but recovered significantly following the December 2021 and February 2022 rainfall events, remaining average to above average for the remainder of the year.

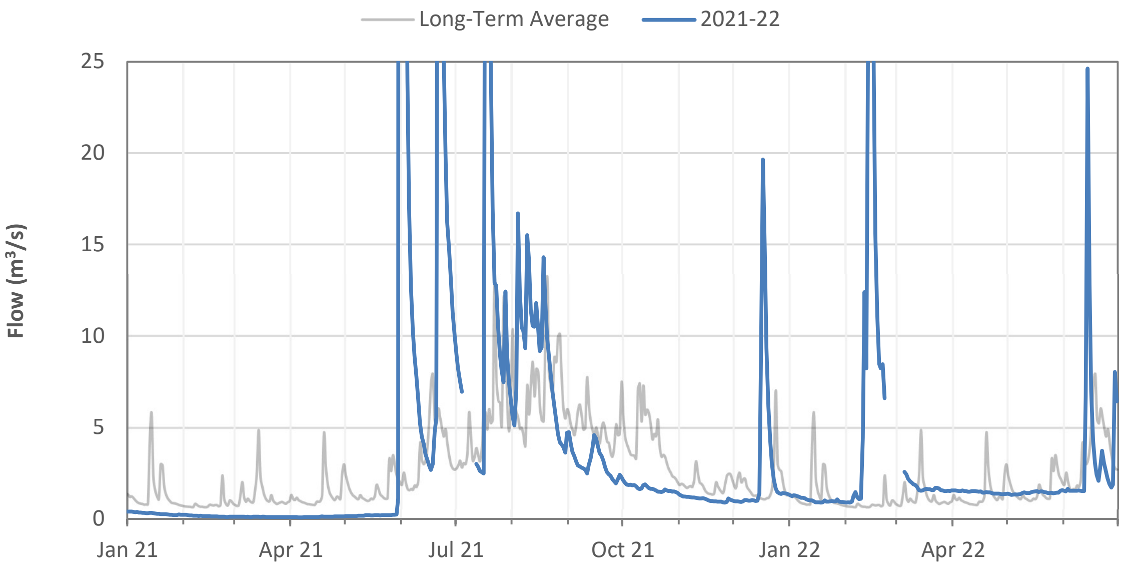

Figure 7. *Mean daily flow in the Selwyn River at Coes Ford during 2021-22 compared to the long-term average (Note: vertical axis only shows flows up to 25 m^3/s). Data from Environment Canterbury.*

Large recharge or high flow events following heavy rainfall can have a significant short-term influence on groundwater and surface water quality. Groundwater quality may also be influenced by inter-annual rainfall variability where extended periods of above average rainfall following similar periods of below average rainfall and can act to flush contaminants accumulated in the soil and unsaturated zone into underlying groundwater. Such short to medium-term climate variability can act to obscure underlying water quality trends.

Overall, the 2021-22 irrigation season can be characterised as being relatively wet, with soil moisture deficits significantly below normal during the summer and autumn period due to significant rainfall events in December 2021 and February 2022.

2.2. Scheme Operation

Between 1 October 2021 and 23 May 2022, the CPW scheme supplied a total of 111.8 million m^3 of water to a total of 259 shareholder properties.

A total of 104.1 million m^3 of water was supplied to Stages 1 and 2 of the Scheme, comprising 98 Stage 1 properties and 130 Stage 2 properties. Of this total volume, 69.4 million m^3 (66.7%) was sourced from run-of-river abstraction from the Rakaia River, with an additional 34.7 million m^3 (33%) of stored water sourced from Lake Coleridge.

A total volume of 7.2 million m^3 was supplied to 31 properties in the Sheffield Scheme area during 2021-22, comprising 5.6 million m^3 (78%) pumped from the Waimakariri River and 1.6 million m^3 (22%) gravity fed from the Kowai River. At total of 0.86 million m^3 of storage was utilised during the 2021-22 year (representing the difference in pond volume between the start and end of the irrigation season).

CPW scheme shareholders also utilised a total of 11.2 million m^3 of groundwater (11% of available allocation) in the Stage 1 area, 14.8 million m^3 (15% of available allocation) in the Stage 2 area and 0.02 million m^3 of groundwater (0.4% of the available allocation) in the Sheffield Scheme area during 2021-22. Cumulative groundwater use on CPW shareholder properties across the whole CPW Scheme area during 2021-22 was equal to 13% of current allocation. Figure 8 shows a breakdown of water use across the CPW Scheme during the 2021-22 season.

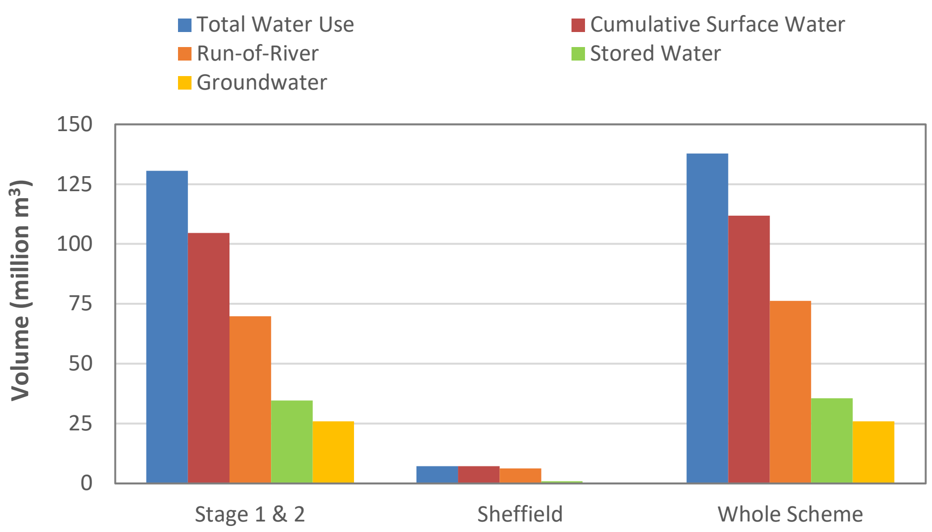

Figure 8. *Water use across the CPW Scheme, 2021-22*

Figure 9 provides a breakdown of seasonal water use for combined Stage 1 and Stage 2 operations since 2018-19 (noting Stage 2 did not operate for the full 2018-19 season). The figure shows total water use in 2021-22 was similar to 2018-19 (albeit with greater use of stored water during 2018-19) and appreciably lower than 2019-20 (-33%) and 2020-21 (-40%), both of which experienced prolonged periods of above average soil moisture deficit during the late summer and autumn period.

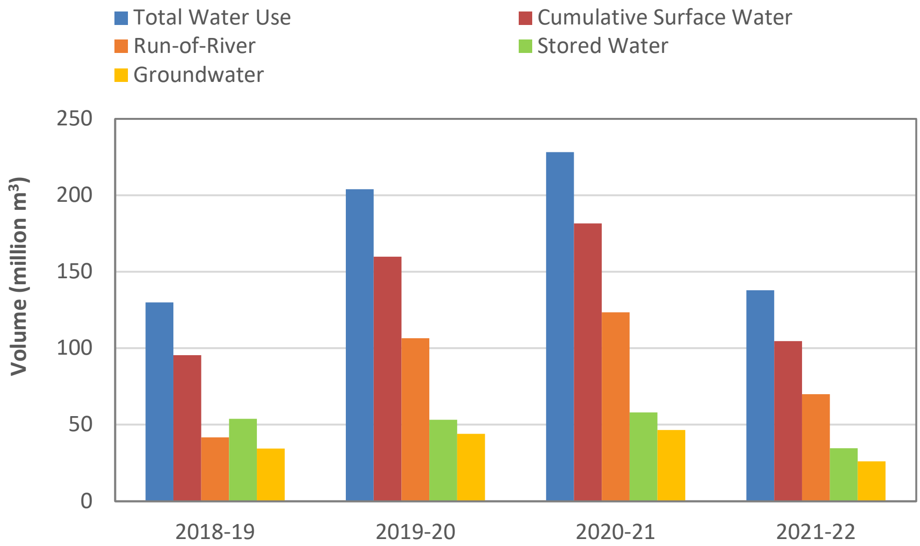

Figure 9. *Combined water use (including groundwater abstraction) in CPW Stage 1 and 2, 2018-19 to 2021-22.*

Figure 10 shows a plot illustrating the combined operation of Stages 1 and 2 of the CPW scheme during the 2021-22 year. The figure shows irrigation demand (black line) increased significantly in mid-October 2021 and ranged between 10 and 20 m^3/s through to early-December when demand reduced significantly following heavy rainfall. Scheme demand increased again in late-December before tailing off through January (during which time a majority of water was derived from storage), declining to near zero following further heavy rainfall in early February 2022. Demand resumed in late February and generally ranged between 5 and 10 m^3/s through to early May. A significant proportion of water was derived from storage during the latter part of the season due to a prolonged period of relatively low river flow reflecting a lack of north-westerly weather conditions.

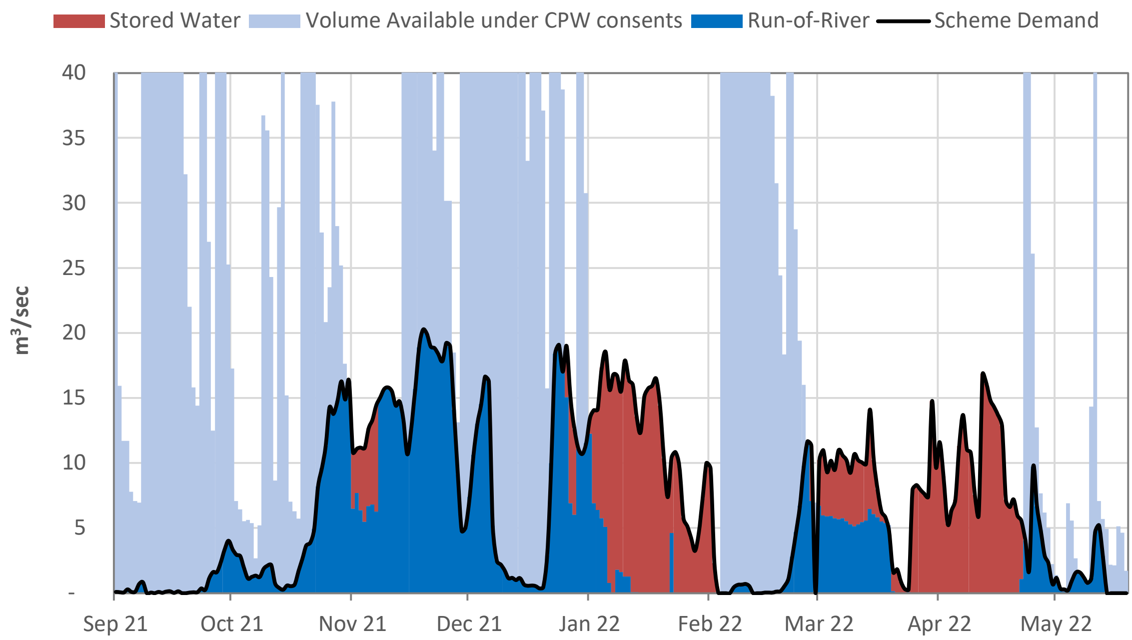

Figure 10. *Schematic illustration of Stage 1 and 2 operations during the 2021-22 year.*

Figure 11 illustrates operation of the Sheffield Scheme during the 2021-22 season. The figure shows water demand was limited through to late October 2021 and declined appreciably following rainfall events in December 2021 and February 2022, remaining low for the remainder of the season. Surface water inflows (from the Waimakariri and Kowai Rivers) largely tracked Scheme demand until the latter part of the season when pond storage was utilised to meet demand due to low flow restrictions on the surface water takes. Pond storage declined to around 50% of capacity by early-May 2022.

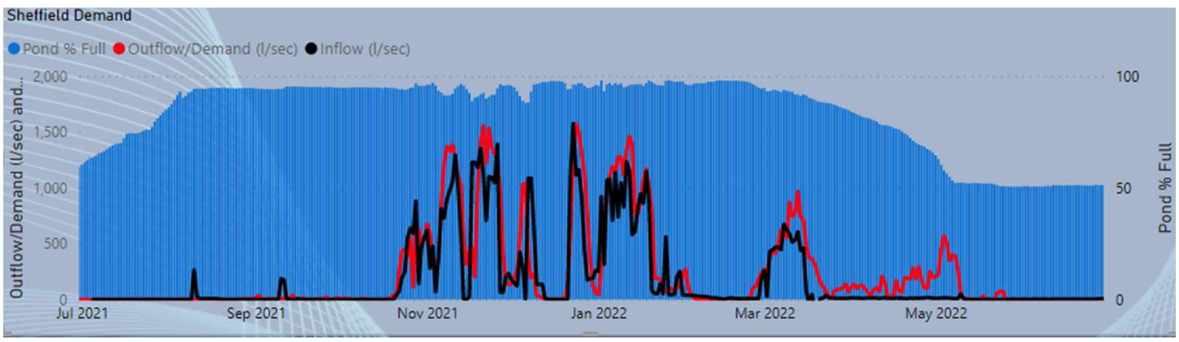

Figure 11. *Schematic illustration of run-of-river abstraction, Scheme demand and storage volumes for the Sheffield Scheme during the 2021-22 year.*

During the 2021-22 year, electricity consumption in the CPW Scheme totalled 9,616 MWh from a total installed pumping capacity of 11.1 MW. Electricity usage comprised the major component (94%) of the overall 10,908 tCO^2e carbon footprint of the Scheme.

2.3. Positive Benefits

Development of the CPW Scheme was forecast to provide a range of economic and social benefits to the wider community. Specific positive benefits resulting from Scheme that have been identified to date include:

- $592 million in increased agricultural output from land irrigated using the CPW Scheme
- Long-term employment for staff on farms where land use has changed to higher value use
- Support for the supply of raw materials to food processing facilities (e.g., Fonterra, McCains, Watties, Synlait)
- Upwards of 1,000 direct and indirect jobs in the wider Christchurch region as a result of the Scheme
- Provision of opportunities for landowners to convert land use to higher value options
- Conversion of unsustainable groundwater use to surface water use – to date CPW Shareholders have reduced their usage of groundwater by more than 50% across the scheme
- Provision of supplementary/backup water supplies for the Springfield and Sheffield communities
- Construction of 20 turnouts (connections to the scheme) to provide contingency for rural fire fighting (8 in Stage 1, 7 in Stage 2 and 5 in the Sheffield Scheme area).

The CPW Scheme has also provided a range of other positive benefits including:

- Implementation of Farm Environment Plans (FEP) on all scheme properties including a reduction in nitrogen losses in advance of LWRP requirements (this extends to approximately 15,000 Ha of land that is not currently irrigated using CPW water)
- Provision of long-term security of water supply for Shareholders (given current resource consents expire in 2047)
- Enabling reliable irrigation which has supported cultivation of alternative, high value crops such as chrysanthemum, hemp, sunflower etc
- Provision of long-term environmental funding to ecological projects and programmes in the Selwyn/Waihora catchment.
- Enabling development of the Selwyn Near River Recharge Project which aims to provide cultural and recreational benefits by augmenting flows in lowland streams in the Selwyn River catchment.
- Establishment of intensive winter grazing plans for all shareholders that are undertaking intensive winter grazing.
- Installation of sensors in CPW monitoring wells to track real-time variations in groundwater nitrate concentrations.
- Provision of 700 hours of training to CPWL shareholders and additional hours to non CPWL shareholders that have also attended nutrient and irrigation management workshops.

3. On-Farm Monitoring

Conditions of the CPW consents and provisions of the LWRP require both CPW and individual Shareholder farmers to undertake an extensive range of on-farm environmental monitoring, management and reporting activities.

3.1. Environmental Management Strategy

Prior to commencement of operations, CPW developed an Environmental Management Strategy (EMS) which established a range of protocols, policies and procedures for operation and management of the Scheme to ensure it achieves high environmental standards, sustainable outcomes and complies with all consent and Regional Plan requirements.

The EMS outlines specific responsibilities for operation of the Scheme including:

- Ensuring that all water users implement on-farm environmental management requirements related to achieving sustainable irrigation
- Monitoring and reporting of environmental performance
- Provision of education and training initiatives
- Funding and management of environmental initiatives, including those required by resource consent conditions, such as Community Liaison Group (CLG), the CPW Environmental Management Fund (EMF) and CPW Te Waihora Environmental Management Fund (TWEMF).

To facilitate adoption of best practice land management, the EMS required a Farm Environment Plan (FEP) to be developed and implemented on each CPW shareholder property supplied with water. Following Plan Change 1 to the LWRP in February 2016, the requirement for FEPs was formally extended to include a majority of agricultural properties larger than 10 Ha where nitrogen loss exceeds 15 kg/ha/year in the Selwyn Waihora zone.

Key components of FEPs include:

- Identification of environmental risks and potential adverse impacts associated with farming activities
- Development and implementation of measures to avoid or minimise identified environmental risks and implement good management practice farming methods
- Development and implementation of monitoring to inform good decision making on-farm
- Calculation and recording of nutrient loss rates and documentation of management practices to maintain, and where required, reduce, losses over time.

All FEPs are audited by a qualified Farm Environment Plan Auditor to provide an independent check that appropriate systems and practices are in place to minimise environmental risks associated with agricultural land use within the Scheme. Auditing is conducted on-farm and is based on sighting of evidence to document and support how FEP objectives and targets are being met. FEP audit results are reported to CPW, individual water users, and to ECan. After the first two years, audits are conducted based on the last grade received. A property receiving an A-grade is audited every three years, a B-grade every 2 years, a C-grade within one year and D-grade within 6 months of the previous audit.

3.2. Irrigated Area and Types

Use of water under by the CPW Scheme is limited by resource consent conditions to a designated area of approximately 60,000 hectares, within a total land area of 100,000 hectares. The total land area (i.e., Farm Enterprise Properties[2]) managed under CPW for 2021-2022 irrigation season was approximately 71,000 hectares. Figure 12 shows the irrigated and dryland portions of the CPW Farm Enterprise Area for 2021-22.

The total Farm Enterprise Area managed under CPW in the Stage 1 area during 2021-22 totalled approximately 30,300 Ha, of which around 22,500 Ha was irrigated using water supplied by CPW. Stage 2 properties cover a cumulative area of approximately 32,400 Ha, approximately 18,200 Ha of which was irrigated with CPW water. The total land area managed under CPW in Sheffield Scheme area during 2021-22 totalled approximately 7,100 Ha, of which around 4,200 Ha was irrigated using water supplied by CPW. The total area of new irrigation under the CPW Scheme (compared to the pre-Scheme baseline) is approximately 21,500 hectares, with the remaining irrigated area converted, either wholly or partially, from other water sources (e.g., groundwater) to CPW supply.

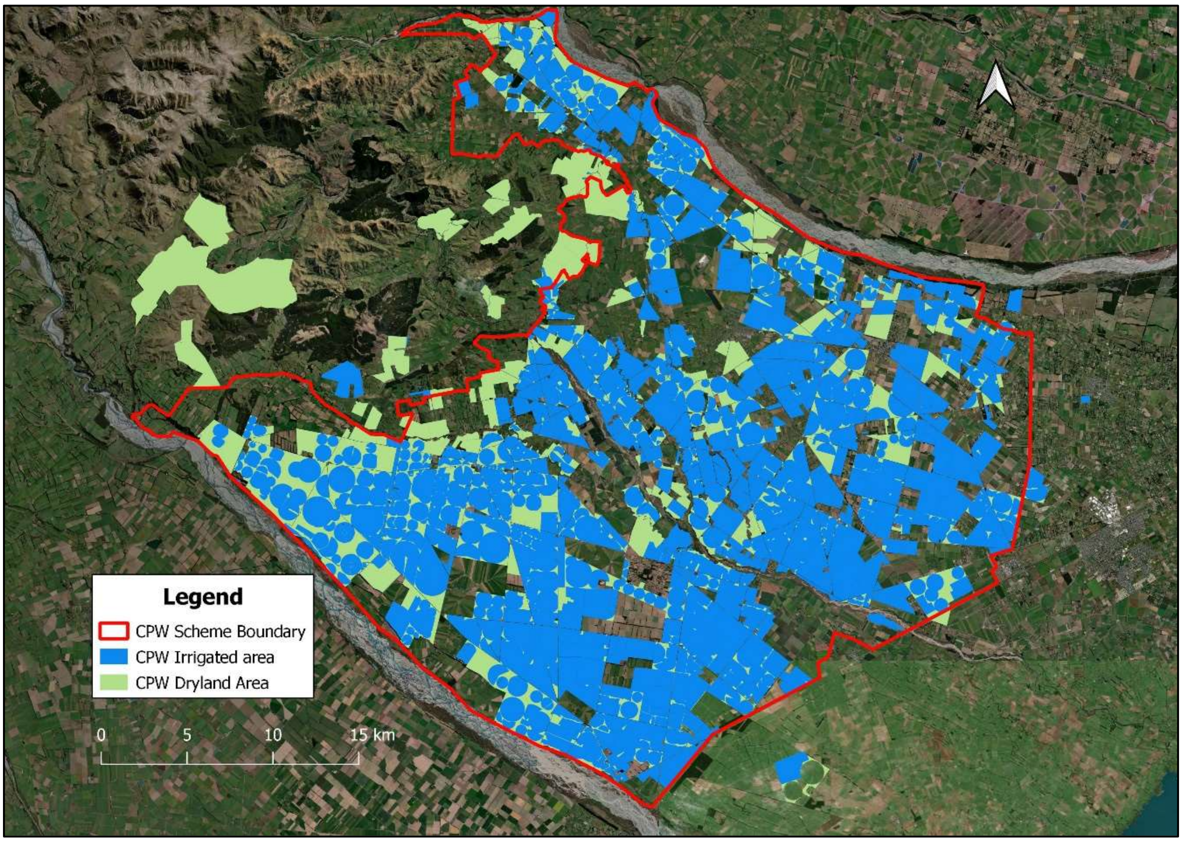

Figure 12. *Dryland and irrigated portions of the CPW Farm Enterprise area.*

[2] Farm Enterprise Properties represent the total area of shareholder land parcels included within the CPW Scheme, only a portion of which may be irrigated using CPW water.

The extent of land included in the Stage 1 and Stage 2 areas, including Farm Enterprise Properties that are either dryland or irrigated using non-CPW sources (i.e., groundwater), is shown on Figure 13. The figure shows a majority of this area is irrigated using either centre pivot irrigators (75 percent of total irrigated area) or travelling irrigators (18 percent of total irrigated area) with a relatively small area of gun, sprayline and solid set irrigation (7%). It is noted a majority of travelling irrigators are used on properties which were irrigated prior to CPW, while new irrigation development predominantly utilises centre pivot irrigators.

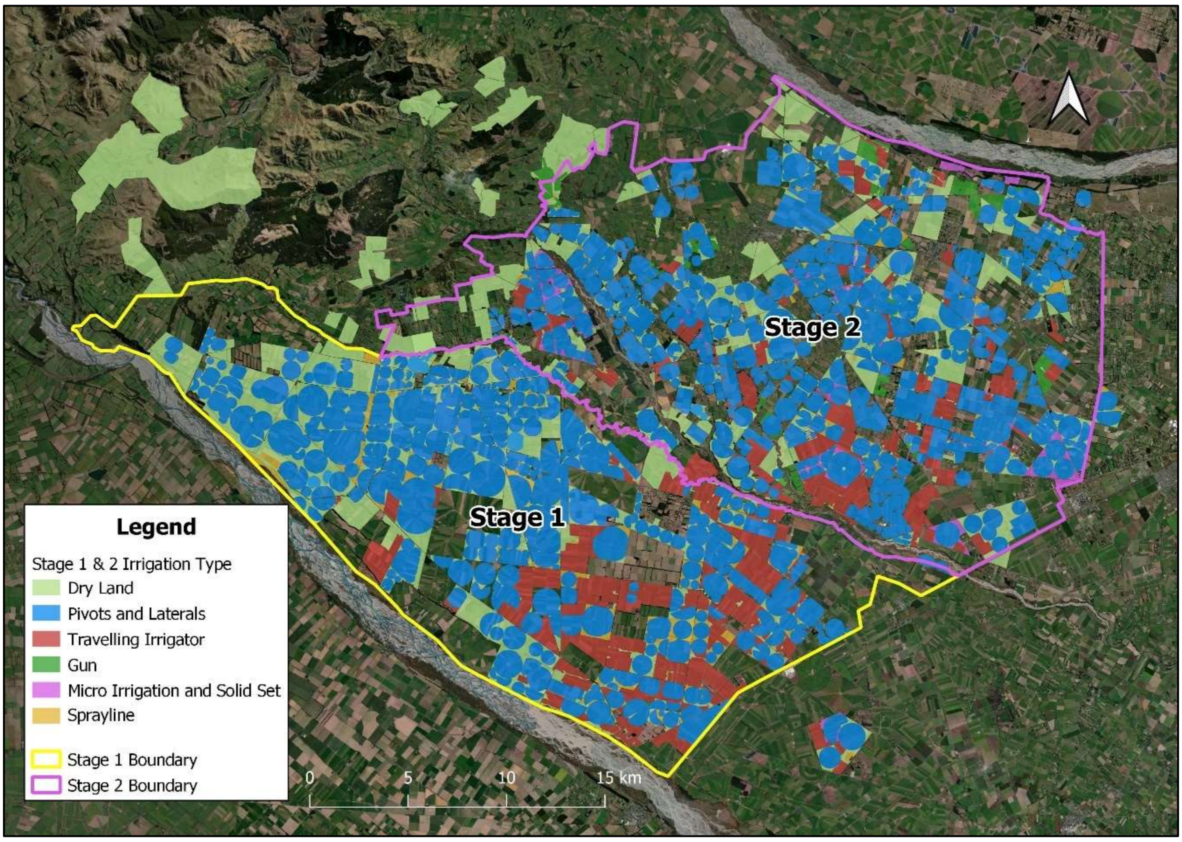

Figure 13. *Irrigated area and irrigation types in CPW Stages 1 and 2, 2021-22.*

The extent of land included in the Sheffield Scheme area (including Farm Enterprise Properties) and the distribution of irrigation system types is shown on Figure 14 below. The figure shows most of the land in the Sheffield Scheme area is irrigated using centre pivot irrigators with approximately 15% of the total area irrigated using travelling irrigators or spraylines.

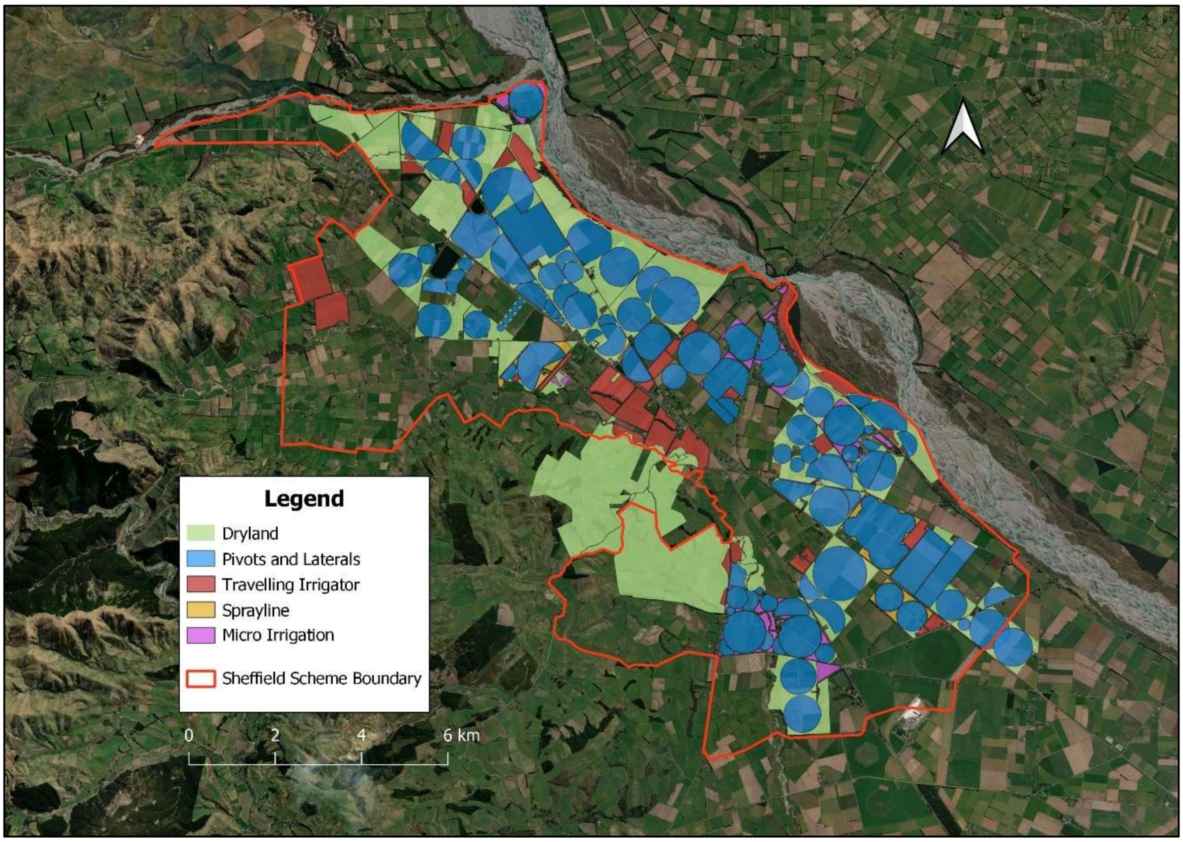

Figure 14. *Irrigated area and irrigation types in the Sheffield Scheme area, 2021-22.*

3.3. Land Use

Figure 15 provides a breakdown of land use (enterprise) types in the CPW Scheme area during the 2021-22 year based on the categories defined in the OverseerFM® nutrient budget model. The data shows that dairy and various combinations of sheep, dairy and beef grazing accounted for a majority of overall land use. From a farm systems perspective these enterprises can be divided into two types: dairy systems, and mixed systems. Approximately 60% of the total area comprise mixed systems that provide flexibility for farmers to respond to changes in market demand without the higher capital investment required to establish a dairy operation. Properties covering around 40% of the total Scheme area also have an interest in arable farming[3].

Since individual scheme stages became operational, sixteen additional dairy platforms have been commissioned within the CPW Scheme area (8 in Stage 1, 6 in Stage 2 and 2 in Sheffield), while 2 properties (in Stage 2) have converted from dairy to alternative land uses.

[3] This is highest in the Stage 2 and Sheffield Scheme areas where Farm Enterprises comprising 60 percent of the total area have an interest in arable farming.

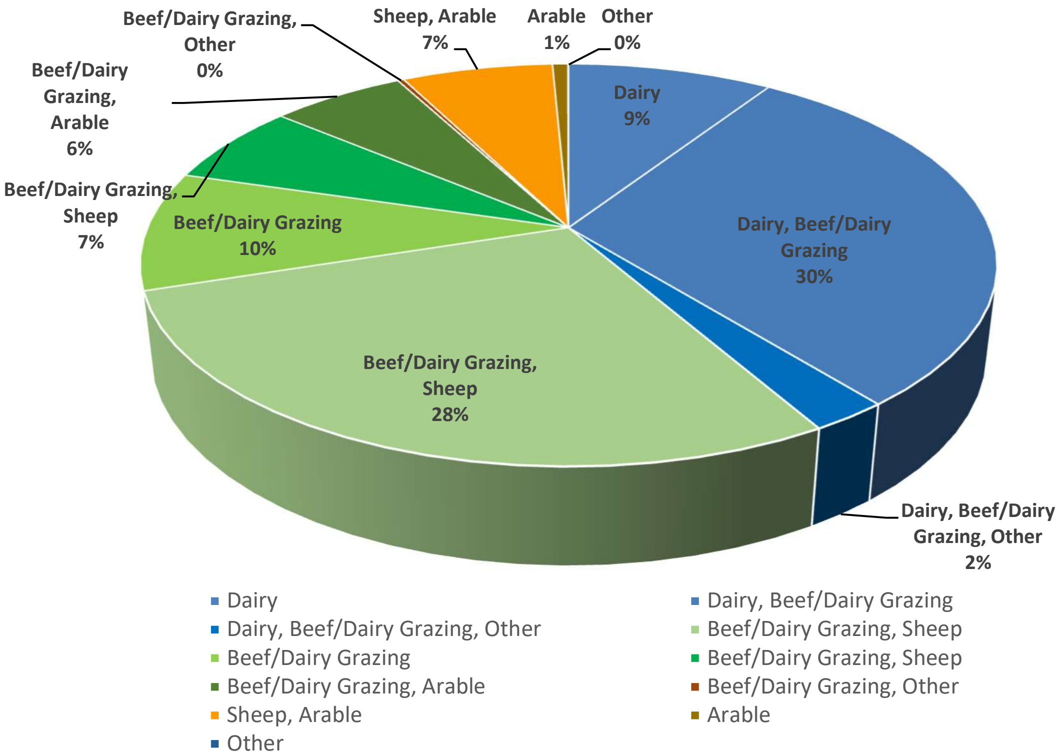

Figure 15. *Land use types in CPW Scheme area, 2021-22*

Figure 16 provides a comparison between baseline (i.e., pre-CPW) land use and current (2021-22) land use across the CPW Farm Enterprise Area based on based on OverseerFM® land use categories established in individual FEPs. The data show the major changes in land use have been a 7,114 Ha (50%) increase in Dairy, Beef/Dairy Grazing and a combined 3,452 Ha (11%) increase in the Beef/Dairy Grazing and Beef, Dairy Grazing, Sheep and Arable land use categories. These changes are balanced by reductions in the land area utilised for Beef, Dairy Grazing + Other, Dairy and Dairy, Beef/Dairy Grazing enterprises. These changes primarily reflect adjustments to land use within existing mixed farming systems, rather than large scale change to, or intensification of, pre-existing (Baseline) land uses.

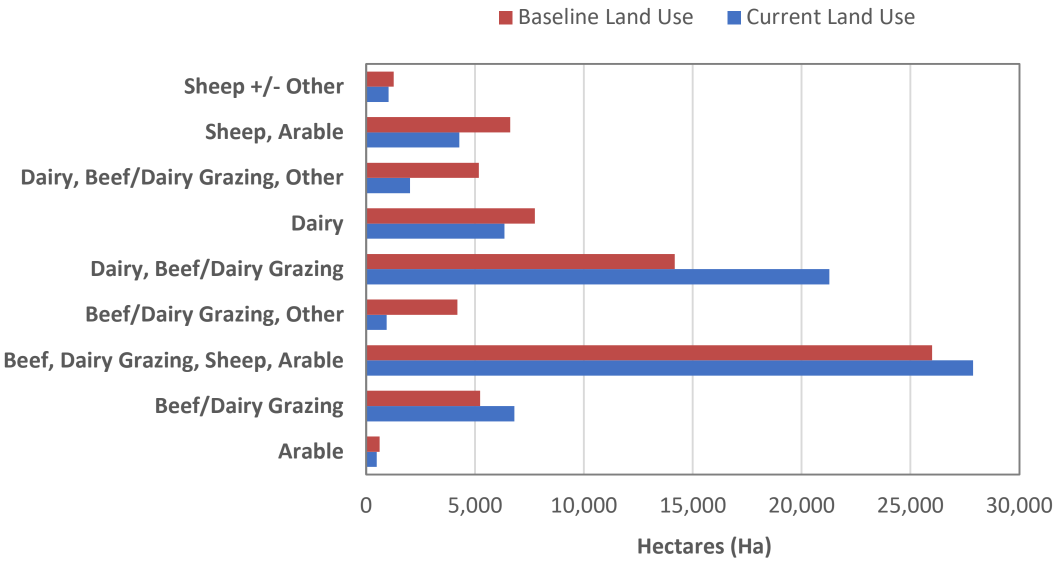

Figure 16. *Comparison of baseline land use (red bars) and 2021-22 enterprise types (blue bars) for CPW Farm Enterprise Properties.*

3.4. Irrigation Water Use

The Scheme-wide average seasonal application rate during the 2021-22 season was 1.07 mm/ha/day. This total is approximately 40 percent lower than the Scheme-wide application rate of 1.8 mm/ha/day during 2020-21, reflecting reduced irrigation demand due to the generally below normal soil moisture deficit which persisted for much of the 2022 summer. Application rates for the individual Scheme stages ranged from 1.42 mm/ha/day in Stage 1 to 0.84 mm/ha/day in Stage 2 and 0.68 mm/ha/day in the Sheffield Scheme area.

As illustrated on Figure 17 below, no individual property exceeded a seasonal application rate of 5.18 mm/ha/day, which is the maximum limit specified in CPWs consent to take and use Scheme water[4]. The high application rate (close to the consent limit) recorded on one property was investigated and found to be related to accuracy of water metering.

[4] It is noted that some groundwater taken is used for purposes other than irrigation, so the rates shown are considered conservative

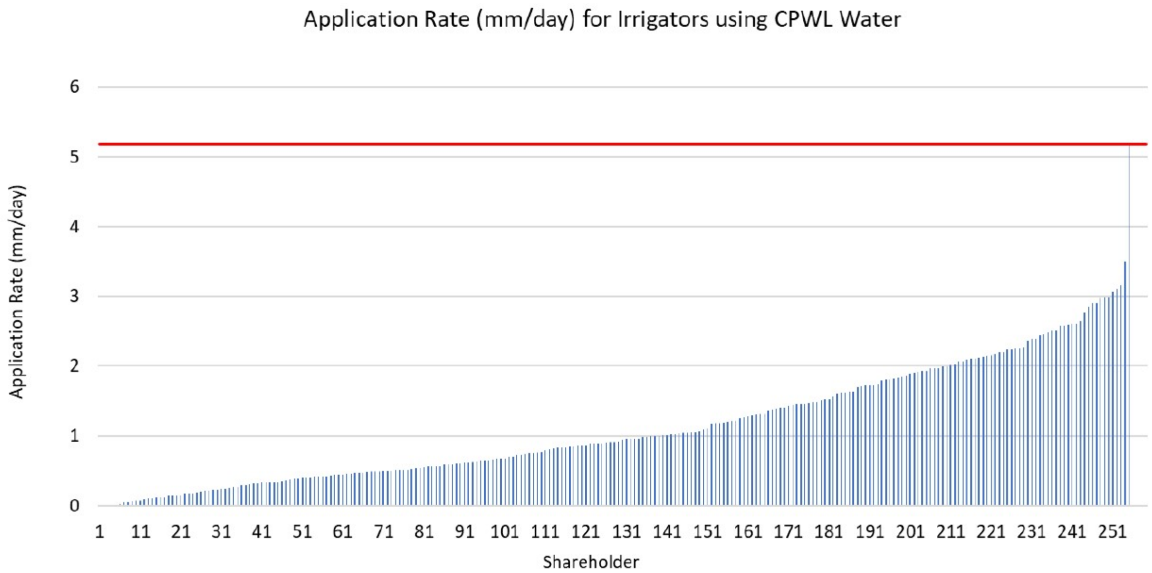

Figure 17. *Seasonal application rate application for Shareholder properties during the 2021-22 season. Red line denotes the maximum seasonal application rate specified in CPWs consents. (Reproduced from CPWL, 2022[5]).*

Table 2 provides a summary of seasonal water use (including CPW water and groundwater) across the CPW Scheme area (including Farm Enterprise Properties) over the past three seasons. Cumulative water use during the 2021-22 season totalled 1,941 m^3/ha (equivalent to a seasonal application depth of 194 mm), comprising 366 m^3/ha of groundwater and 1,575 m^3/ha of CPW water. This total was approximately 40% lower than application rates during the two preceding seasons[6] due to the wetter than average conditions through summer 2022.

Table 2. *Average seasonal irrigation application rates across the Scheme area (including Farm Enterprise Properties), 2019-20 to 2021-22.*

Year	Water Source	Stage 1 & 2 (m^3/Ha)	Sheffield (m^3/Ha)	Whole Scheme (m^3/Ha)
2021-22	CPW	1,637	1,014	1,575
	Groundwater	406	28	366
	Total	**2,043**	**1,042**	**1,941**
2020-21	CPW	2,840	1,577	2,714
	Groundwater	729	206	677
	Total	**3,569**	**1,783**	**3,391**
2019-20	CPW	2,505	1,817	2,432
	Groundwater	690	210	642
	Total	**3,191**	**2,027**	**3,074**

[5] CPWL, 2022; Annual Compliance Report – Central Plains Water Limited. Report submitted to Environment Canterbury, August 2022.

[6] Note: Scheme demand during the 2019-20 year was reduced during the 2020 COVID lockdown period.

3.4.1. Groundwater Conversion to CPW Scheme

One of the key benefits associated with the Scheme identified in the Selwyn - Te Waihora Zone Solutions Package was a reduction in the volume of groundwater utilised for irrigation across the Central Plains area, due to substitution with water derived from alpine sources (i.e., run-of-river and storage takes from the Rakaia and Waimakariri Rivers). The reduction in groundwater abstraction was expected to result in positive benefits associated with an increase in groundwater storage and correspondingly higher flows in lowland streams. A target of an 80% reduction in the volume of groundwater abstraction across the Rakaia-Selwyn and Selwyn-Waimakariri allocation zones was identified in the Selwyn-Waihora Zone ZIP Addendum (i.e., this aims to reduce groundwater usage to less than 20% of the allocated volume).

Figure 18 shows the percentage of total groundwater allocation utilised by farms in the CPW Scheme area between 2015-16 and 2021-22. The data show groundwater use across the Scheme area has declined appreciably since Stage 1 commenced operations in 2015-16. Since the full scheme commenced operations in 2018-19, groundwater usage has ranged between 14% and 27% of the total volume allocated (slightly higher in 2019-20 and 2020-21 due to prolonged dry conditions and lower in 2021-22 due to significant rainfall during the summer period). This indicates groundwater usage across CPW properties has approximately halved since Scheme commencement and currently sits close to (or below) the ZIP Addendum target.

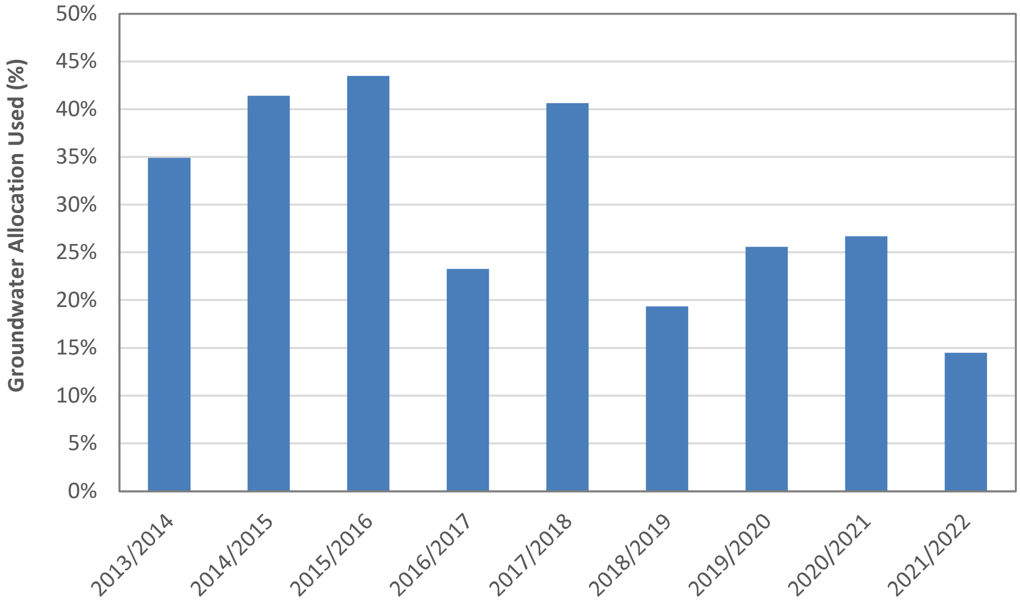

Figure 18. *Percentage of total groundwater allocation used by farms in the Stage 1, Stage 2 and Sheffield Scheme areas, 2014-15 to 2021-22.*

It is noted that estimates of the percentage of total groundwater allocation used are complicated by the expiry, partial replacement or surrender of individual water permits over time. The volume of groundwater used across the wider CPW scheme area is expected to continue to decline over coming seasons as on-farm irrigation systems are modified or replaced and confidence in the reliability of supply for of the CPW Scheme increases.

Figure 19 provides a comparison of actual and consented groundwater use on properties within the CPW Scheme area which hold existing groundwater abstraction consents. The figure shows that approximately half of properties holding existing groundwater consents used little to no groundwater during the 2021-22 season. For these properties, irrigation water was derived solely from the CPW Scheme and groundwater use typically comprised stock, dairy shed and/or household water supply. With few exceptions, groundwater usage was significantly below consented volumes for the remaining properties.

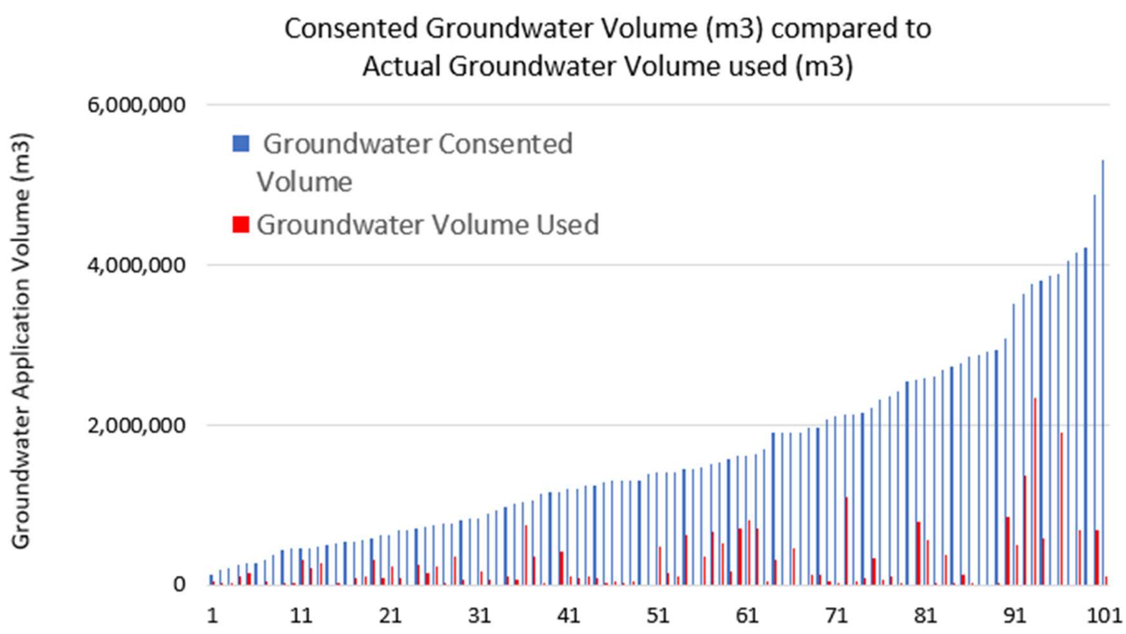

Figure 19. *Comparison of consented and actual groundwater use within the CPW Scheme, 2021-22 (blue bars indicate groundwater allocation volumes per shareholder property, red bars actual volumes used). Reproduced from CPW (2022).*

3.5. Farm Environment Plans

A FEP is the key environmental management tool that helps farmers recognise on-farm environmental risks and sets out a programme to manage those risks. It is also a mechanism which has been adopted in the LWRP to enable water quality objectives in the Selwyn - Te Waihora zone to be achieved.

FEPs are unique to each individual property and reflect the type of farm operation, the local climate and soil type, and the goals of the land user. The FEP covers management areas including:

- Irrigation management, including efficient water use
- Nutrient management
- Soil management
- Point source management (offal holes, farm rubbish & silage pits etc)
- Collected animal effluent management

- Native plants and animals
- Waterbodies - riparian drains, rivers, wetlands and lakes
- Water use (excluding irrigation water)

Under CPWs EMS, FEPs form a key component of the overall environmental compliance requirements. The frequency of FEP audits varies according to the current grading assigned to individual properties with properties assigned an A-grade audited every four years, B-grade properties audited every second year, C-grade properties annually and D-grade properties a minimum of six monthly[7]. However, the FEP must also be updated if anything on-farm changes e.g., a farm system, property ownership or manager.

Of the 114 CPW properties audited during 2021-22, 92 (80.7%) received an A-grade, 19 (16.7%) a B-grade, 2 (1.8%) a C-grade and 1 (0.9%) a D-grade. The two properties assigned a C-grade during the 2021-22 season received this grading as they were unable to provide a current nutrient budget, Winter Grazing Management Plan or a Performance Assessment for their irrigation system. One of the properties receiving a C-Grade also required Irrigation Management training and Soil Moisture monitoring while the other needed accurate fertiliser records and to ensure that the farm owned equipment that was used for spreading fertiliser is correctly calibrated for the product used. The property that initially received a D-grade was subsequently re-audited receiving a B-grade after substantial improvements were made to record keeping, soil moisture monitoring and effluent management.

Figure 20 compares audit grades received for CPW properties between the 2016-17 and 2021-22 years (noting inclusion of different groups and numbers of Shareholder properties in each year). The figure shows a consistently low proportion of properties (<6%) assigned either C or D-grades[8]. The figure shows a consistent increase in the percentage of properties assigned a A-grade (reaching 81% of properties audited in 2021-22) and a corresponding decline in the percentage of properties assigned a B-grade reflecting an ongoing increase in FEP audit grades. The exception to this pattern is the 2018-19 season when properties in the Stage 2 area were audited for the first time. Audit grades for these properties have improved over subsequent years in line with those across the wider scheme.

[7] https://www.ecan.govt.nz/reporting-back/farm-environment-plan-audits/#:~:text=Each%20financial%20year%2C%20Environment%20Canterbury,maximum%20four%2Dyear%20audit%20cycle.

[8] The percentage of properties receiving a D-grade appears high during the 2020-21 year due to the low number of audits completed (37) compared to previous years (typically >130).

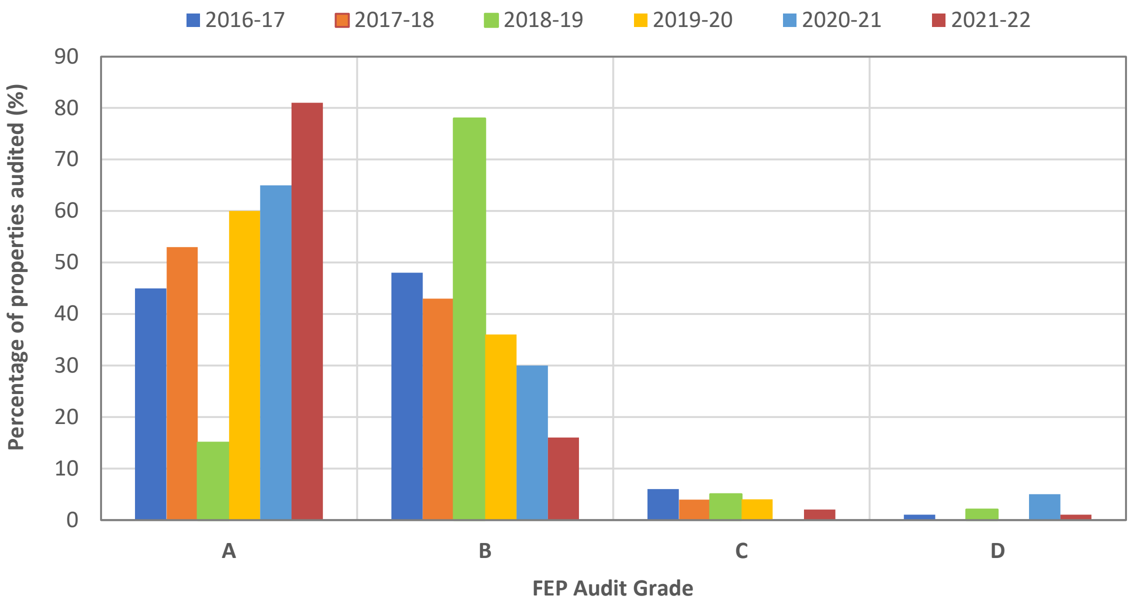

Figure 20. *Comparison of FEP audit grades for the 2016-17 to 2021-22 irrigation seasons (noting inclusion of different properties and varying numbers of audits in individual seasons).*

3.5.1. Nutrient Budgets and Nitrogen Allocation

During development of the Selwyn Te Waihora Solutions Package a "Look-up Table" (LUT) was used to estimate nitrogen losses and derive an estimated source nitrogen load and concentrations from the catchment. The pastoral farm types in the LUT were subsequently updated using the OverseerFM® version 6.2.0 (LUT patch) and estimated nitrogen loads and concentrations updated for inclusion in Variation 1 to the Land and Water Regional Plan (LWRP).

Table 11(i) of the LWRP establishes a limit for nitrogen losses in Selwyn Waihora zone of 5,044.4 tonnes/year by 2037. Of this total, 358 tonnes/year is allocated to CPW to provide for the conversion of dryland into irrigated land. This allocation is in addition to the assessed dryland nitrogen baseline losses of 621 tonnes/year for CPW Scheme enterprise properties, giving a total Nutrient Discharge Allowance (NDA) for the CPW scheme of 979 tonnes/year, as specified in Table 11(j) of the LWRP[9]. It is noted that these figures have been updated using more recent versions of OverseerFM® to derive an updated NDA for the CPW Scheme.

Nutrient losses for properties in the CPW Scheme are managed collectively by CPW. The permitted cumulative nitrogen loss allowance for the Scheme is the sum of baseline losses for each individual Farm Enterprise Property, plus an allowance for new irrigation. Using the current version of OverseerFM®, baseline (i.e., pre-CPW) nitrogen losses from CPW Shareholder properties are calculated to be 3,378 tonnes N/year (this includes nitrogen loss from farms irrigating pre-CPW as well as losses from dryland properties) with an additional sub-licence provided of 986 tonnes N/year

[9] This allowance is for 22,991 ha of new irrigation, of which approximately 21,500 ha has been taken up.

for conversion of dryland to irrigation under CPW. This equates to a cumulative (2018[10]) NDA of 4,364 tonnes/year for the CPW Scheme[11].

To achieve specified water quality outcomes, Policy 11.4.16(1) of the LWRP required farming activities in the Selwyn Waihora catchment to achieve a 14.4% reduction in nitrogen losses beyond those that could be reasonably anticipated by adopting good management practices by 1 January 2022.

Nutrient Budgets and FEPs have been prepared and audited for all Stage 1, Stage 2 and Sheffield Scheme properties. Table 3 compares the calculated 2021-22 N loss from CPW properties against the calculated Scheme baseline NDA and the total Permitted NDA discharge allowance (including the allowance for additional CPW irrigation). The figures show current nutrient losses from the CPW scheme are 730 tonnes N/year (21.6%) below the pre-Scheme Baseline and 1,716 tonnes N/year (39.3%) below the 2017 Permitted NDA for the Scheme. Current nutrient losses from CPW properties are therefore significantly lower than the minimum required to achieve the nutrient loss reduction targets established in the LWRP.

Table 3. *Comparison of 2021-22 nutrient losses for the CPW Scheme with Baseline and Permitted NDAs.*

	Nitrogen Loss (tN/yr)
Pre-CPW (Baseline) NDA	3,378
Permitted NDA	4,364
2021-22 Nutrient Losses	2,648
Current CPW reduction below Baseline NDA	730 (-21.6%)
Current CPW reduction below Permitted NDA	1,716 (-39.3%)

Figure 21 illustrates the Baseline, Permitted and Actual Nitrogen losses calculated for CPW Scheme over the 2018-19 to 2021-22 seasons. The figure illustrates the ongoing decline in Actual Nitrogen losses which are significantly lower than the minimum loss reduction target established in the LWRP.

[10] i.e., prior to Nitrogen loss reductions required in the LWRP.

[11] This number differs from that listed in the LWRP reflecting changes in the OverseerFM® assessment methodology. Given differences between individual OverseerFM® versions, the relative change between baseline and current nutrient loss estimates is a key metric.

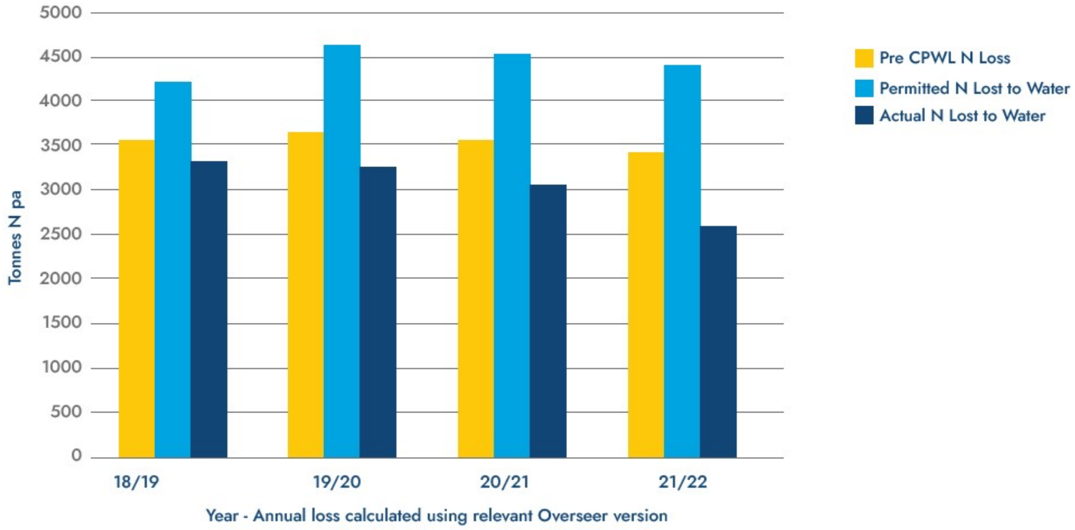

Figure 21. *Baseline, Permitted and Actual Nitrogen losses for the CPW Scheme, 2018-19 to 2021-22. (Reproduced from CPW (2022b[12])).*

3.6. Environmental Initiatives

CPW provides ongoing training and assistance to shareholders related to a range of irrigation and environmental management issues, including development and implementation of FEP requirements. Additional training has also been provided in terms of irrigation management and FEPs via workshops for all users within the Scheme area. CPW has also developed systems to enable ready access to climate data to assist shareholders irrigation management and provides support to assist owners/managers to undertake testing of the performance of their irrigation infrastructure.

CPW has a significant focus on assisting shareholders to focus on improving farm practices, with the current emphasis on assisting shareholders with grazing management plans. Other initiatives undertaken during the 2021-22 year included:

- Meeting with each shareholder that has an audit in the next irrigation season (2022/2023)for a pre-audit check (including ensuring wintering plans are in place).
- Contacting and working with each dairy support property to ensure a wintering plan in place for the upcoming irrigation season
- Resourcing two staff for whom the primary focus is being available to the shareholders to assist on farm environmental plans, farm environment plan audits, nutrient budgets, nitrogen loss reductions and planting.
- Assisting two staff members to complete the advanced Sustainable Nutrient Management in NZ Agriculture.
- Assisting three staff members to complete training for Irrigation New Zealand Performance Assessment Code of Practice.
- Continuing assistance with riparian planting for properties along waterways, including applications for external funding.

[12] Central Plains Water Limited Annual Report 2022.

Other initiatives proposed for 2022-23 include:

- Inclusion of an Intensive Winter Grazing module in the FEP audits.
- Follow-up checks on properties that are deemed higher risk during the year to ensure adherence with Intensive Winter Grazing plans and that actions identified (e.g., fencing) are being addressed.
- Workshops focussed on Greenhouse Gasses and Soil Health.
- Establishment of Catchment Groups

4. Environmental Monitoring

Requirements for extensive monitoring of potential environmental effects resulting from operation of the Scheme are specified in conditions of CPWs resource consents for the take and use of water. Details of this monitoring programme are outlined in a Ground and Surface Water Monitoring Plan (GSWMP) which consists of two parts:

- Part I: an outline of the CPW monitoring programme (e.g., monitoring sites, parameters measured, monitoring frequency etc.)
- Part II: specification of trigger levels for the monitoring programme, along with procedures to be followed in the advent that trigger levels are exceeded.

Results and interpretation of environmental monitoring undertaken for the Scheme are provided in an *Annual Ground and Surface Water Monitoring Report* (GSWMP), which forms one component of the overall resource consent compliance monitoring for the Scheme.

Development of the GSWMP and the subsequent monitoring process is overseen by a Ground and Surface Water Expert Review Panel (GSWERP) which was established in 2013. This panel is responsible for overseeing and directing the ground and surface water monitoring program undertaken by CPW, as well as response to trigger level exceedances and/or public complaints. As required by CPW's consents, GSWERP members include representatives from SDC, ECan and Ngai Tahu, alongside independent experts with knowledge and skills specific to hydrogeology and groundwater quality, hydrology and surface water quality, land drainage in the Selwyn/Waihora catchment.

4.1. Environmental Baseline

Ongoing operation of the Scheme has resulted in changes to historical land use, recharge and water abstraction patterns across the mid to upper sections of the Central Plains area. These changes have the potential to alter water quality and quantity parameters in downstream receiving environments (groundwater, rivers and streams, and Lake Ellesmere/Te Waihora).

Increased groundwater recharge from irrigation using water from alpine rivers across the CPW Scheme area, coupled with a reduction in the volume of groundwater used for irrigation, is anticipated to result in an overall increase in groundwater levels and flows in lowland streams. While such effects can have a positive impact on environmental values associated with these waterways, increased groundwater levels and stream flows also have the potential to result in higher water tables and associated drainage issues around the margins of Lake Ellesmere/Te Waihora.

Groundwater flowing through the Central Plains aquifer system is ultimately discharged to lowland rivers and streams around the margins of Lake Ellesmere/Te Waihora so changes to the quality and quantity of groundwater potentially impact on ecological and environmental values associated with these waterways, as well as the lake itself. However, due to the slow rate of groundwater flow (which varies spatially and with depth) it may take between 10 and 30 years depending on location, for water recharged on the Central Plains area to drain to Lake Ellesmere/Te Waihora. These variable time lags complicate interpretation of water level, flow and quality monitoring results, particularly when the period of historical information available is short, and monitoring results may also be influenced by factors external to the scheme (such as non-CPW land use and modifications to hydrological environments).

Interpretation of monitoring results is also complicated by climatic variability. For example, as illustrated in Figure 5 above, the above average rainfall recorded during the 2017-18 season contrasts with significantly below average rainfall during the 2020-21 season. Such intra-seasonal variability in rainfall, groundwater recharge and surface water flows can result in short to medium-term effects that obscure longer-term, underlying trends in groundwater levels, groundwater quality, streamflow and surface water quality. In addition, as noted in Section 2.1 above, variations in the timing and magnitude of rainfall during individual seasons (such as significant rainfall event which occurred during early February 2022) may also contribute to short-term variability in water quantity and quality in receiving environments.

Given the Scheme operates in an area with an extensive history of agricultural development, the existing state of water quality and quantity differs significantly from its 'natural' state. Consequently, environmental effects arising from the Scheme are assessed in terms of a pre-Scheme 'baseline' (i.e., the state and underlying trends in water quality and quantity in the absence of the Scheme). To better quantify 'baseline' water quality and water quantity prior to Scheme development, a review of all available monitoring data for the Central Plains area was commissioned by GSWERP in 2013. In addition, conditions of consents operated by CPW also required monitoring of groundwater and surface water quantity and quality prior to individual Scheme stages becoming operational to assist establishment of an environmental baseline.

Assessing the overall environmental effects of the CPW Scheme therefore requires monitoring data which is collected on an ongoing basis to be assessed in terms of the pre-Scheme baseline, as well within the context of shorter-term (episodic or inter-annual) variations associated with natural climate fluctuations.

4.2. Environmental Monitoring Programme

The CPW environmental monitoring programme is specified in Part 1 of CPW's Ground and Surface Water Monitoring Plan. In summary, the monitoring programme consists of four components:

1. 29 surface water quality monitoring sites.
2. 4 lake water quality monitoring sites.
3. 20 groundwater quality monitoring sites.
4. 12 groundwater level monitoring sites.

As illustrated on Figure 22, the surface water quality monitoring sites include:

- 4 sites upstream of the Scheme (US1 to US4).
- 4 sites within the Scheme area (IS1 to IS4).
- 1 site on downstream boundary of the Scheme (SWSH).
- 8 sites in the headwaters of lowland streams (SF1 to SF8).
- 8 sites near the confluence of lowland streams and Te Waihora/Lake Ellesmere (T1 to T8).

- 4 sites in the SDC stock water race system at the downstream boundary of the Scheme.

Surface water quality sites are monitored monthly for a range of water quality parameters including dissolved and particulate nutrients, indicator bacteria (*E.coli*) and physical parameters such as pH, temperature and dissolved oxygen concentrations. A sub-set of the CPW surface water quality compliance monitoring sites are monitored by Environment Canterbury as part of its State of the Environment network, with the remainder monitored by CPW.

The monitoring network also includes 4 sites located in Lake Ellesmere/Te Waihora (3 around the lake margins and one mid-lake site). These sites are monitored monthly by ECan for a range of parameters including nutrients and chlorophyll-*a* which enable calculation of Trophic Level Index (TLI_3). TLI is an overall measure of lake water quality which allows comparison between individual waterbodies and lake types[13].

As shown on Figure 23, the CPW groundwater quality monitoring network comprises twenty monitoring bores (8 within or down-gradient of the Stage 1 area, 10 within or down-gradient of the Stage 2 area and 2 in the Sheffield Scheme area). These groundwater quality sites are sampled quarterly for a range of chemical and microbial water quality indicators.

It is noted that the CPW groundwater quality monitoring bores are constructed with long screened intervals to enable collection of water quality samples from close to the water table (within 1 metre). In contrast, typical water supply bores in the Central Plains area are constructed with relatively short screened intervals positioned well below the water table, so they do not necessarily draw water from the upper levels of the aquifer. This aspect of construction is important to note when interpreting CPW groundwater quality monitoring results, as contaminants associated with overlying land use are typically concentrated near the water table, reducing at deeper levels in the underlying aquifer. Collection of samples from close to the water table in the CPW monitoring bores is therefore inferred to provide a conservative (or '*worst case*') assessment of groundwater quality at any given location, which may differ from results of monitoring undertaken on other 'conventionally' screened bores in the local area.

Increased groundwater flow resulting from Scheme operation has the potential to result in an increase in groundwater levels in lowland areas of the Central Plains as groundwater flows toward coastal discharge areas. Depending on the magnitude and spatial distribution of groundwater mounding associated with the Scheme[14], such an increase in groundwater levels has the potential to result in a range of environmental effects ranging from positive benefits associated with increased baseflows in lowland streams, to adverse effects on land drainage around the margins of Lake Ellesmere/Te Waihora. Trigger levels have been established for 12 groundwater level sites down-gradient of the Scheme. These sites are monitored on a monthly basis as part of the ECan State of the Environment groundwater monitoring network and have a long monitoring history to enable any changes in groundwater levels to be evaluated in an appropriate historical context.

[13] see https://www.lawa.org.nz/learn/factsheets/lake-trophic-level-index/ for more information

[14] The potential magnitude and extent of mounding is significantly reduced compared to that assessed during the CPW resource consent process due to the subsequent decision to pipe a majority of the distribution system (which significantly reduces losses compared to that occurring from open races).

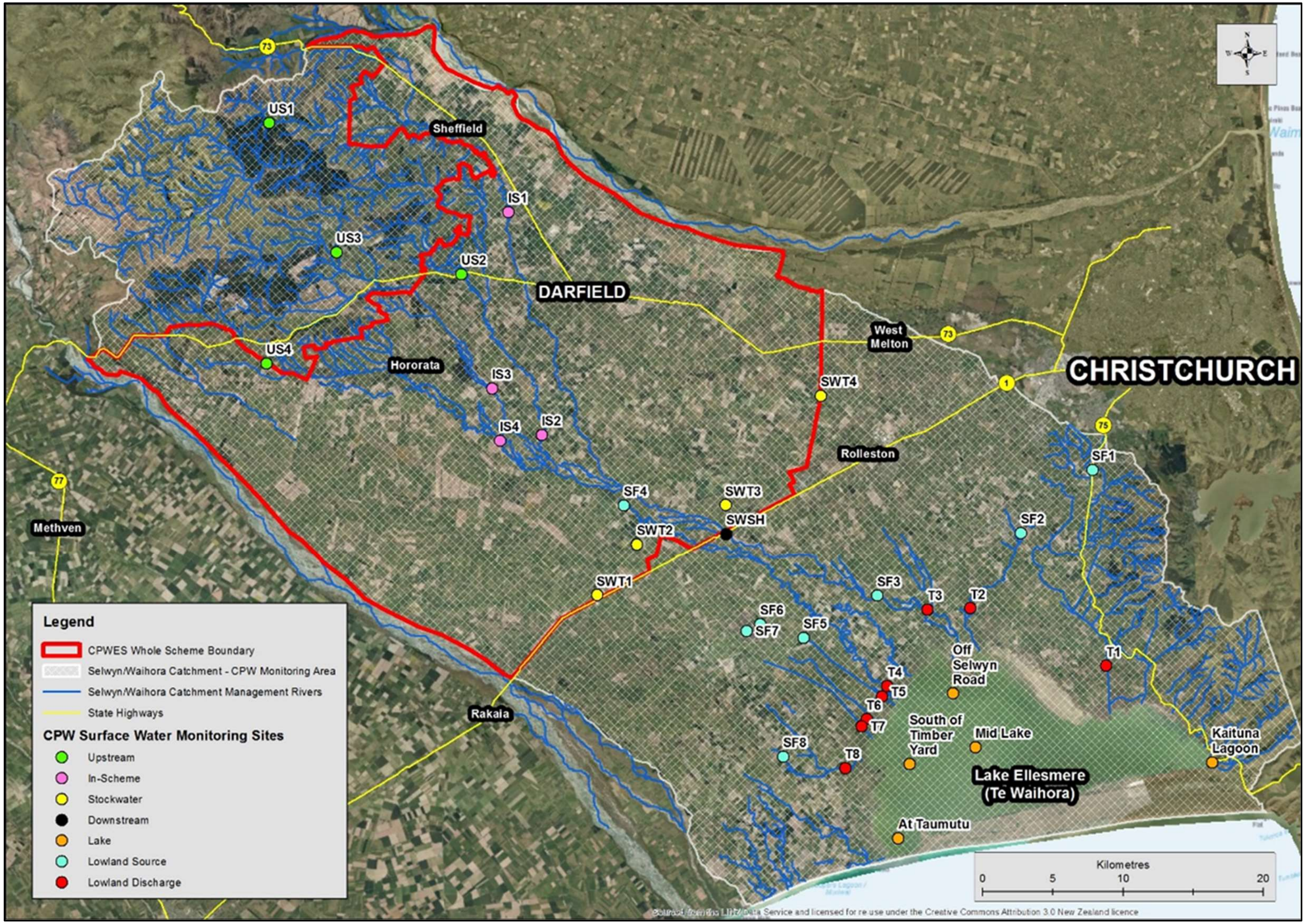

Figure 22. Surface water quality monitoring sites for the CPW scheme (reproduced from CPW, 2021).

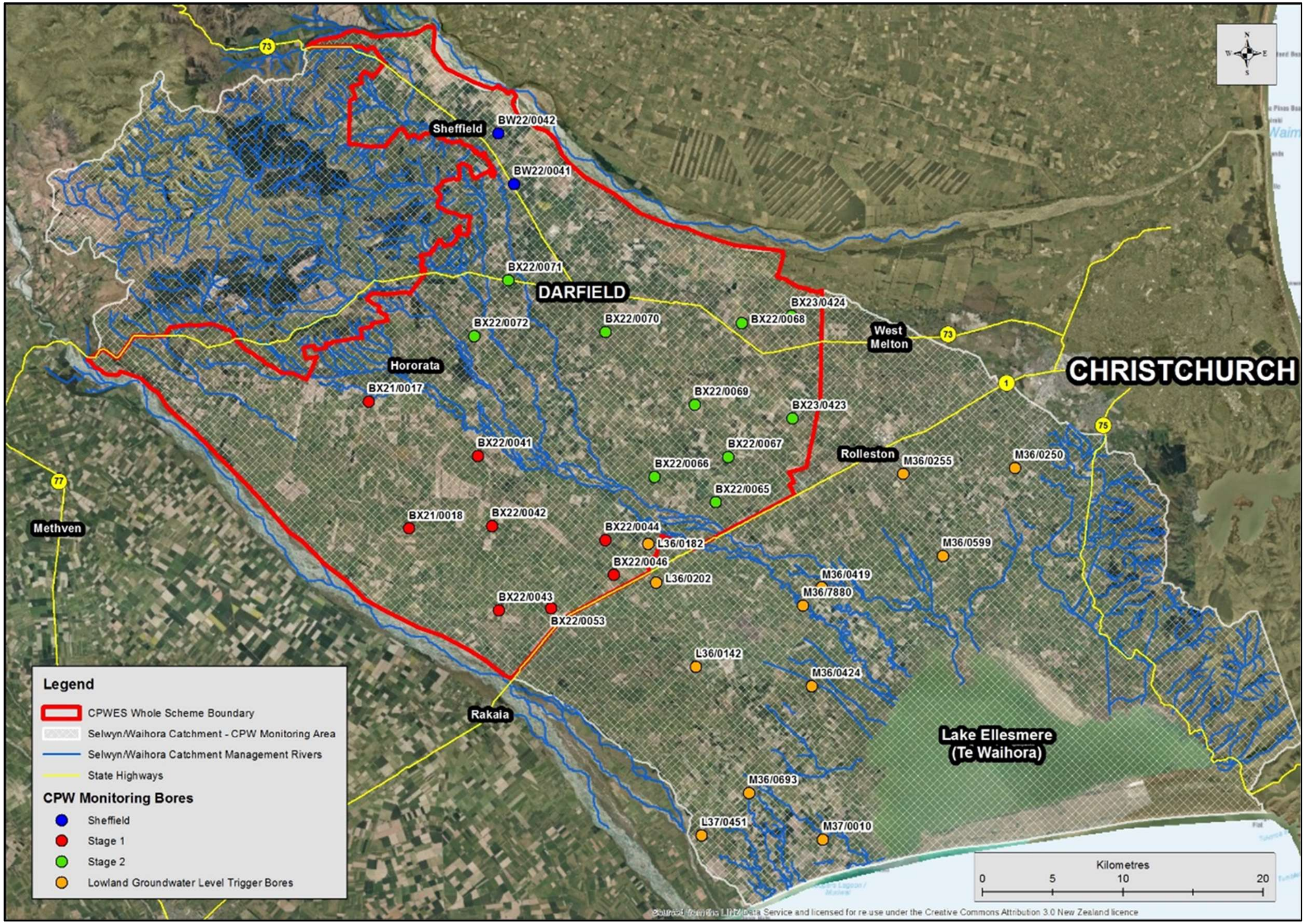

Figure 23. Groundwater quality and level monitoring sites for the CPW scheme (reproduced from CPW, 2021).

4.3. Environmental Management

Part II of the CPW GSWMP establishes trigger levels for nominated parameters including:

- Nitrate-Nitrogen concentrations at surface water quality monitoring sites.
- Trophic Level Index (TLI_3), Total Phosphorus and Chlorophyll-*a* at lake monitoring sites.
- Nitrate-Nitrogen and *E.coli* concentrations at groundwater quality monitoring sites.
- Groundwater levels in lowland monitoring wells.

The nominated trigger levels are based on relevant water quality standards established in the LWRP or, in the case of groundwater levels, the range of historical measurements. The triggers provide a basis for evaluation of CPW environmental monitoring results. Once a nominated trigger level is exceeded, the GSWMP establishes a procedure which must be followed to firstly identify if the monitoring results represent a departure from 'background' concentrations, levels and/or trends and, if they do, specific steps which must be followed to investigate and mitigate the potential cause of the trigger level exceedance. This process is overseen by the GSWERP.

4.4. 2021-22 Monitoring Results

Results from the CPW environmental monitoring programme are summarised in the *Annual Ground and Surface Water Monitoring Report 2021/22* which was reviewed and approved by GSWERP in November 2022.

4.4.1. Surface Water Quality

Water quality triggers for CPW surface water quality monitoring are summarised in Table 4 below. These triggers are equivalent to limits for surface water quality established in the LWRP. The triggers differentiate between hill-fed streams (those predominantly sourced from runoff in upper catchment areas) and spring-fed streams on the lower plains (which derive a majority of flow from groundwater drainage).

Table 4. *CPW Surface water quality triggers for Nitrate-Nitrogen (mg/L)*

River Type	CPW Surface Water Monitoring	
	Annual Median	Annual 95^{th} Percentile
Hill-fed Lower	1.8	2.6
Spring-fed Plains	5.2	7.4

Table 5 summarises trigger level exceedances for Nitrate-N concentrations at CPW monitoring sites during the over the past six irrigation seasons. The data show that during the 2021-22 season, median Nitrate-N triggers were exceeded at 3 hill-fed sites and 6 spring-fed sites, with 3 hill-fed sites and 3 spring-fed sites also exceeding the 95^{th} percentile trigger. The number of surface water quality sites exceeding Nitrate-N trigger levels during the 2021-22 year was within the range observed during previous seasons, although it is noted number of Spring-fed Plains sites exceeding the 95th percentile trigger was the lowest recorded.

Table 5. *Summary of surface water quality Nitrate-N trigger level exceedances for CPW sites, 2016-17 to 2021-22.*

River Type	Year	Sites	Samples*	Sites exceeding annual Nitrate median	Sites exceeding annual 95th percentile
Hill-fed Lower	2021-22	9	89	3	3
	2020-21	9	71	2	2
	2019-20	9	74	4	4
	2018-19	9	80	1	1
	2017-18	9	93	3	4
	2016-17	9	71	2	1
Spring-fed Plains	2021-22	16	208	6	3
	2020-21	16	162	5	5
	2019-20	16	177	5	5
	2018-19	16	198	5	5
	2017-18	16	198	6	7
	2016-17	16	144	6	6

* The number of samples varies between years due to the presence/absence of flow at individual monitoring sites

As shown of Figure 24 below, surface water median Nitrate-N trigger level exceedances during 2021-22 were recorded at 3 hill-fed sites within the Scheme area (Hawkins River (IS1), Waianiwaniwa River (IS2) and Hororata River (IS4)), with 95th percentile exceedances also recorded at the same sites. Median Nitrate-N triggers were exceeded at three lowland sites (Selwyn River spring source upstream and downstream (SF3 and T3) and Boggy Creek downstream (T6)) while both median and 95th percentile triggers were exceeded at 3 additional sites (Doyleston Drain source (SF7) and Harts Creek upstream and downstream (SF8 and T8)). Lowland sites recording median Nitrate-N trigger level exceedances during the 2021-22 year were the same as those exceeding trigger levels during the previous three seasons (with the addition of the Boggy Creek downstream site (T6)).

Although exceeding triggers, 2021-22 annual median Nitrate-N concentrations at hill-fed sites were within the range recorded historically. The single exception was at the in-scheme Hororata River site where the 2021-22 median Nitrate-N concentration was marginally higher (0.02 g/m^3) than that previously recorded. Annual median Nitrate-N concentrations in lowland streams were within the historical range at all sites.

Several spring-fed streams also exhibit a consistent decrease in Nitrate-N concentrations between their spring-sourced headwaters and their lower reaches (e.g., LII (SF2 and T2), Irwell River (SF4 and T4), Hanmer Road Drain (SF5 and T5), Doyleston Drain (SF7 and T7) and Harts Creek (SF8 and T8)). This decrease is generally attributed to uptake by of nutrients by periphyton and aquatic plants and/or the dilution by groundwater inflows that have been denitrified as they seep upwards through low permeability confining sediments.

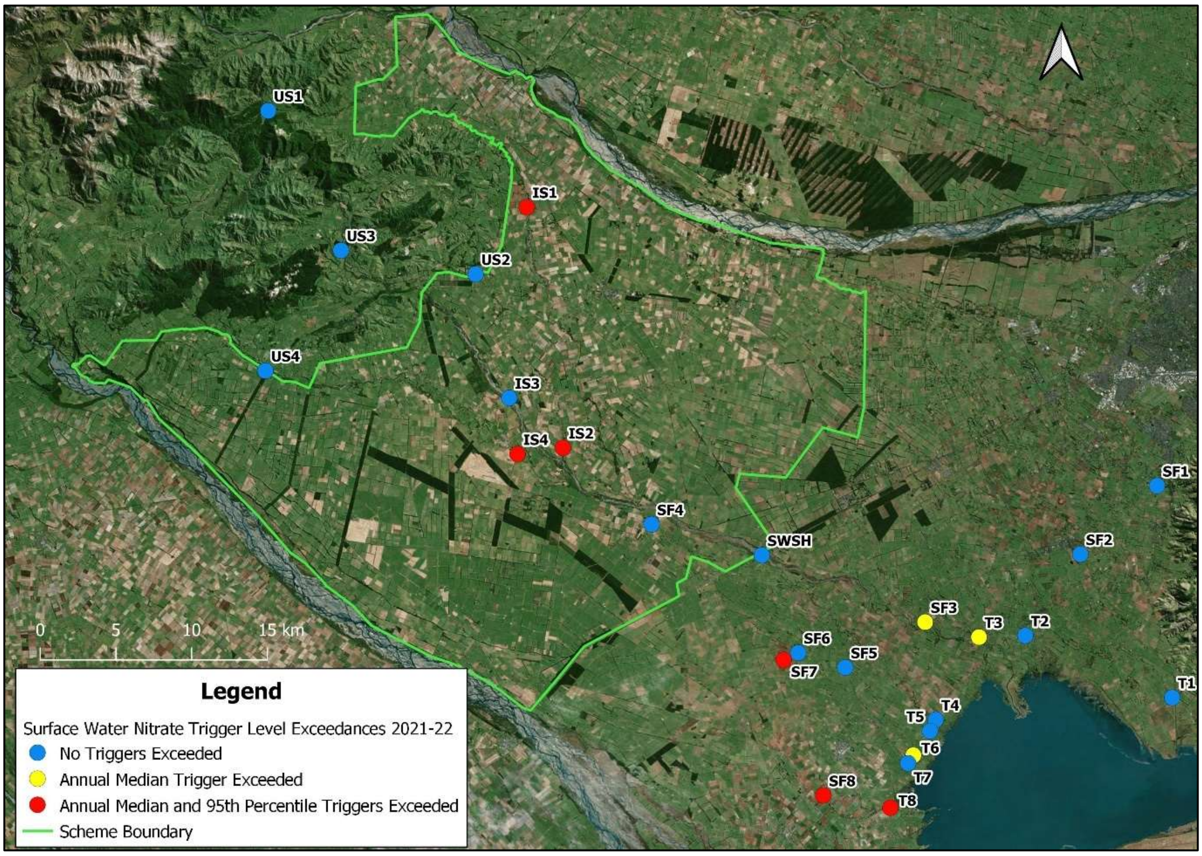

Figure 24. *CPW surface water nitrate trigger level exceedances during 2021-22.*

Figures 25 and 26 below compare annual median nitrate concentrations from the 2015-16 to 2021-22 seasons against the relevant Nitrate-Nitrogen triggers for hill-fed and spring-fed streams. The data show a wide range in both the magnitude and temporal variation of median nitrate concentrations at individual monitoring sites. For example, while upstream monitoring sites (including US1 to IS4) generally exhibit nitrate concentrations well below trigger values, many lowland sites (including SF3, SF7, SF8, T3 and T8) exhibit concentrations consistently above the trigger values. Similarly, while nitrate concentrations are relatively stable at many sites, others either exhibit significant temporal variability between individual years (SWSH, IS2, SF6 and T3) or indicate overall increasing (IS3, IS4, T2, T3, T6, T8) or decreasing (IS1, SF1, SF4, SF5, T1 and T4) concentrations over time.

As a result, while surface water monitoring shows an overall increase in median nitrate concentrations from headwater to lowland areas, results from individual monitoring sites exhibit significant variability between individual catchments and monitoring locations. This variability is inferred to reflect a complex interaction between multiple factors influencing water quality, including climate, local and upstream land use, time lags in the groundwater system (particularly important in spring-fed streams), as well as instream processes in different waterways. Such spatial and temporal variability inevitably complicates attribution of observed variations in water quality associated with the Scheme, from those reflecting background (i.e., pre-scheme) water quality or external influences.

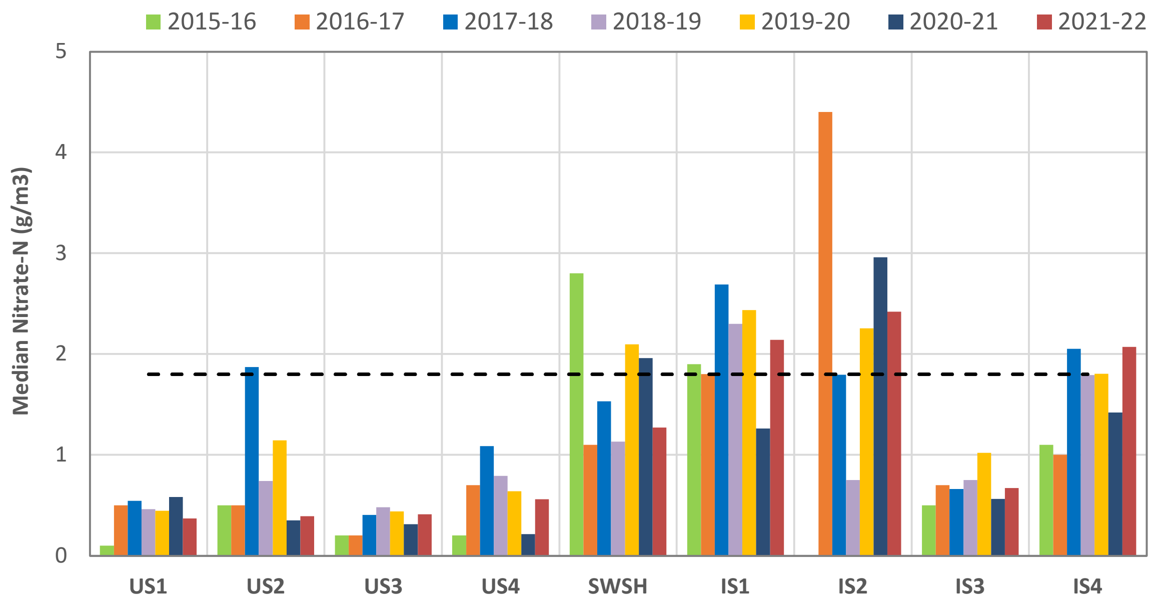

***Figure 25**. Annual median nitrate concentrations at hill-fed lower sites, 2015-16 to 2021-22 (black line denotes trigger level)*

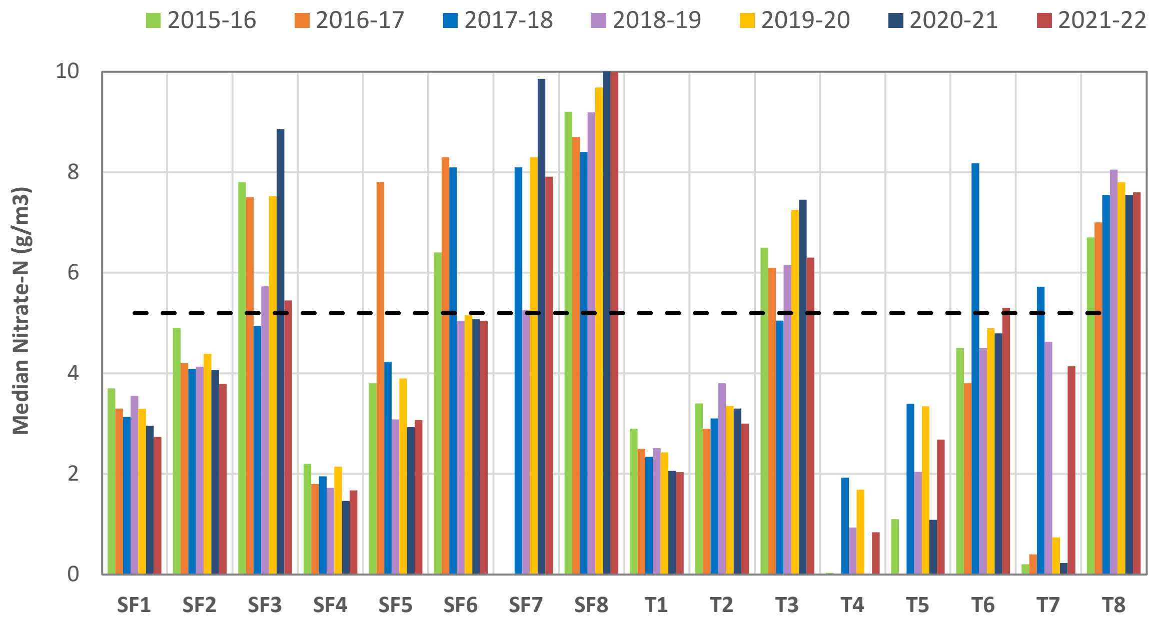

***Figure 26.** Annual median nitrate concentrations at spring-fed plains sites, 2015-16 to 2021-22 (black line denotes trigger level)*

It is noted that the GSWERP baseline water quality report identified historical nitrate concentrations (i.e., pre CPW) that exceeded the CPW water quality triggers in the Hawkins River, Selwyn River, Boggy Creek and Harts Creek. As illustrated in the examples from Harts Creek and the Selwyn River shown in Figure 27 and Figure 28 below, many of these waterways have a history of elevated and/or increasing nitrate concentrations that pre-date CPW Scheme operations. Although 2021-22 concentrations are high in the historical context, recent years appear to indicate a levelling-off (or slight reversal) in previously increasing trends. Although encouraging, ongoing monitoring will be required to confirm the permanency of any reductions (or reversal) in historical water quality trends.

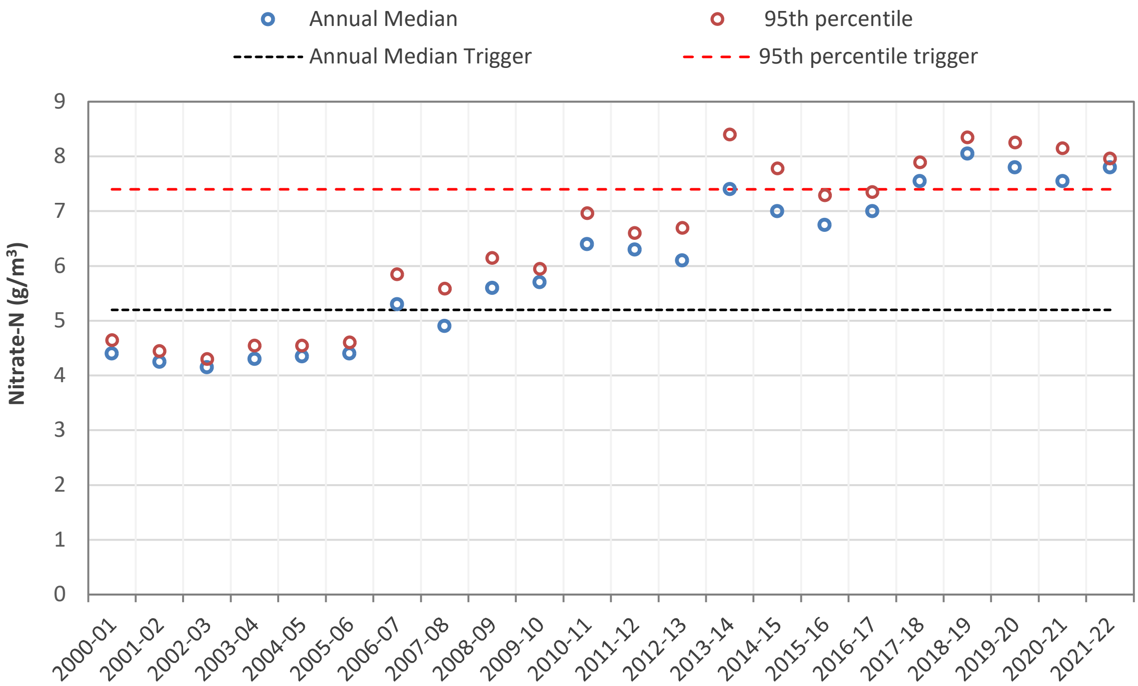

Figure 27. *Annual median and 95th percentile nitrate-nitrogen concentrations at the Harts Creek downstream site (T8), 2000-01 to 2021-22.*

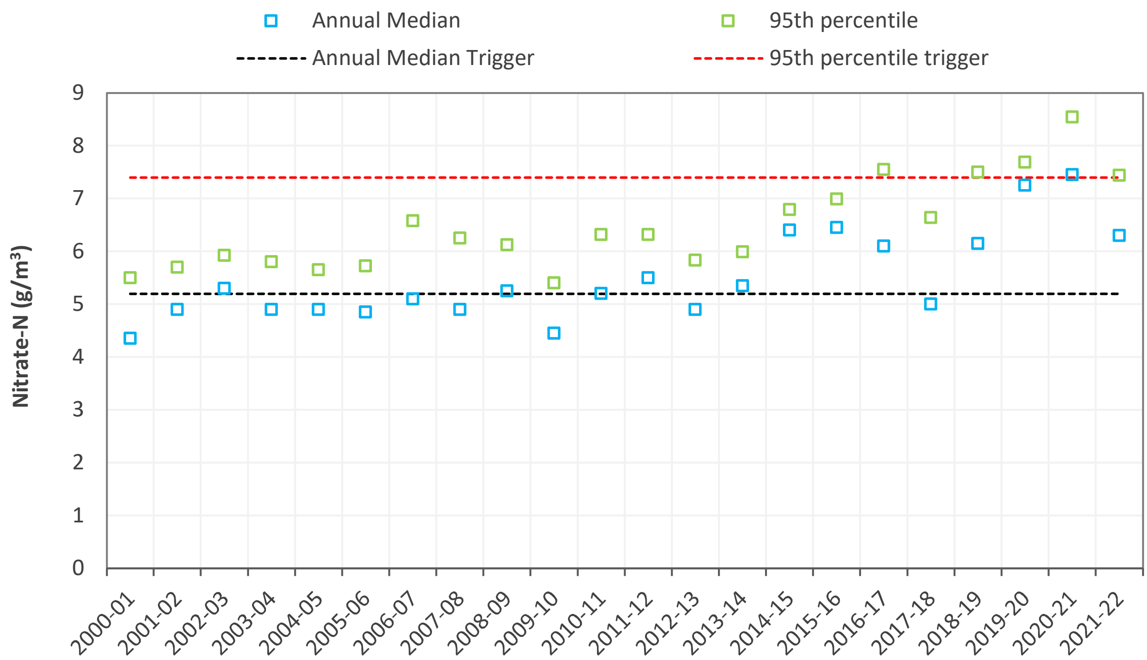

Figure 28. *Annual median and 95th percentile nitrate-nitrogen concentrations at the CPW Selwyn River downstream monitoring site (Coes Ford), 2000-01 to 2021-22.*

Overall, although surface water triggers were exceeded at nine sites in the CPW monitoring network during the 2021-22 year, observed concentrations are generally consistent with the historical baseline (either the observed range or historical trends). Consequently, monitoring data collected to date does not show any clearly discernible effects of the Scheme on surface water quality either within, or down-gradient, of the Scheme area. Some monitoring sites do appear to indicate a reduction in historical increasing Nitrate-N trends, however ongoing monitoring will be required to establish the permanency of such changes.

4.4.2. Lake Water Quality

Lake Ellesmere/Te Waihora is the ultimate receiving environment for a significant proportion of surface water and groundwater flows from the CPW Scheme area. Land use and land management activities in the Scheme area therefore have the potential to influence lake water quality. Trigger levels established by GSWERP for lake water quality are listed in Table 6. These trigger levels are equivalent to water quality limits contained in Table (I) of the LWRP.

Table 6. Lake water quality triggers

Monitoring Location	Chlorophyll-*a* (µg/L)[(b)]	Total Phosphorus (mg/L)[(b)]	Total Nitrogen (mg/L)[(b)]	TLI_3[(a)]
Mid-Lake	74	0.1	3.4	6.6
Lake Margins	no trigger	no trigger	no trigger	6.0

(a) TLI is calculated as TLI_3 (using TP, TN and Chl-a)

(b) As a maximum annual average determined from 12 (monthly) rounds of monitoring results.

Table 7 provides a summary of CPW lake water quality monitoring results for the 2021-22 year. The figures show CPW triggers were exceeded for Chlorophyll-*a*, Total Phosphorus and TLI_3 at the mid-lake site, and for TLI_3 at the three lake margin monitoring sites.

Table 7. *2021-22 CPW lake water quality monitoring results (figures in bold denote concentrations exceeding trigger levels)*

Site	Chlorophyll-*a* µg/L	Total Phosphorus mg/L	Total Nitrogen mg/L	TLI_3
Mid-Lake	**125**	**0.22**	2.32	**7.04**
Lake Margin Sites				
- Off Selwyn River Mouth	128	0.20	2.46	**7.04**
- South of Timber Yard	133	0.20	2.36	**7.03**
- Taumutu	132	0.21	2.26	**7.03**

Figure 29 shows annual median Total Nitrogen, Total Phosphorus and Chlorophyll-*a* concentrations recorded at the mid-Lake monitoring site from 2000/01 to 2021-22. The figure shows 2021-22 Total Nitrogen concentrations were well below the trigger level, while both Chlorophyll-a and Total Phosphorus were above their respective trigger levels. Although elevated, concentrations of all three parameters during 2021-22 remained within the historical range.

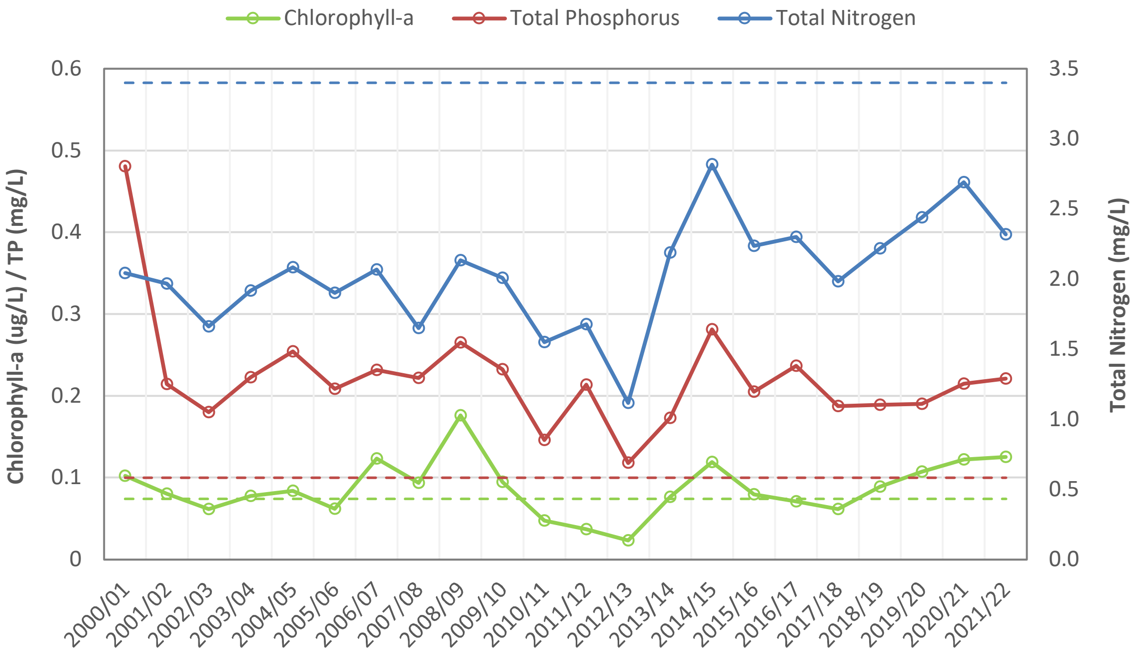

Figure 29. *Annual median Chlorophyll-a, Total Phosphorus and Total Nitrogen values at the mid-lake monitoring site, 2000/01 to 2019/20 (dotted lines indicate trigger levels for individual parameters).*

As shown on Figure 30 below, during 2021-22 TLI_3 values exceeded trigger levels at all monitoring sites, with values at lake margin monitoring sites almost identical to values recorded at the mid-Lake site. TLI_3 values at all lake margin sites exhibit a similar temporal trend, with values declining between 2015-16 and 2017-18 then increasing over the subsequent period, while TLI_3 values at the mid-lake site were the highest since 2015-16. However, as illustrated on Figure 31, although above the respective triggers, TLI_3 values recorded during the 2021-22 year were within the historical range. The overall increase in TLI_3 values at all monitoring sites site since the 2017-18 season follows a period of generally decreasing concentrations between 2014-15 and 2017-18. Such inter-annual variability is observed through the historical record, potentially reflecting a complex mix of factors including climate, land use and the lake opening regime.

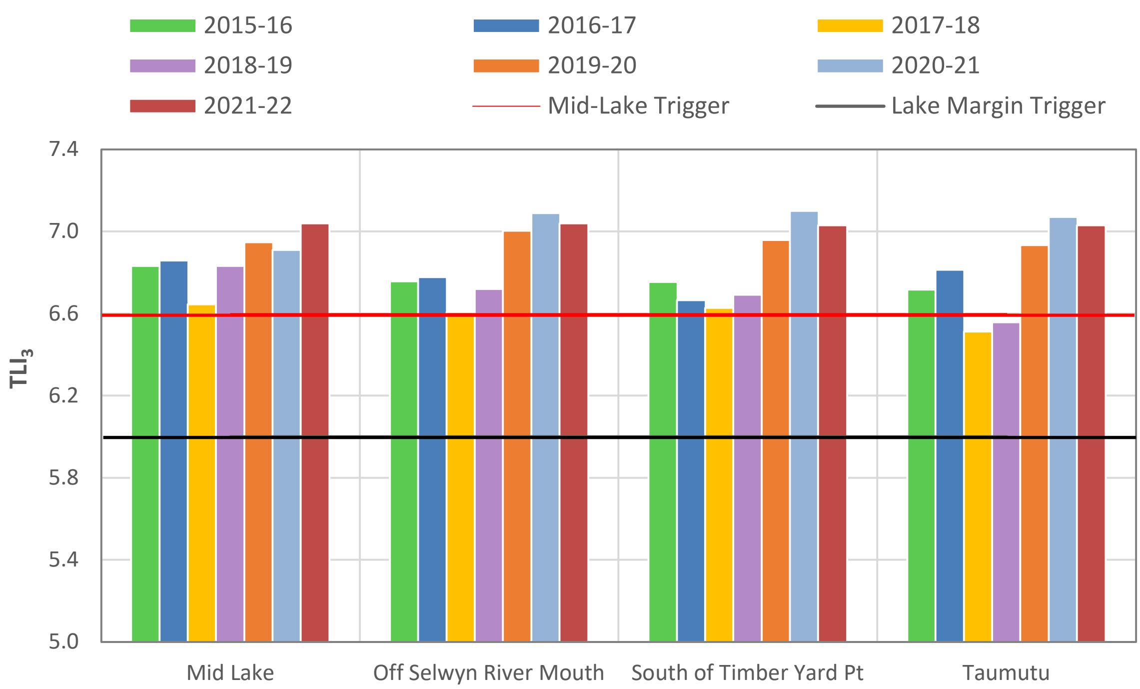

Figure 30. *Calculated TLI3 values at the four Lake Ellesmere/Te Waihora monitoring sites, 2015/16 to 2019/20 (red line = mid-lake trigger, black line = lake margin trigger).*

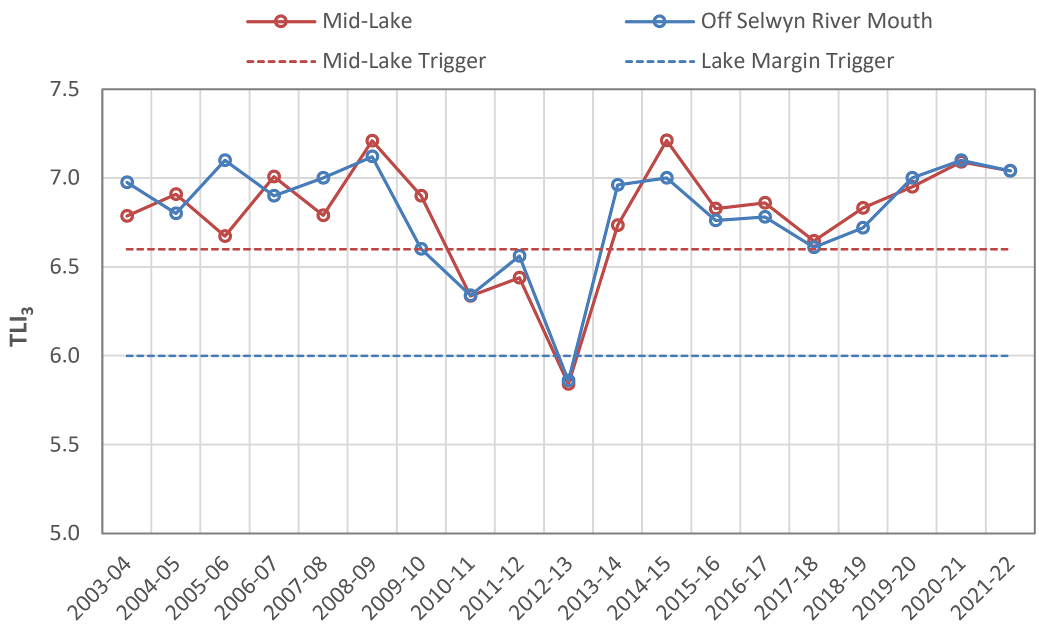

Figure 31. *TLI_3 values at the Mid-Lake and Off Selwyn River Mouth sites, 2002/03 to 2019/20*

Overall, during the 2021-22 year lake water quality triggers in Lake Ellesmere/Te Waihora were exceeded at both mid-lake and lake margin monitoring sites. However, concentrations of indicator parameters and calculated TLI_3 values were within the historical range and do not exhibit any readily discernible change that can be related to CPW activities which commenced during the 2015-16 season[15].

4.4.3. Groundwater Quality

Trigger levels for CPW groundwater quality monitoring are summarised in Table 8 below. These triggers are equivalent to the limits for groundwater quality in the Selwyn-Waihora zone established in the LWRP.

Table 8. Groundwater quality triggers for CPW monitoring

Contaminant	Measurement	Trigger
Nitrate-Nitrogen	5-year annual average concentration[(a)]	7.65 mg/L
E.coli	Median concentration[(b)]	<1 organism/100 millilitres

(a) In shallow groundwater <50 metres below ground level

(b) Measured over the length of record

Two years of groundwater monitoring data were collected by CPW prior to the commencement of irrigation in each stage of the Scheme. This data (combined with results of historical ECan monitoring)

[15] Particularly given the relatively indirect connection (and potential lags) between the CPW Scheme area and the lake via the groundwater system and/or lowland streams.

forms the baseline against which future groundwater quality within the CPW Scheme area can be assessed.

4.4.3.1. Nitrate-Nitrogen

Figure 32 shows the spatial distribution of 5-year annual average Nitrate-N concentrations across the CPW Scheme area. The figure shows Nitrate-N concentrations exceed the 7.65 mg/L trigger level in four of the eight monitoring bores sampled in the Stage 1 area (BX21/0017, BX22/0043[16], BX22/0046 and BX22/0053) and eight of the ten monitoring bores sampled in the Stage 2 area (BX22/0065, BX22/0067, BX22/0068, BX22/0069, BX22/0070, BX22/0072, BX23/0423 and BX23/0423). However, given Stage 2 commenced operations during the 2018-19 season, only water quality results from the Stage 1 and Sheffield Scheme areas can be directly compared with triggers for the CPW Scheme[17].

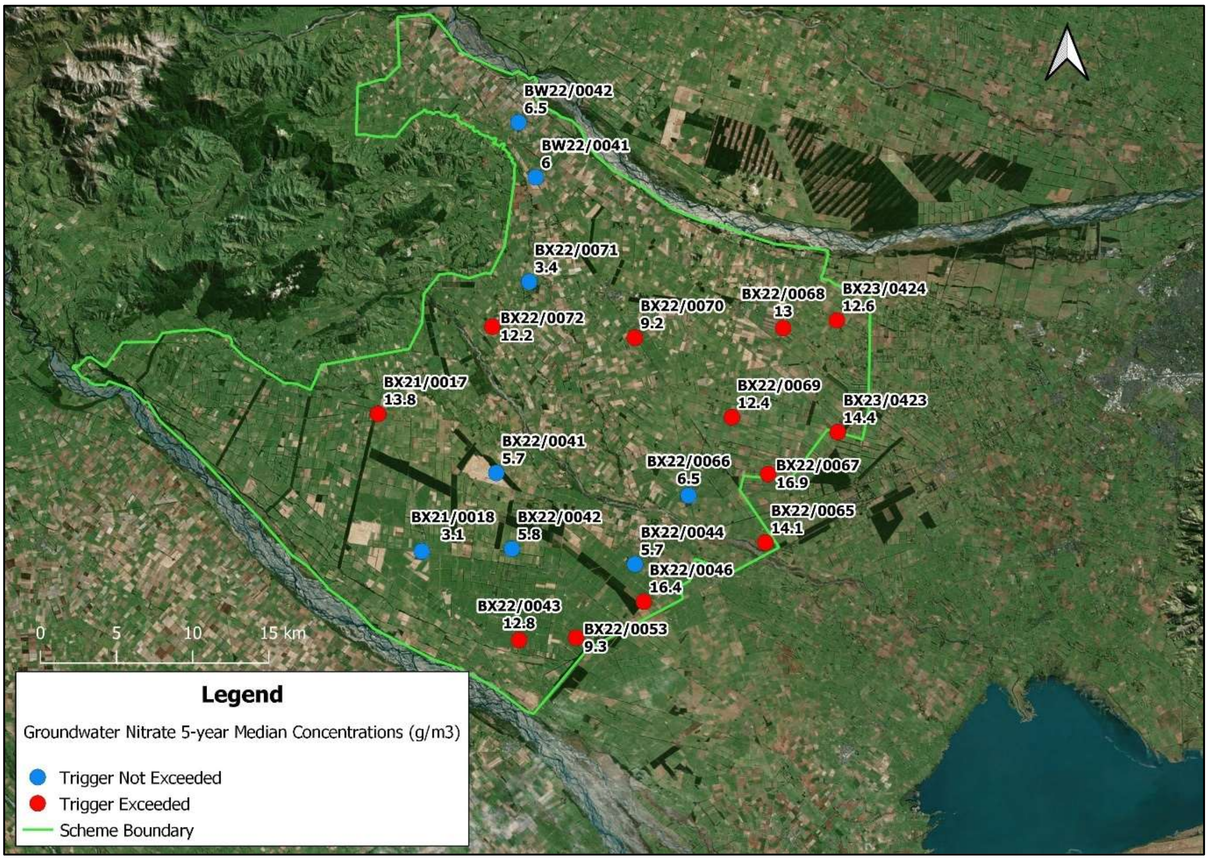

Figure 32. *5-year (2017-18 to 2021-22) annual average Nitrate-N concentrations in CPW monitoring bores.*

Figure 33 shows annual average nitrate concentrations in Stage 1 and Sheffield Scheme monitoring bores between 2015-16 and 2021-22. While five monitoring bores exceed the 7.65 g/m^3 5-year annual average trigger, the data show significant variability in nitrate concentrations in individual monitoring

[16] Technically Nitrate-N concentrations in BX22/0043 do not exceed the trigger level because groundwater levels at this site are >50 m below ground level (the triggers listed in Table 8 apply to shallow groundwater <50 m bgl).

[17] 5-year annual average Nitrate-N concentrations are calculated from data recorded between the 2017-18 and 2021-22 seasons. Data recorded in the Stage 2 area during the 2016-17 and 2017-18 seasons form part of the pre-Scheme baseline.

bores over time. A marked increase in Nitrate-N concentrations observed in several bores (e.g., BZ21/0017, BX22/0046 and BX22/0053) during the 2017-18 year coincides with a period of significant recharge during autumn and winter 2017 which followed an extended period of below normal rainfall over the preceding three seasons. Annual average Nitrate-N concentrations measured in all monitoring bores during 2021-22 remained within the historical range.

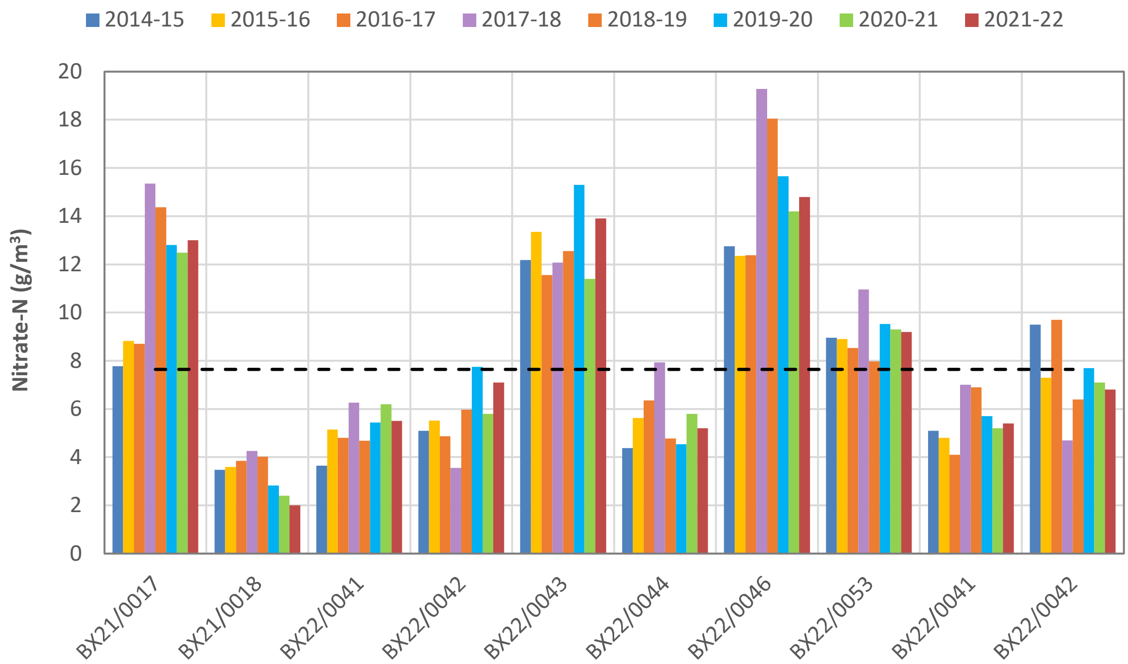

Figure 33. *Annual median groundwater nitrate concentrations in the CPW Stage 1 and Sheffield Scheme areas, 2014-15 to 2021-22 (Black line indicates the CPW trigger value).*

Figure 34 shows a plot of quarterly groundwater nitrate concentrations in selected CPW monitoring bores between 2014-15 (i.e., prior to commencement of Stage 1 operations) and 2021-22. While the data indicate Nitrate-N concentrations have remained relatively low and stable at some sites (e.g., BX21/0018 and BX22/0071), many others exhibit appreciable temporal variability, particularly following the wet autumn and winter in 2017. The significant increase in nitrate concentrations during 2017 (observed in all three Scheme stages) is attributed to the large volume of recharge mobilising excess nitrogen from the soil and underlying unsaturated zone following 3 years of generally below normal winter recharge. While this effect was observed across all three Stages, only Stage 1 of the CPW Scheme was operating at this time. Except for BX22/0068, groundwater Nitrate-N concentrations during 2021-22 remained below peak values recorded during the 2017-18 season.

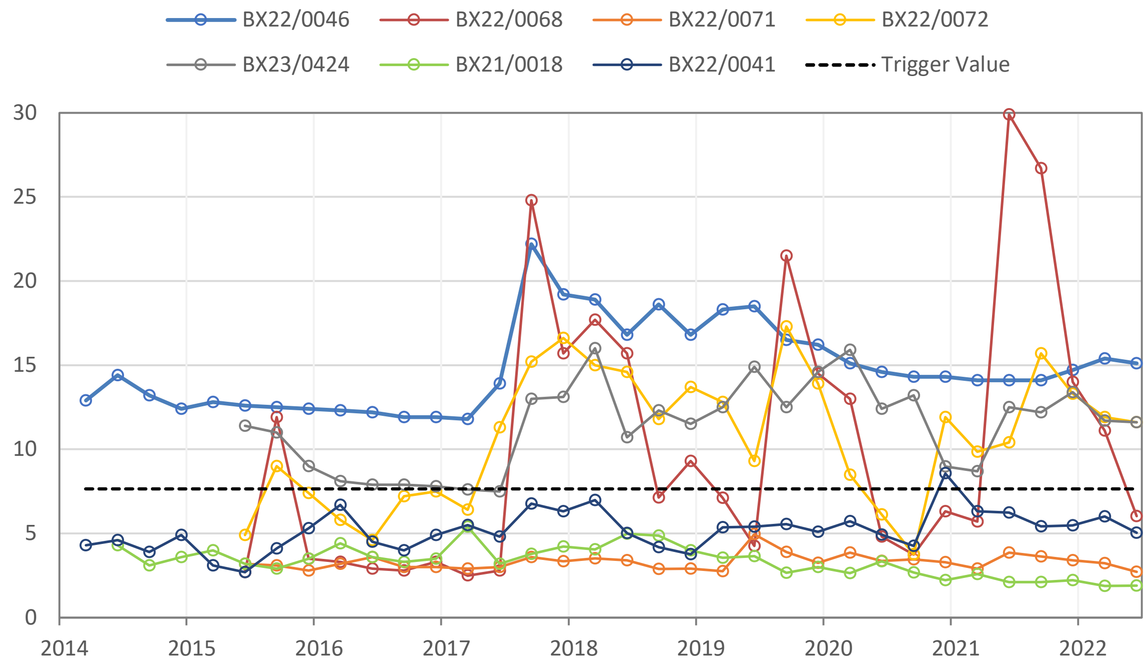

Figure 34. *Mean annual groundwater nitrate concentrations in the Stage 1 area, 2014-15 to 2021-22 (black line indicates CPW 5-year annual average trigger)*

It is also noted that a significant proportion of groundwater quality monitoring sites in both the Stage 1 and Stage 2 areas exhibited nitrate concentrations in excess of the GSWERP nitrate triggers in baseline data collected prior to commencement of Scheme operations. Average annual Nitrate-N concentrations in five of eight monitoring bores exceeded the 7.65 g/m^3 trigger during the 2013-14 and 2014-15 seasons, while eight of ten monitoring bores in the Stage 2 area showed similarly elevated Nitrate-N concentrations during the 2016-17 to 2017-18 baseline period.

4.4.4. Continuous Nitrate Monitoring

During the 2021-22 season CPW commenced installation of continuous nitrate monitoring sensors in several Scheme compliance monitoring wells. These sensors utilise UV LED technology to measure the nitrate concentration in groundwater in real-time. During the 2021-22 season nitrate sensors operated in three monitoring bores (BX21/0017, BX22/0044 and BX22/0046). Seven additional nitrate sensors were installed during spring 2022 and a further two are on order at the time of writing.

Figure 35 shows a plot of groundwater nitrate concentrations from the three continuous monitoring sites operating during the 2021-22 season along with rainfall recorded at the ECan Ridgens Road monitoring site. Overall, the data show contrasting seasonal variations in nitrate concentrations in the individual monitoring bores. For example, while BX22/0046 shows a relatively stable increase in nitrate concentrations from 13.3 to 15.0 g/m^3 over the 2021-22 year, concentrations in BX22/0017 declined appreciably (from >14.0 g/m^3 to around 10 g/m^3) over the same period, with appreciable reductions in nitrate concentrations observed following large rainfall events in December 2021 and February 2022. BX22/0044 also showed an overall decrease in nitrate concentrations during the 2021-

22 season (from 8.0 to 4.0 g/m³), with nitrate concentrations both increasing and decreasingly slightly following individual rainfall events.

Ongoing monitoring of temporal variation in nitrate concentrations will contribute to improved understanding of factors influencing temporal variations in groundwater nitrate concentrations both at individual monitoring sites and across the wider Scheme area more generally.

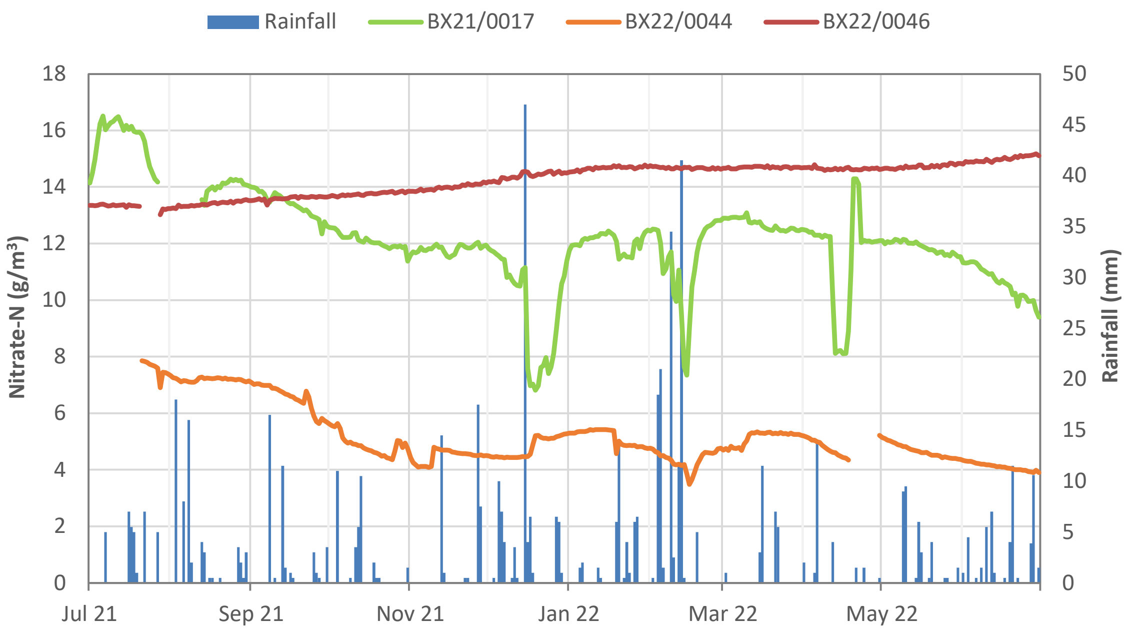

Figure 35. *Groundwater Nitrate concentrations recorded in three CPW monitoring bores and rainfall at Ridgens Road, 2021-22.*

Overall, while monitoring data from the 2021-22 year show elevated groundwater nitrate concentrations (in excess of GSWERP triggers) in approximately 60% of CPW monitoring bores, the following points are noted:

- Due to the construction of the CPW monitoring bores and the sampling methodology utilised, nitrate concentration from CPW monitoring likely reflect 'worst case' nitrate concentrations recorded immediately below the water table.
- Significant temporal variability in nitrate concentrations is observed between individual monitoring bores. Several sites exhibit a marked increase in nitrate concentrations (above trigger levels) during 2017. This increase is attributed to a period of above average rainfall during autumn/winter 2017 which mobilised excess nitrogen from the soil and underlying unsaturated zone following 3 years of generally below normal winter recharge. Similar, although less pronounced, effects are observed following significant rainfall events in December 2021 and February 2022.
- With few exceptions, groundwater Nitrate-N concentrations observed during the 2021-22 year were lower than peak values recorded during the 2017-18 year.

These observations are consistent with data presented in the GWSERP Baseline Water Quality Report which showed a significant number of bores (>30%) in the Central Plains area sampled by ECan between 2010 and 2013 exhibited nitrate concentrations in excess of the nominated trigger value, with approximately 40 percent of wells also exhibiting statistically significant increasing trends in nitrate concentrations.

4.4.4.1. Microbial Quality

As shown on Figure 36 below, the intermittent presence of low levels of indicator bacteria (*E.coli*) was observed in a significant proportion (50%) of CPW monitoring wells during the 2021-22 year. Thirteen of eighty samples tested (16%) returned positive detections of indicator bacteria, with a significant number of positive detections (at 7 out of the 10 sites returning positive results) observed during the March 2022 sample round which followed a significant rainfall event the previous month.

Within the operational Stage 1 area, low levels of *E.coli* (<6 MPN) were detected on a single sampling occasion in one monitoring bore (BX21/0018) and twice in another (BX22/0044). Positive detections of *E.coli* bacteria were recorded in 6 of the 10 monitoring bores in the Stage 2 area during 2021-22, with a total of 8 samples (20%) returning positive results. The highest concentrations (<200 MPN) and most frequent *E.coli* detections (3 out of 4 samples) were recorded in BX22/0067, a bore which exhibited similarly elevated frequency of *E.coli* detection during previous seasons. The single detections of *E.coli* in the remaining five Stage 1 bores were at concentrations less than 10 MPN. Low concentrations of *E.coli* were also detected in both Sheffield Scheme bores (BW22/0042 and monitoring BW22/0043) during the March 2022 sample round.

Where a positive *E.coli* detection was recorded in CPW monitoring, a follow-up assessment was undertaken to identify potential causes. This assessment considered factors such as climate (rainfall) preceding sample collection, land use (stocking) in the vicinity of the bore, irrigation activities, as well as the general condition of land surrounding the bore at the time of sampling. The assessment also considered potential water quality risks for nearby bores used for potable or farm supply. Aside from the February 2022 rainfall event, no obvious cause was identified for the remaining positive *E.coli* detections recorded.

It is noted that the rate of positive E.coli detections across the CPW groundwater monitoring network in 2021-22 was lower than that recorded during the preceding two seasons (22.5% of samples in 2020-21 and 17.5% of samples in 2019-20). Overall detection rates for indicator bacterial across the CPW monitoring network are similar to those reported for ECan's annual regional groundwater surveys from 2009 to 2020 (3.7% to 14% of bores sampled), particularly given the construction of the CPW monitoring bores and sampling methodology utilised (i.e., long-screen bores with samples collected immediately below the water table surface).

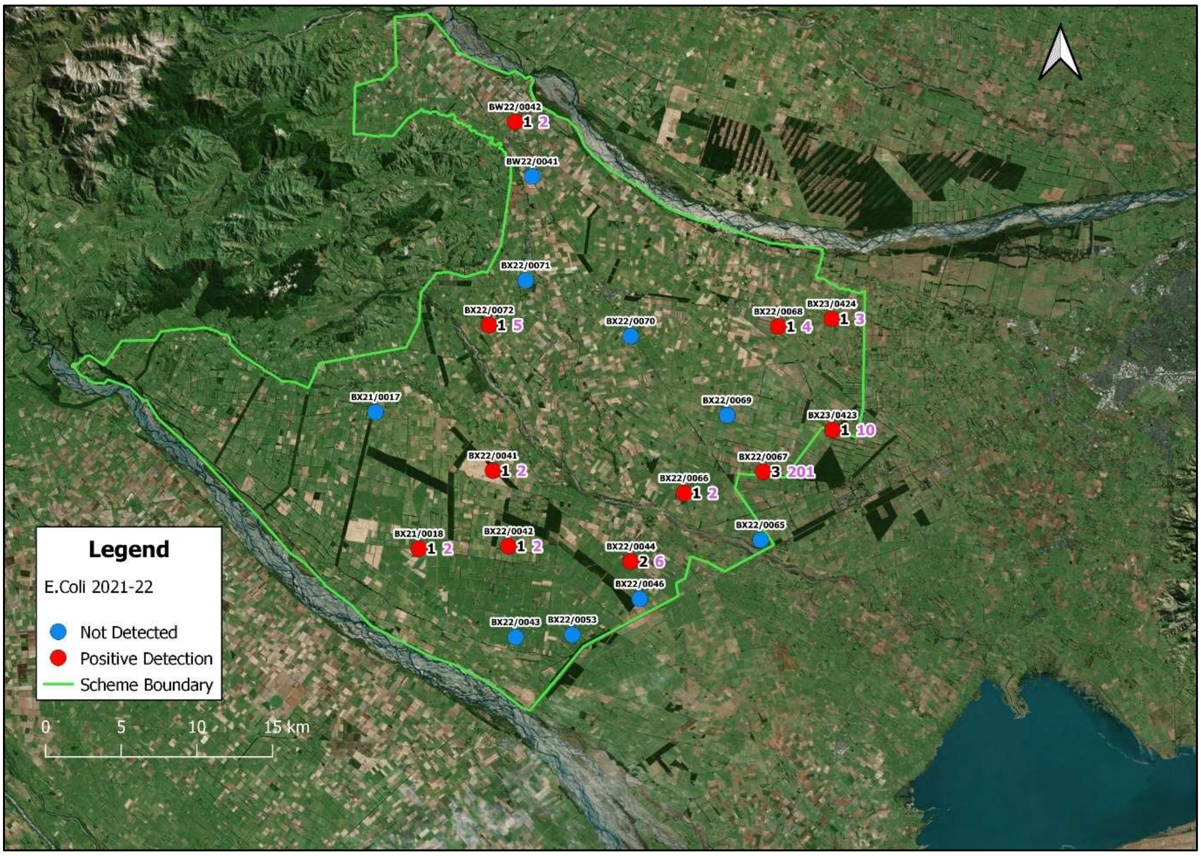

Figure 36. *Positive E.coli detections in CPW monitoring bores, 2021-22 (black numbers indicate number of positive detections at each site, magenta numbers indicate maximum concentration).*

Overall, the incidence of microbial contamination in CPW monitoring bore during 2021-22 was similar to, or slightly lower, than previous seasons and at a similar rate to that observed in the ECan regional groundwater quality monitoring. As in previous seasons, positive detections of indicator bacteria appear to follow large rainfall events but do not exhibit any clear relationship to surrounding land use.

4.4.5. Groundwater Levels

Increased irrigation of alpine-sourced water and decreased abstraction of groundwater has the potential to result in elevated groundwater levels in areas down-gradient of the CPW Scheme. While providing positive benefits in terms of discharge in spring-fed streams, elevated groundwater levels also have the potential to result in adverse effects on land drainage, particularly around the margins of Lake Ellesmere/Te Waihora.

4.4.5.1. In-Scheme Groundwater Levels

Figure 37 shows a plot of groundwater level data recorded in three bores monitored by ECan within the CPW Scheme since the mid to late-1970s (i.e., >40 years of ~monthly water level data). The figures show groundwater levels at all three sites trending toward the upper extend of the historical range during the latter part of the 2021-22 season. While this water level recovery appears to be driven largely by increased recharge associated with above average rainfall during the 2017-18, 2019-

20 and 2021-22 seasons, reduced seasonal variation due to the reduction in deep groundwater abstraction subsequent to the commissioning of Stage 1 in 2015-16 is evident in the data from L35/0181 located near Dunsandel.

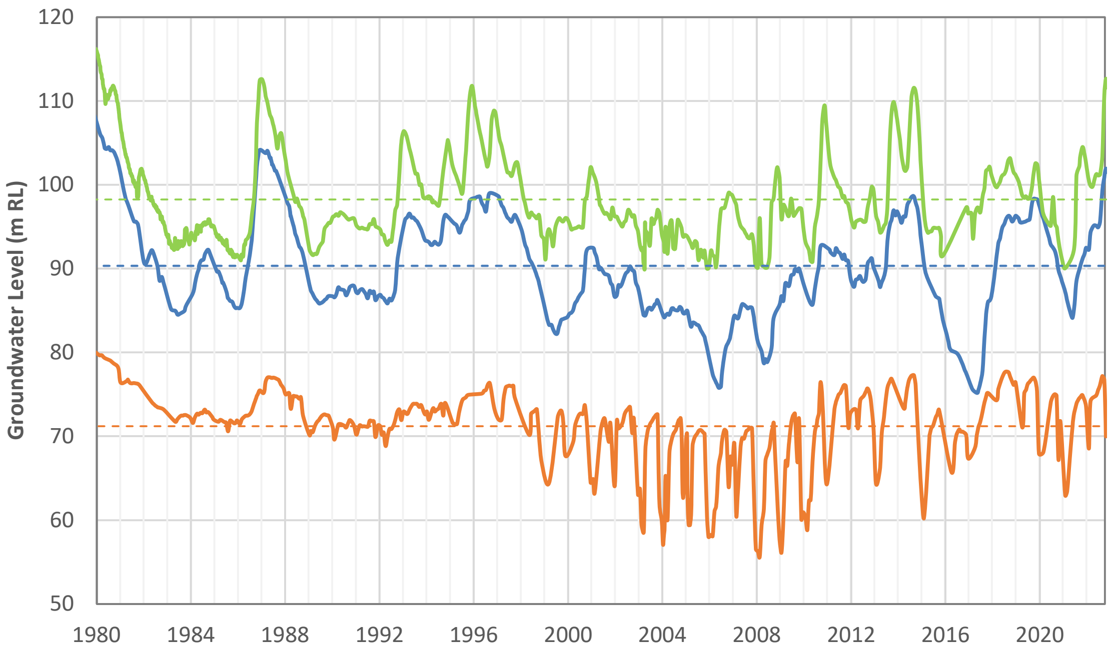

Figure 37. *In-scheme groundwater from long-term ECan monitoring sites at Dunsandel (L35/0181), Greendale (L36/0063) and Kirwee (L35/0163) compared to monthly average values (dotted lines indicate long-term average values, 1980-2022).*

4.4.5.2. Lowland Groundwater Levels

The GSWERP established triggers for (high) groundwater levels in 12 bores located down-gradient of the Scheme which are currently monitored either automatically, or on a regular (monthly) basis, by ECan. These monitoring sites, shown in Figure 38 below, were selected on the basis of having a long historical record (>40 years) to account temporal changes in groundwater levels associated with natural climate variability. Triggers for high groundwater levels were established at the 95th percentile of the historical record for individual monitoring sites.

Figure 39 shows groundwater level variations at two representative monitoring sites (M36/0250 near Broadfield and M36/0424 near Doyleston) between 2000 and 2020. The figure shows groundwater levels at the two sites have remained well below their respective triggers since 2017-18 when groundwater levels across the lowland area were elevated due to high rainfall during autumn and winter 2017. Other lowland monitoring sites exhibited similar trends during the 2021-22 year.

CPWL did not receive any complaints concerning elevated groundwater levels or adverse impacts on land drainage or on-site wastewater systems in the Lowland Plains area during the 2021-22 year.

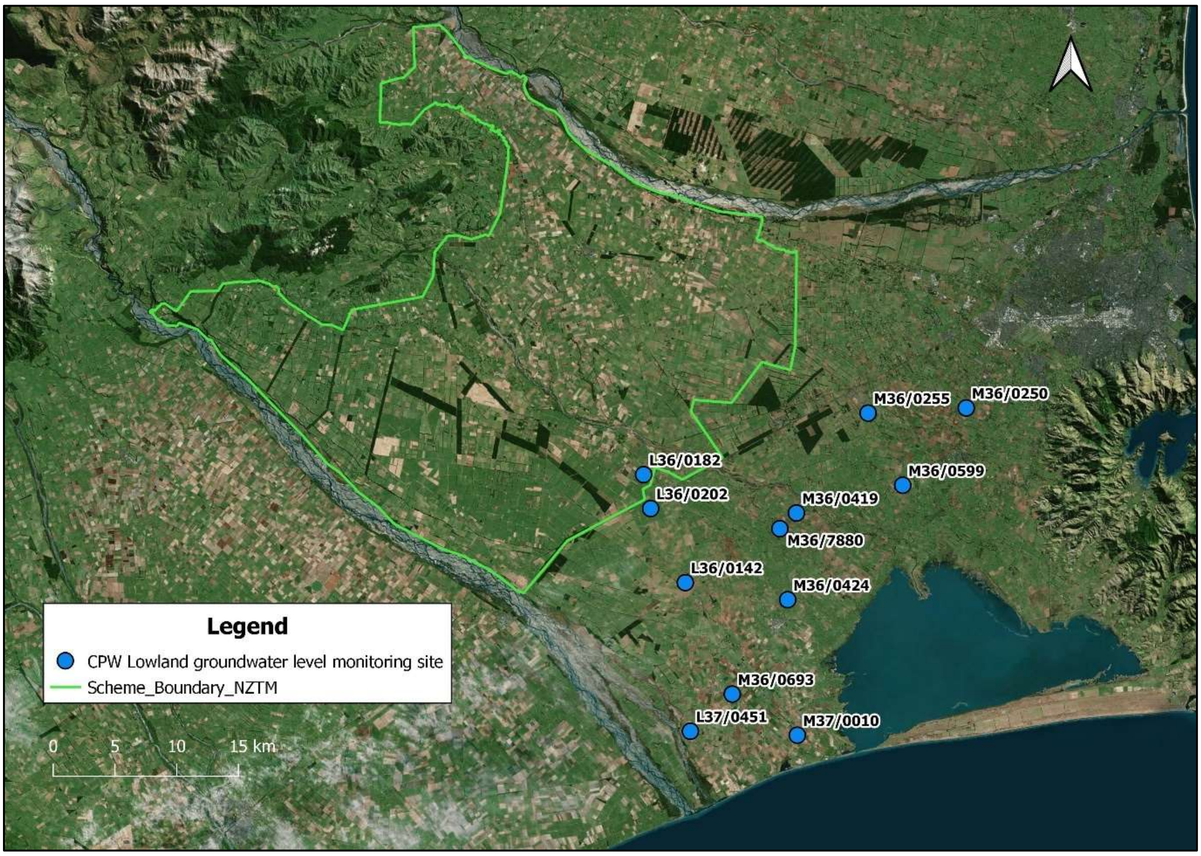

Figure 38. *CPW lowland groundwater level monitoring sites*

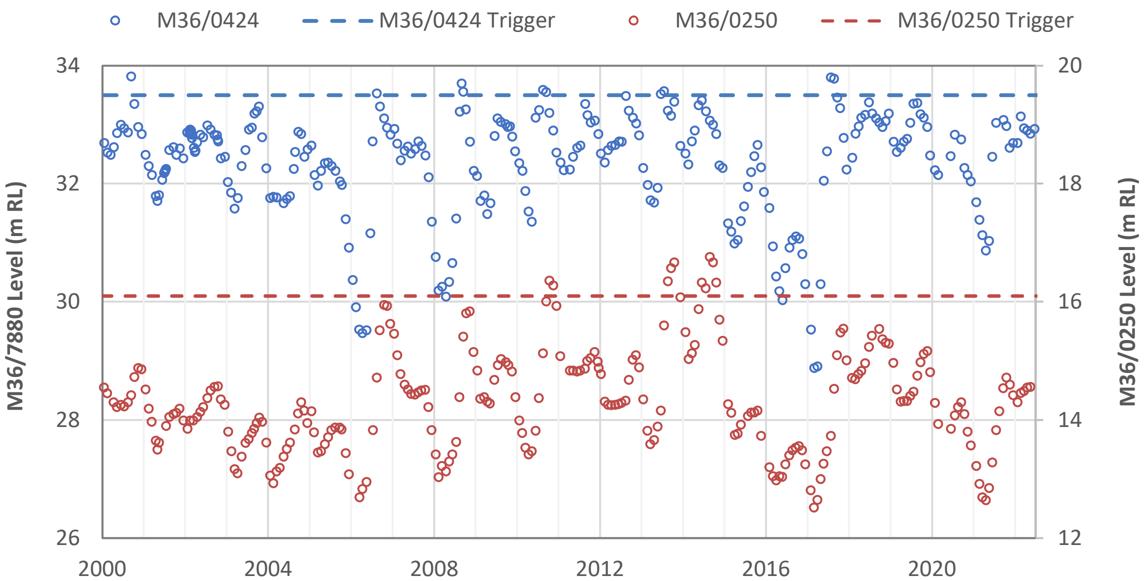

Figure 39. *Groundwater levels (markers) and respective triggers (dotted lines) for monitoring bores M36/0250 and M36/0424, 2000 to 2022.*

4.4.6. Summary

Water quality monitoring results recorded in the CPW monitoring network during the 2021-22 year indicate surface water quality, groundwater quality and lake water quality exceeded trigger levels established in Part II of the CPW GSWMP[18] at a number of monitoring sites located both in, and down-gradient of, the Stage 1, Stage 2 and Sheffield Scheme areas. Although trigger level exceedances were recorded, monitoring results show groundwater, surface water and lake water quality during 2021-22 was either within the historical (i.e., pre-CPW) range or consistent with long-term trends in baseline water quality, flows and levels.

The *Annual Ground and Surface Water Monitoring Report 2021/22* produced by CPW was approved by the GSWERP in November 2022 as providing a valid interpretation of monitoring results for the 2021-22 year. The report also notes that there were no complaints related to surface water quality, groundwater quality, land drainage or effects on on-site wastewater discharges received by CPW during the 2021-22 year.

4.5. Environmental Mitigation and Enhancement

4.5.1. Environmental Management Funds

In addition to an extensive environmental monitoring programme, part of the mitigation package offered by CPW during the resource consent process involved the establishment of funding for three environmental initiatives:

- The CPWL Environmental Management Fund (EMF)
- Te Waihora Environmental Management Fund (TWEMF); and
- Te Waihora Lake Opening.

The EMF and TWEMF were established during the 2015-16 irrigation season. Contributions to these funds are provided by Scheme shareholders. Due to the staged nature of Scheme development, annual contributions to these funds increased as the area under irrigation expanded, with full contribution to the fund (from all three stages) commencing during the 2018-19 year.

Between 2015/16 to 2021-22 cumulative EMF funding totalled $627,524, with $94,793 generated during the 2021-22 year. An independent Environmental Management Fund Committee (EMFC) is responsible for managing and allocating distributions from the EMF to environmental initiatives within the Selwyn Waihora catchment. Figure 40 provides a breakdown of funding allocated by the EMF between 2015-16 and 2021-22. The figure shows a majority of funding ($482,607 or 77%) has been allocated to native planting, with a further $85,699 (14%) allocated to wetland/SNA protection[19].

[18] These trigger levels are consistent with equivalent environmental limits established in the LWRP

[19] Note: funding generated during a given season is allocated for projects during the following year.

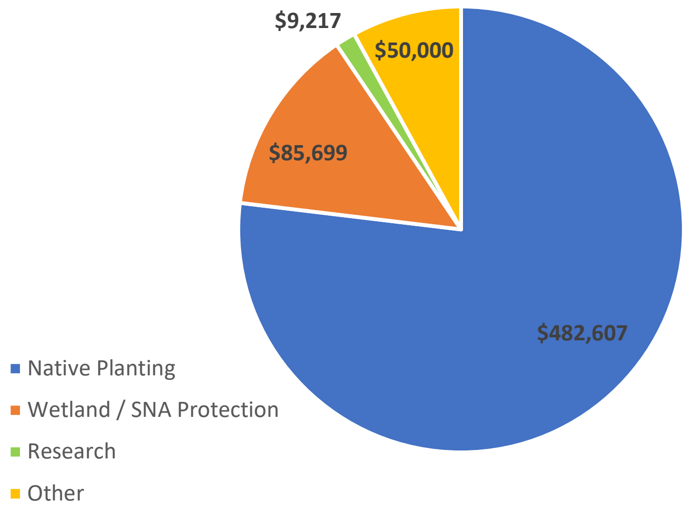

Figure 40. *Breakdown of funding allocated by the EMF, 2016-17 to 2021-22.*

As above, the primary focus of the EMF is the enhancement of biodiversity across the Selwyn/Waihora catchment. One of the regular recipients of the Fund, Te Ara Kakariki Greenway Canterbury Trust (TAK), have used CPW-sourced funding for their annual Spring plant out days, funding landowner initiatives, school education and maintenance of established sites enrolled in their successful Greendot Programme. The EMF have elected to continue their ongoing support for TAK as the organisation is now seen as one of the key promoters for biodiversity and narrowing the divide between urban and rural communities, along with the huge success of their work to date. Figure 41 illustrates the number of native plantings enabled by EMF funding across the wider Central Plains area since 2016-17.

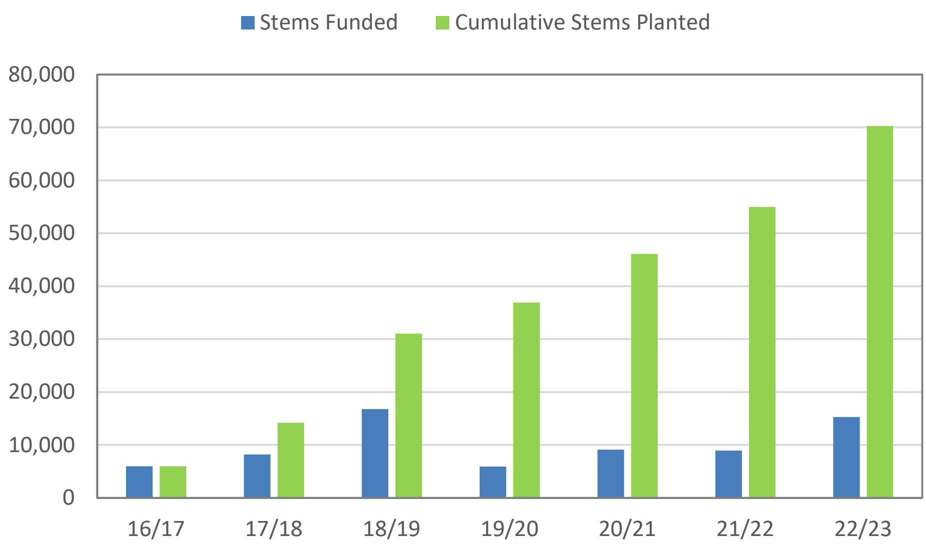

Figure 41. *Native plantings enabled by EMF funding 2016-17 to 2022-23.*

The TWEMF fund is provided directly to Ngai Tahu who manage allocation and annual reporting of fund expenditure. To date funding has been provided to the TWEMF for the period 2015 to 2022. Details and priorities for initiatives associated with the restoration of health/mauri of the environment in the vicinity of Lake Ellesmere/Te Waihora are still being determined by iwi. Cumulative funding provided by CPW to the TWEMF over the 2015-16 to 2021-22 period totals $373,851.

The CPW Scheme contributed a total of $59,347 + GST towards costs associated with opening of Te Waihora/Lake Ellesmere by ECan during the 2021-22 season. Cumulative funding provided for Te Waihora Lake Opening by CPW over the 2015-16 to 2021-22 period totals $160,926.

Table 9 summarises cumulative CPW funding for environmental initiatives established through the CPW resource consent process.

Table 9. *Summary of cumulative CPW funding for environmental initiatives, 2015-16 to 2021-22.*

Initiative	**Cumulative Funding Allocated ($)**
CPW Environmental Management Fund	$627,524
Te Waihora Environmental Management Fund	$373,851
Te Waihora Lake Opening	$160,926
Total	**$1,162,300**

In addition to environmental initiates established through the resource consent process, CPW also provides funding for a range of other environmental projects. This funding, summarised in Table 9 below includes the installation of continuous nitrate monitoring described in Section 4.4.4 above, establishment of a weather station and potential evapotranspiration (PET) to provide irrigators with real-time information of weather conditions and likely irrigation demand, a contribution to assist updating of the numerical groundwater model for the Central Plains area as well as significant funding of biodiversity/planting plans for properties mainly in the Hororata/Selwyn River area.

Table 10. *CPW funding for environmental projects, 2012-16 to 2021-22.*

Project	**Funding ($)**
Nitrate Sensors	$62,361
SFF Optical Sensors for N fertilising dairy pastures	$14,663
CPWL potential evapotranspiration (PET) monitoring	$48,596
Biodiversity and Ecological Plans	$116,866
Workshops	$25,357
Weather Station	$19,911
Updating of groundwater model	$25,000
Total	**$312,754**

4.5.2. Targeted Stream Augmentation

A targeted stream augmentation project has been developed by CPW in conjunction with ECan to utilise ‘spare’ CPW water to augment natural flows in the Selwyn River catchment in a manner that provides significant environmental benefits to the river system, while respecting cultural values associated with the mixing of waters. The project is a key component in the Canterbury Water Management Strategy. It was recommended by the Selwyn Waihora Water Zone Committee and included in their Zone Implementation Programme addendum (ZIPA) in 2013. The project is also an excellent fit for CPW's strategic goal of delivering sustainable water to the Central Plains area and the augmentation of the groundwater aquifers contributes to the environmental goals of the business.

The Selwyn Near River Recharge project includes the construction of an off-take on the Central Plains Water scheme that supplies up to 3.5m^3/s of Rakaia River Water into an infiltration basin beside the upper Selwyn River during dry periods. Water discharged into the infiltration basin percolates through the groundwater system beneath recharging the aquifer and ultimately increasing baseflow discharge in spring-fed streams across the down-gradient area. Operation of the scheme is not expected to increase the length of time the Selwyn River flows under the SH1 bridge.

Between late April and 29 May 2021, the project was commissioned and was monitored as it was run at a variety of flow rates. Operations ceased in late May 2021 to enable CPW to undertake winter maintenance.

Due to rainfall/climate/river flow conditions no water was released via the Near River Recharge project during the 2021-22 year. However, it is anticipated that extended operation of the project during future seasons will provide significant cultural and recreational benefits in waterways including tributaries of the Hororata River (home to the endangered Kōwaro/Canterbury mudfish) and the lower Waikirikiri / Selwyn River (enhancing flow at the Chamberlains Ford and Coes Ford recreation areas).

At the project site, significant rockpile habitat for lizards has been created and a Tōtara forest has been planted with the assistance of Greendale School, who have adopted the site as a Living Laboratory through Enviroschools.

5. Summary

During the 2021-22 irrigation season (1 September 2021 to 23 May 2022) the CPW Scheme delivered 111.3 million m^3 of water to a total of 259 shareholder properties. This total comprised 75.7 million m^3 of water taken directly from the Rakaia and Waimakariri Rivers, with the balance (35.6 million m^3) derived from water storage. Properties in the CPW Scheme also utilised 26.0 million m^3 of groundwater (equivalent to 13% of the total volume authorised by existing resource consents).

Cumulative rainfall in the Central Plains area during the 1 September 2020 to 14 May 2021 irrigation season generally between 10 to 20 percent above the long-term average. However, this rainfall was not evenly distributed through the season. While rainfall was close to, or slightly below, normal through much of the season, large rainfall events in December 2021 and February 2022 significantly reduced soil moisture deficits (and consequently irrigation demand) through the summer and autumn of 2022. The average seasonal irrigation application rate (CPW Scheme water and groundwater) across the Scheme area (including Farm Enterprise Properties) during 2021-22 was 1,941 m^3/ha (equivalent to a seasonal application depth of 194 mm), comprising 366 m^3/ha of groundwater and 1,575 m^3/ha of CPW water. These application rates were approximately 40 percent lower than those occurring during the preceding two seasons (2019-20 and 2020-21).

Water quality monitoring results recorded for the CPW monitoring programme during the 2021-22 year indicate surface water quality, groundwater quality and lake water quality exceeded trigger levels established for the Scheme at a number of monitoring sites located both in Stage 1 and Stage 2 areas, as well as down-gradient of the Scheme. The recorded trigger level exceedances are consistent with the historical range and/or background trends observed prior to commencement of CPW operations. No obvious effects on water quality, groundwater levels or surface water flows attributable to operation of the Scheme were observed during the 2021-22 year.