Central Plains Water Trust

Annual Sustainability Report 2017-18

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- December 2018

Report prepared by

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List of Abbreviations

CCC	Christchurch City Council
CLG	CPW Community Liaison Group
CWMS	Canterbury Water Management Strategy
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
TLI3	Trophic Level Index
ZIP	CWMS Selwyn Waihora Zone Implementation Plan

Executive Summary

The Central Plains irrigation scheme (the Scheme) commenced operations in 2015, with the final stage (Stage 2) being commissioned in October 2018. The completed scheme supplies water to an area of approximately 47,000 hectares between the Waimakariri and Rakaia rivers.

Stage 1 of the Scheme completed in September 2015 provides irrigation water to an area of approximately 23,000 hectares between the Rakaia and Selwyn rivers. Stage 1 incorporates a 17km long canal to supply water from the Rakaia River to 130km of underground pipes, which in turn deliver water to 125 farm turnouts. The 4,600 ha Sheffield Scheme is a stand-alone project that commenced operations in November 2017 utilising water from the Kowhai and Waimakariri Rivers in combination with a large storage pond constructed near Springfield. Stage 2 of the CPW Scheme was commissioned in spring 2018 to provide irrigation water to an area of approximately 20,000 ha between the Selwyn and Waimakariri Rivers.

The 2017-18 irrigation season was preceded by a period of high rainfall during the 2017 winter months. This rainfall reduced requirements for irrigation during the following spring. However, an extended period of low rainfall from late October to December 2017 reduced soil moisture levels, resulting in a significant increase in water demand. During this period river flows steadily declined requiring the use of greater volumes of stored water to maintain reliability of supply.

From January to May 2018 rainfall totals were average to above average, reducing irrigation requirements during the typical period of highest demand. Reflecting the rainfall that has occurred since early 2017, groundwater levels and flows in rivers and streams across much of the wider Central Plains area during 2017-18 were the highest observed for several years.

The 2017-18 irrigation season for Stage 1 ran from 1 September 2017 to 1 May 2017. During this period, the Scheme supplied 80 million m^3 of irrigation water to farms in the Stage 1 area comprising 49 million m^3 of water taken directly from the Rakaia River and 31 million m^3 of stored water supplied by TrustPower from Lake Coleridge. The Sheffield Scheme commenced operations in November 2017 and supplied approximately 7 million m^3 of water to farms in the Scheme area, comprising 5.7 million m^3 taken directly from run-of-river takes and 1.3 million m^3 of stored water.

During the 2017-18 year direct abstraction from surface water totalled 21 and 12 percent of the volume potentially available under resource consents for Stage 1 and the Sheffield Scheme respectively. In combination with the use of stored water, this provided a reliable supply of irrigation water to shareholders while having no measurable effect on naturally occurring discharge in the Rakaia or Waimakariri Rivers during periods of mid to low flows.

Key Statistics for the CPW 2017-18 Irrigation Season

	Stage 1	Sheffield*
Number of Properties Supplied	132	33
Total Volume of Water Delivered	79.6 million m^3	7.0 million m^3
Total Volume of Water from Storage	30.9 million m^3	1.30 million m^3
Length of 2017-18 Irrigation Season	243 days	176 days
Days with partial or full restriction on river take	67	82
Available Surface Water Allocation Taken	21%	12%

* The Sheffield Scheme did not operate for the full 2017-18 irrigation season

Water quality monitoring results recorded as part of the in the CPW monitoring programme during the 2017-18 year indicate surface water quality, groundwater quality and lake water quality exceeded trigger levels established for the Scheme[1] at a number of monitoring sites located both in Stage 1 and the Sheffield and Stage 2 areas (where CPW had not commenced delivering water during the 2017-18 year).

Trigger level exceedances at many monitoring sites during 2017-18 followed an extended period of high rainfall during the 2017 winter that resulted in significant groundwater recharge and maintained high flows in surface waterways. These short-term climate-related effects tend to obscure underlying background trends in water. The high rainfall during the 2017-18 year also resulted in exceedances of lowland groundwater level triggers similar to those observed following previous wet winters.

[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 from 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 consents to CPWL. CPWL is responsible for constructing and operating the Scheme, and for all consent compliance and reporting. For the purposes of this document, CPWT and CPWL are referred to collectively as CPW.

1.2. Scheme Development

As shown on Figure 1, development of the Scheme was undertaken in three stages.

Stage 1 provides irrigation water to an area of approximately 23,000 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. 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.

The Sheffield scheme, covering approximately 4,600 Ha commenced operations in November 2017. This component of the scheme is physically separate from Stages 1 and 2, supplying irrigation water, stockwater, 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 river intakes are restricted.

Stage 2 supplies an irrigable area of approximately 20,000 hectares between the Selwyn and Waimakariri rivers. Construction of Stage 2 commenced in early 2017, with the scheme becoming operational in October 2018. This component of the Scheme is a fully piped network that utilises water from the Rakaia River intake (including Lake Coleridge storage).

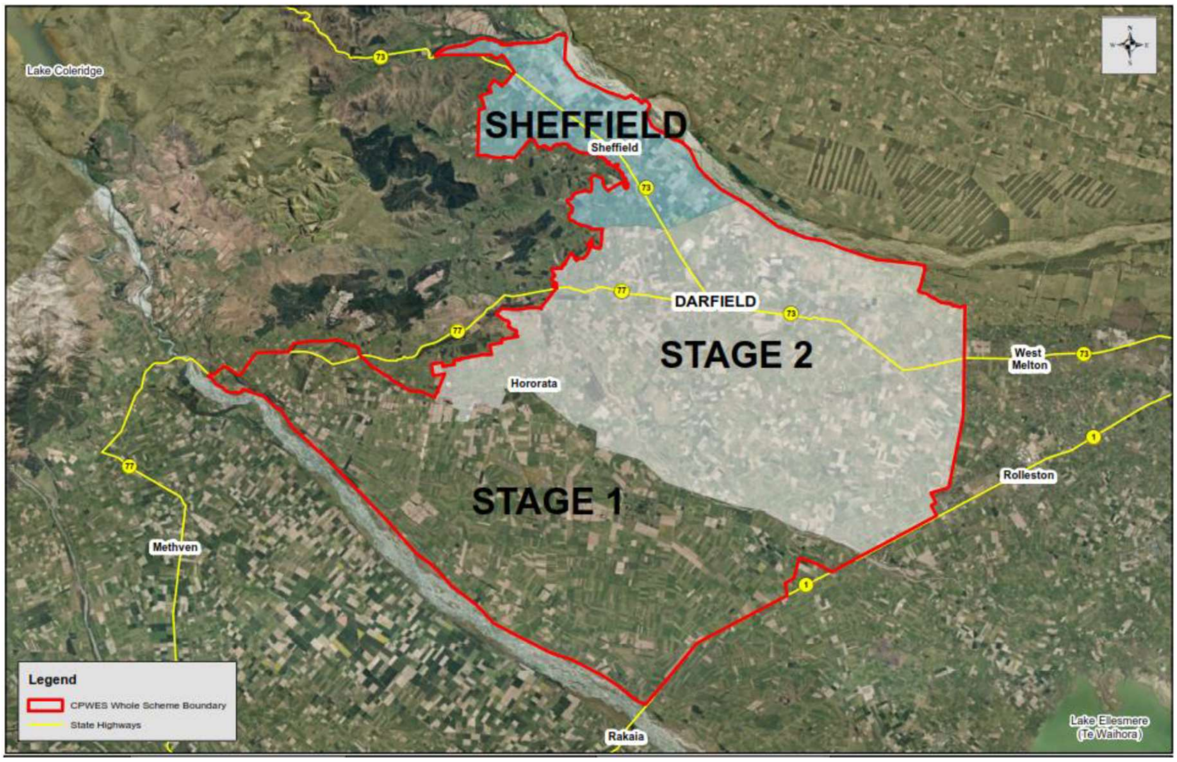

Figure 1. *Layout of the CPW scheme*

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 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 cumecs of flow above the specified minimum, 1 cumec 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 low supply reliability (i.e. it is cut off first as river flows decline). As a consequence of these restrictions, the full volume of allocation held by CPW can only be taken for around 63 percent of the time during the irrigation season, potentially resulting in low reliability of supply for scheme users. In order to ensure an adequate reliability of supply for irrigation, CPW have an agreement with TrustPower 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.

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 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 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 Te Waihora, thereby improving water quality and quantity across the wider Zone.

Recommendations in the Selwyn 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 Waihora zone in the LWRP include:

- Prohibiting new 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 Te Waihora/Lake Ellesmere 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. 2017/18 Annual Summary

2.1. Climate

During the 2017-18 year, cumulative rainfall totals were above the long-term average (LTA) across the Central Plains area. As illustrated on Figure 2, a total of 1,151 mm of rainfall was recorded at NIWA weather station 4702 (located approximately 4km west of Hororata) between July 2017 and June 2018, the sixth highest July to June total since records began at this site in 1890.

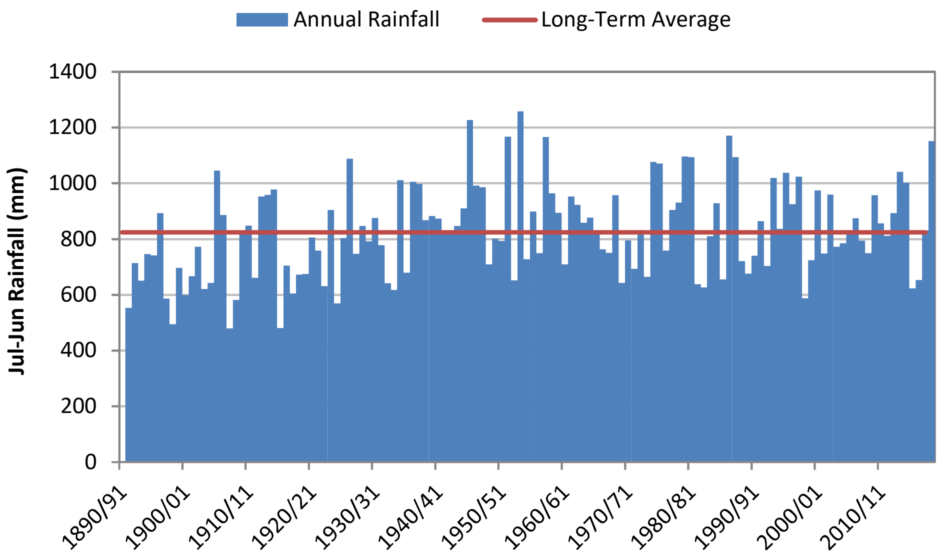

Figure 2. *Historical July to June rainfall at Hororata (4702), 1890-91 to 2017-18 (Data from NIWA CliFlo database)*

Except for an extended dry period from late October to December, monthly rainfall totals were average to above average throughout most of the 2017-18 year. As shown on Figure 3, monthly rainfall recorded at Hororata, Rigdens Road and Burnham exhibited a relatively consistent pattern across the whole of the Central Plans area during 2017-18, with monthly totals almost three times July and February averages and between 150 and 200% of average in August, October, January and April. In contrast, November rainfall was exceptionally low, with no rainfall recorded in eastern parts of the Central Plains area.

The temporal variation in rainfall through the 2017-18 year is reflected in the accumulated soil moisture deficit. As shown on Figure 4 below, reflecting the wet conditions during winter soil moisture deficit in the Central Plains area was less than average through to early November when it increased rapidly due to the extended period of low rainfall during November and December. Following rainfall in early January, soil moisture deficit remained well below normal for the remainder of the 2017-18 season.

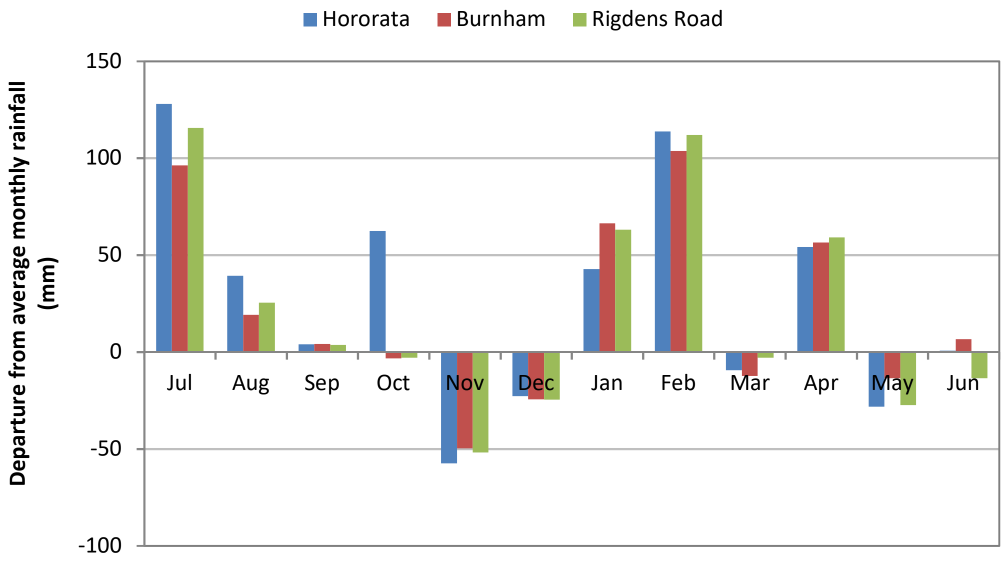

Figure 3. *Departure from average monthly rainfall at Hororata, Burnham and Rigdens Road during the 2017-18 year (Data from NIWA CliFlo database and Environment Canterbury)*

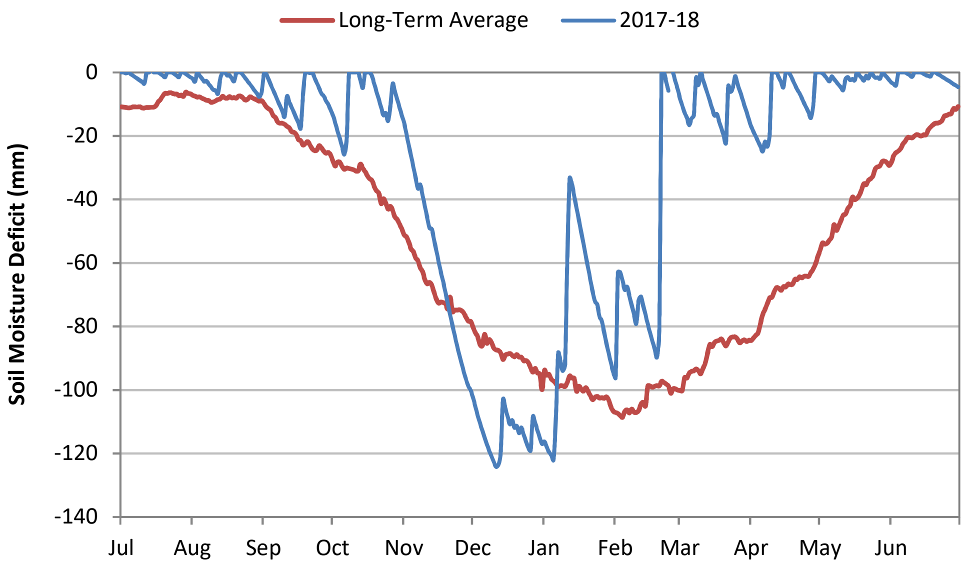

Figure 4. *Soil moisture deficit at Hororata during 2017-18, compared to the long-term average (Data from NIWA CliFlo database, Station No. 4702)*

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 2017-18 year remained above average throughout the year, despite the period of low rainfall in early summer. In contrast, cumulative rainfall was below normal during the 2014-15 and 2015-16 seasons, only returning to normal during the latter part of the 2016-17 year. This transition from an extended period of low rainfall to more recent normal to above normal conditions is reflected in groundwater level and flow monitoring results for the 2017-18 year.

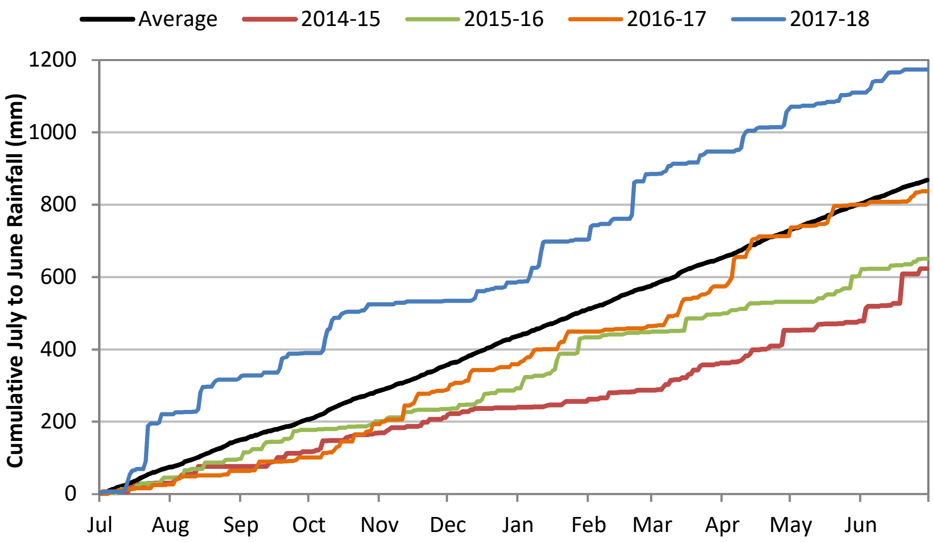

Figure 5. *Cumulative (July to June) rainfall at Hororata, 2014-15 to 2017-18*

The effects of the extended period of average to above average rainfall from early 2017 through to 2018 were observed in groundwater levels and stream flows across the wider Central Plains area during the 2017-18 year. Figure 6 shows a plot of groundwater levels in ECan long-term monitoring wells located at various sites around the Central Plains. All sites exhibit an increase in groundwater levels following rainfall in winter 2017. This recovery continued following the early onset of recharge in autumn 2018, with groundwater levels at the end of the 2017-18 year well above the long-term average throughout the Central Plains area.

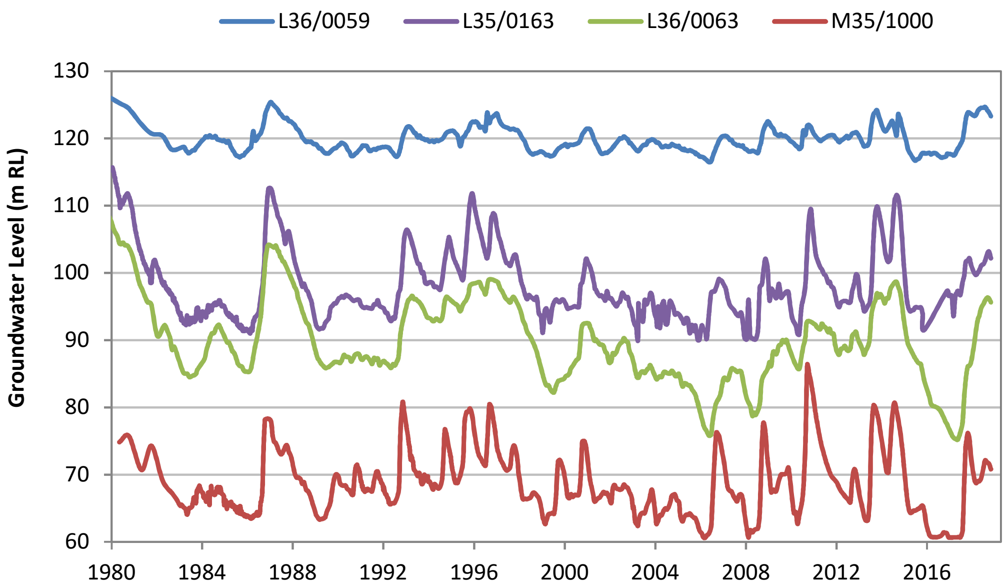

Figure 6. Groundwater levels recorded in L36/0059 (Hororata), L35/0163 (Kirwee), L36/0063 (Greendale) and M35/1000 (West Melton) from 1980 to 2018 (Data from Environment Canterbury)

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 2017-18 year with the long-term average for this site. The figure shows sustained periods of high flow following significant rainfall events during winter and spring 2017. River flows declined to below average from November through to February reflecting the low rainfall during this period but recovered to above average in response to rainfall from late February through to June.

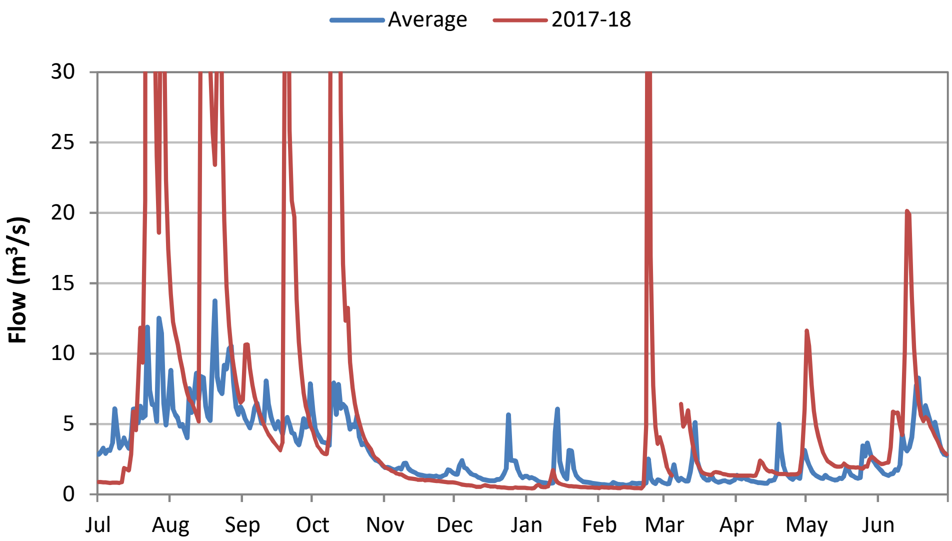

Figure 7. *Flow in the Selwyn River at Coes Ford during 2017-18 compared to the long-term average. Note: scale only shows flows below 30 m³/s. (Data from Environment Canterbury)*

Large recharge or high flow events following heavy rainfall can have a significant short-term influence on groundwater and surface water quality. As discussed in greater detail in Section 4, the high rainfall during winter 2017 (following three years of average to below average rainfall) resulted in short-term variations in groundwater and surface water quality at many sites across the Central Plains. These climate-related variations act to obscure underlying trends, with similar short-term effects observed at sites both within and downstream of the CPW Scheme as well as at upstream sites and in areas where the CPW scheme had not commenced operating.

Overall, the 2017-18 irrigation season can be characterised as being wetter than normal except for a short dry spell from late October to December.

2.2. Construction Activities

Commissioning of the Sheffield Scheme was completed in 2017, with the scheme commencing operations in late November. The initial period of operations provided an operational challenge with water availability restricted due to declining river flows having to be balanced against demand for irrigation water and requirements to progressively fill the Springfield storage pond to obtain necessary regulatory approvals for pond construction.

Construction activities on the Stage 2 scheme advanced during the 2017-18 year toward the target date for commencement of operations on 1 September 2018. Heavy rainfall during the 2017 winter provided challenges for construction activities due to general ground conditions, high groundwater levels and constraints associated with construction of river crossings in actively flowing waterways. Two construction-related compliance incidents were recorded during the 2017-18 year. Both incidents related to sedimentation issues associated with pipeline installations under waterways during adverse weather conditions. Once notified, appropriate mitigation actions were initiated to minimise the scale and extent of these events.

2.3. Scheme Operation

Between 1 September 2017 and 1 May 2018 a total of 79.6 million m^3 of water was supplied by the CPW scheme to 105 properties in the Stage 1 area. This total comprised 48.6 million m^3 of run of river water from the Rakaia River, with an additional 31.0 million m^3 (representing 39% of the total volume supplied) of stored water sourced from Lake Coleridge. CPW scheme shareholders also utilised a total of 18.4 million m^3 of groundwater (18% of the available allocation) during the 2017-18 season.

Figure 8 provides a comparison of water use in the Stage 1 area over the 2015-16, 2016-17 and 2017-18 irrigation seasons. The figure shows total water use (i.e. groundwater plus surface water) during the 2017-18 year was approximately 20% higher than 2016-17 but less than 90% of that used in 2015-16. The volume of run of river abstraction from the Rakaia River was the lowest in the three years of operation, while the volume of storage used was the highest. This reflects the extended period of low rainfall from late November to December which was experienced across the whole region, rather than normal summer ‘drought’ when dry conditions on the Canterbury Plains are often associated with westerly airflows that result in elevated rainfall and river flows in alpine catchment headwaters.

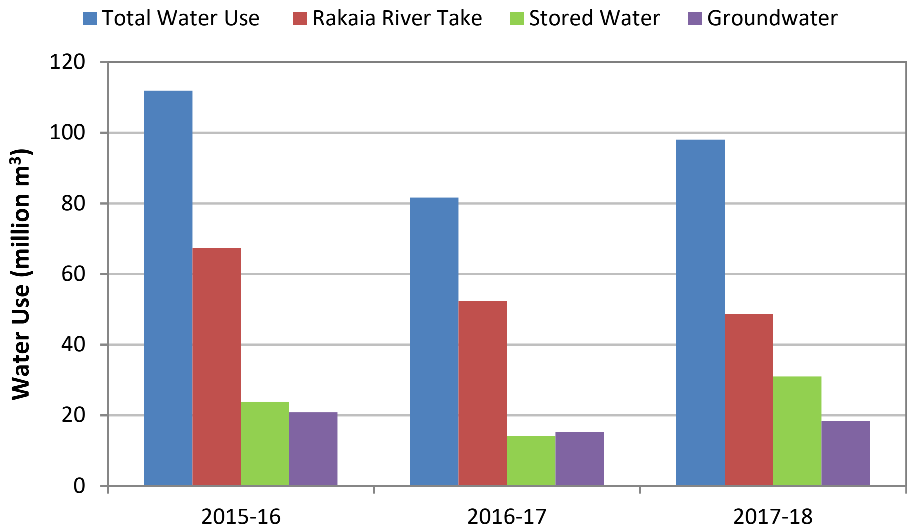

Figure 8. *Water use in the CPW Stage 1 Scheme, 2015-16 to 2017-18*

Figure 9 shows a plot illustrating operation of the Stage 1 scheme during the 2017-18 year. The figure shows irrigation demand (blue line) increasing through late October 2017 to reach a maximum of approximately 10 m^3/s from early November through to early January. Reflecting declining river flows (purple line) during this period, the volume of water able to be taken directly from the Rakaia River (green bars) was insufficient to meet irrigation demand necessitating the extensive use of stored water from Lake Coleridge (red bars) from early November to early January. Aside from a short period during late January, river flows remained sufficiently high to meet reduced irrigation demand for the remainder of the season.

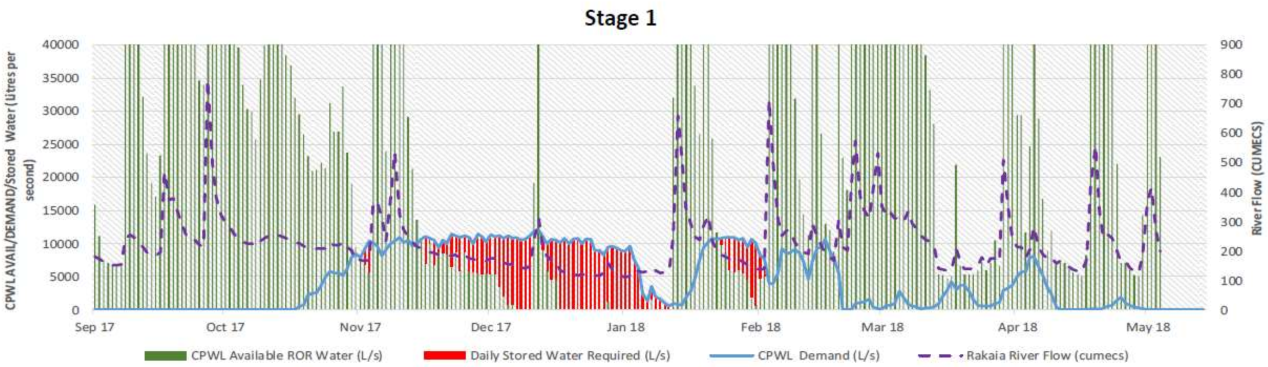

Figure 9. *Schematic illustration of Stage 1 operations during the 2017-18 year.*

From early November 2017 to 1 May 2018, a total of 7.0 million m^3 of water was supplied to 33 properties in the Sheffield Scheme area. This total comprised approximately 5.7 million m^3 of run-of-river water taken from the Kowai and Waimakariri Rivers, with an additional 1.3 million m^3 of stored water utilised when abstraction of surface water was restricted by low river flows during December and January. An additional 2 million m^3 of water was abstracted to fill the Springfield storage pond which reached 100% storage in mid-January 2018. Properties in the Sheffield

Scheme also utilised a combined total of 0.9 million m^3 of groundwater (24% of the available allocation) during the 2017-18 season.

Figure 1 shows a schematic illustration of Sheffield Scheme operation during 2017-18. The figure shows commissioning of the scheme commencing with initial filling of the Springfield storage pond (blue shaded area) in early November. Supply of water to shareholders (orange line) commenced in late November with initial demand of up to 1.6 m^3/s tailing off through to early January due to the progressive restriction of surface water takes and a requirement to maintain pond storage to obtain regulatory approvals. Following rainfall in early January, pond storage water increased close to 100%. Water demand remained relatively modest through the summer and autumn months reflecting the greater rainfall over this period.

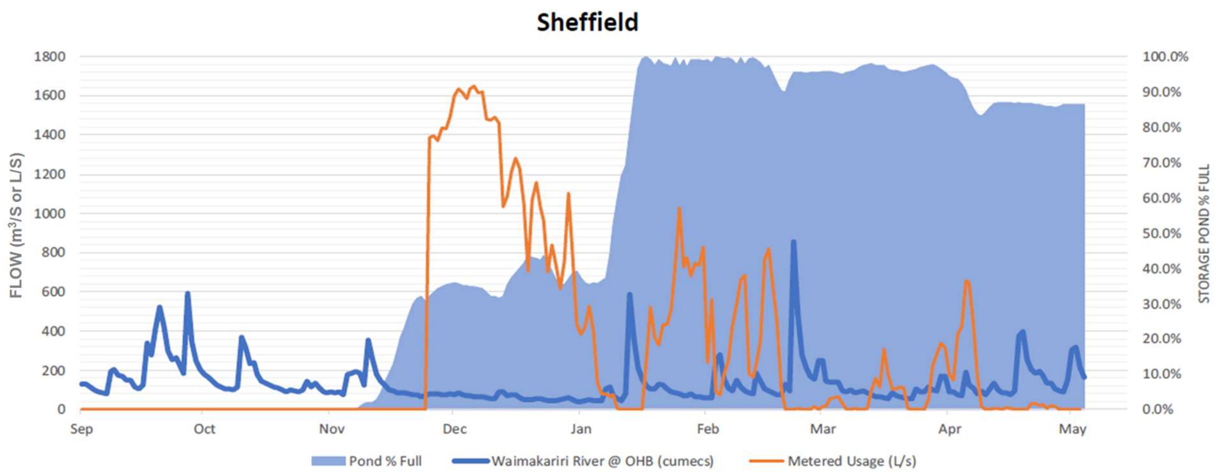

Figure 10. *Schematic illustration of Sheffield Scheme operations during the 2017-18 year.*

One compliance incident related to operation of the Sheffield Scheme was recorded during the 2017-18 season. This incident related to programming of automated controls on pumps at the Waimakariri River intake. This incident was remedied by introduction of a failsafe system to ensure water abstraction does not exceed allocated volumes when low flow restrictions are in place.

2.4. Positive Benefits

Development of the CPW Scheme was forecast to provide a range of economic and social benefits to the wider community. Limited data has been collated to accurately quantify these effects as construction of the scheme has only recently been completed. Specific positive benefits resulting from Scheme construction include:

- Approximately 180 direct jobs and up to 1,700 indirect during four-year construction phase;
- Provision of supplementary/backup water supplies for the Springfield and Sheffield communities;
- Delivery of reliable, high quality stock water across the command area;
- Construction of 18 turnouts (connections to the scheme) to provide contingency for rural fire fighting; and

- A reduction in electricity demand of approximately 17 MW due to the provision of pressurised supply to farms (and associated reduction in groundwater pumping).

Anecdotal information also suggests other positive benefits associated with the scheme including:

- Increased business activity and new businesses directly resulting from Scheme operations;
- Mitigation of climatic effects on agricultural land uses;
- Positive financial impacts on farming enterprises; and
- A reported boost to school role (Hororata);

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 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 and 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; and
- 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 requires 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; and
- 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 on an annual basis 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 four 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 the Scheme is limited by resource consent conditions to a designated area of approximately 60,000 hectares, within a command area of 100,000 hectares.

The total land area managed under CPW in Stage 1 during 2017-18 totalled 33,288 Ha (including Farm Enterprise properties), of which 22,765 Ha was irrigated using water supplied by CPW.

The total land area managed under CPW in Sheffield Scheme area during 2017-18 totalled 7,439 Ha (including Farm Enterprise properties), of which 4,647 Ha was irrigated using water supplied by CPW.

The distribution of irrigation system types within the Stage 1 area is shown on Figure 11. A majority of land is irrigated using either centre pivot irrigators (74 percent of total irrigated area) or travelling irrigators (21 percent of total irrigated area). 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 11. *Irrigated area and irrigation types for CPW Stage 1, 2017-18*

The distribution of irrigation system types within the Sheffield Scheme area is shown on Figure 12 below. The figure shows a majority of land is irrigated using centre pivot irrigators with less than 15% of the total area irrigated using travelling irrigators or spraylines.

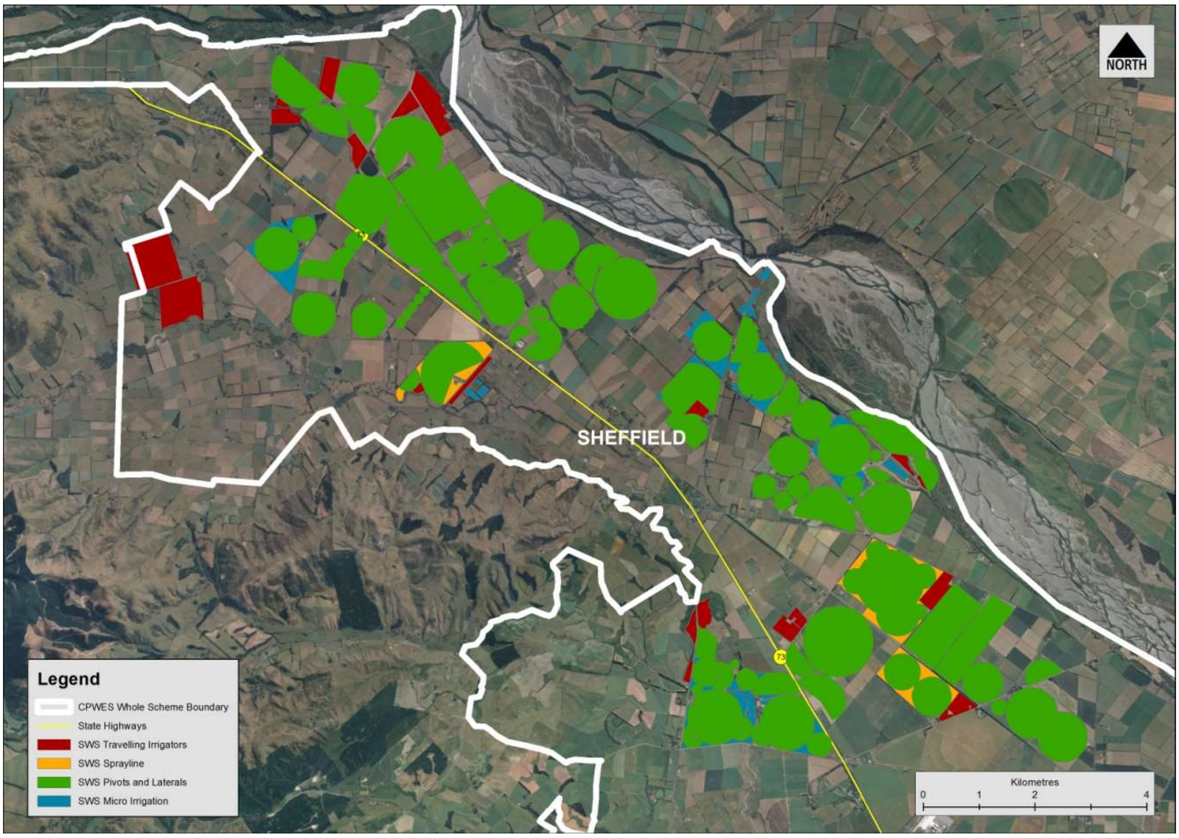

Figure 12. *Irrigated area and irrigation types for CPW Sheffield Scheme, 2017-18*

3.2.1. Irrigation System Performance

During the 2017-18 year a project administered by Irrigation New Zealand (with the support of multiple partners including CPW) was undertaken to quantify the performance of irrigation systems in the Selwyn Waihora zone. The project involved physical testing of irrigation systems to determine application rates (i.e. the amount of water that is applied per unit area) and distribution efficiency (i.e. how evenly water is applied over the coverage area). Data was also collected to investigate drivers for change, technology uptake, and barriers to irrigation farmers achieving industry agreed Good Management Practice (GMP)[2]. While only half of the study participants were enterprises taking water from the CPW Scheme, results provide a useful snapshot of irrigation system performance across the wider Central Plains area.

The study found that 68% (80) of the irrigation systems tested were modern, highly efficient spray system (centre pivot or linear move). Of these highly efficient systems, 20% were fitted with variable rate irrigation (VRI) technology. This technology allows irrigation to be applied more accurately spatially, accounting for uneven terrain or variation in soil types and soil depth.

Older system types like Roto-Rainers and Turbo-Rainers represented around 28% of the systems included in the study. These systems are slowly being replaced as they reach the end of their

[2] https://www.irrigationnz.co.nz/PracticalResources/GMP/Overview

effective operating life. The simplicity and the low level of technical knowledge required to maintain these systems remains attractive to many farmers. Hard Hose guns, K-Line, and Long Laterals remain systems of choice for hard-to-fit areas or corner in-fill.

Sixty-five (55%) of the systems tested achieved the industry agreed 0.8 or higher benchmark for distribution uniformity. However, of the participating farms, cumulatively only 43% of all new centre pivots, regardless of technology options, made the industry performance benchmarks, 45% of machines 2 to 5 years, 36% of machines 5 to 10 years and 40% of machines 10 to 15 years. The study noted that the percentage of older systems attaining performance benchmarks improved as components of the systems past their operating life and were replaced. The low percentage of relatively new machines achieving benchmarks was identified as an area that the service industry must address through improved commissioning processes.

The study also identified that regulation and scheme requirements were the biggest drivers for irrigation system change. However, it noted that the willingness to invest capital into irrigation system upgrades based solely on water use efficiency is related to primary commodity prices, with irrigators unsurprising less willing to invest in new plant and technology when cashflow is constrained. The study also identified that around 60% of irrigating farmers are using soil moisture monitoring technologies to better schedule the timing of their irrigation.

3.3. Land Use

Figure 13 provides a breakdown of land use (enterprise) types in the CPW Stage 1 area over the 2017-18 year based on the categories defined in the Overseer® 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 land use perspective these enterprises can be divided into two types: dairy systems, and mixed systems. It is noted approximately 40 % 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. The spatial distribution of land use types is shown on Figure 14 below.

Figure 15 provides a comparison between baseline land use (i.e. pre-CPW) and 2017-18 land use in the Stage 1 area based on the FEP. The data show that land use has remained relatively constant over the three years since the scheme commenced operations with the major change being a 34 % reduction in the area of Sheep, Beef/Dairy grazing which has largely been balanced by an increase in Beef/Dairy grazing enterprises. The overall expansion of dairy enterprises following commencement of Stage 1 operations equates to around 5% of the total scheme area.

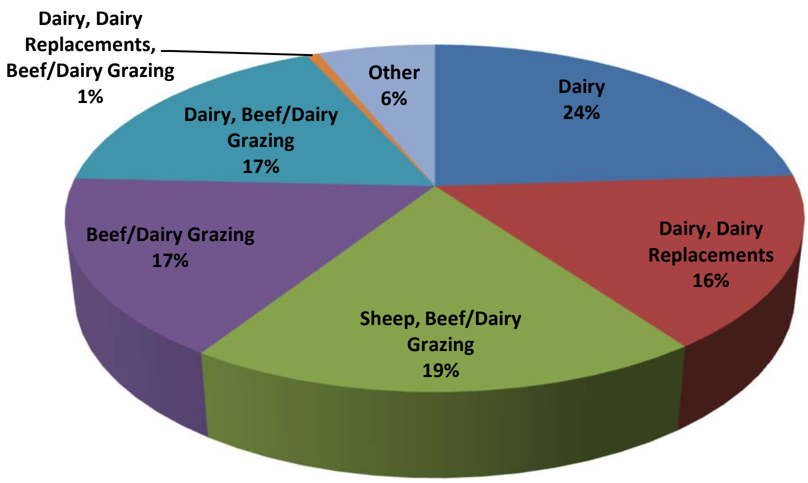

Figure 13. *Land use types in CPW Stage 1 area, 2017-18*

Figure 14. *Spatial distribution of land use types in CPW Stage 1 area, 2017-18*

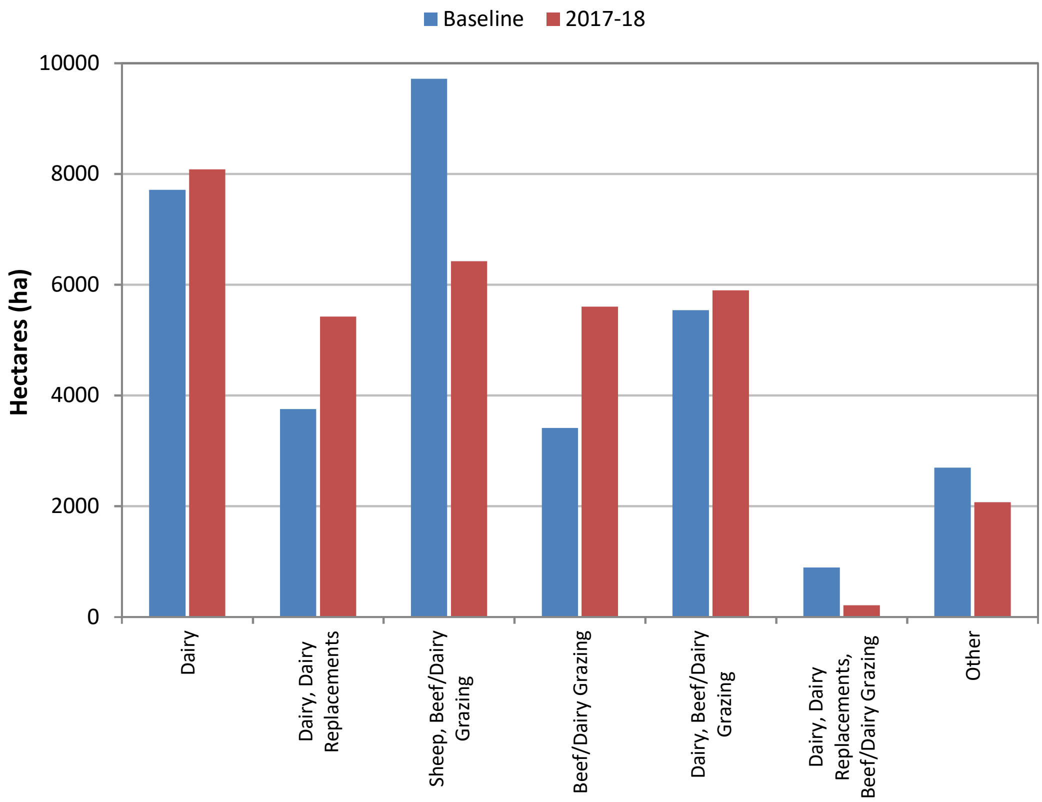

Figure 15. *Comparison of baseline (i.e. pre-CPW) and 2017-18 enterprise types in the Stage 1 area.*

Figure 16 provides a breakdown of farm enterprise types in the Sheffield Scheme area during 2017-18. The figure shows Sheep, Beef/Dairy grazing is the dominant land use accounting for 61% of the total scheme area, with Beef/Dairy grazing accounting for a further 17%. Figure 17 shows the spatial distribution of farm enterprise types in the Sheffield Scheme area. Figure 18 compares baseline (i.e. pre-CPW) and 2017-18 land use in the Sheffield Scheme area, again showing relatively limited changes in land use following commencement of CPW operations.

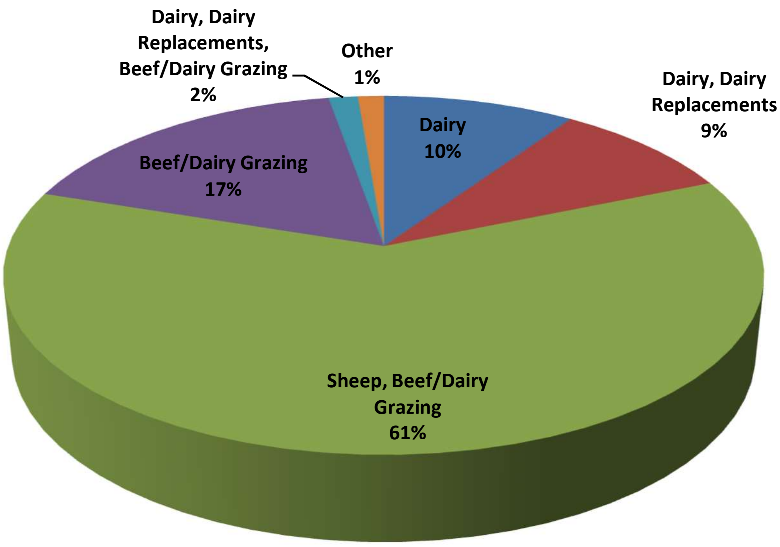

Figure 16. *Land use types in CPW Sheffield Scheme area, 2017-18*

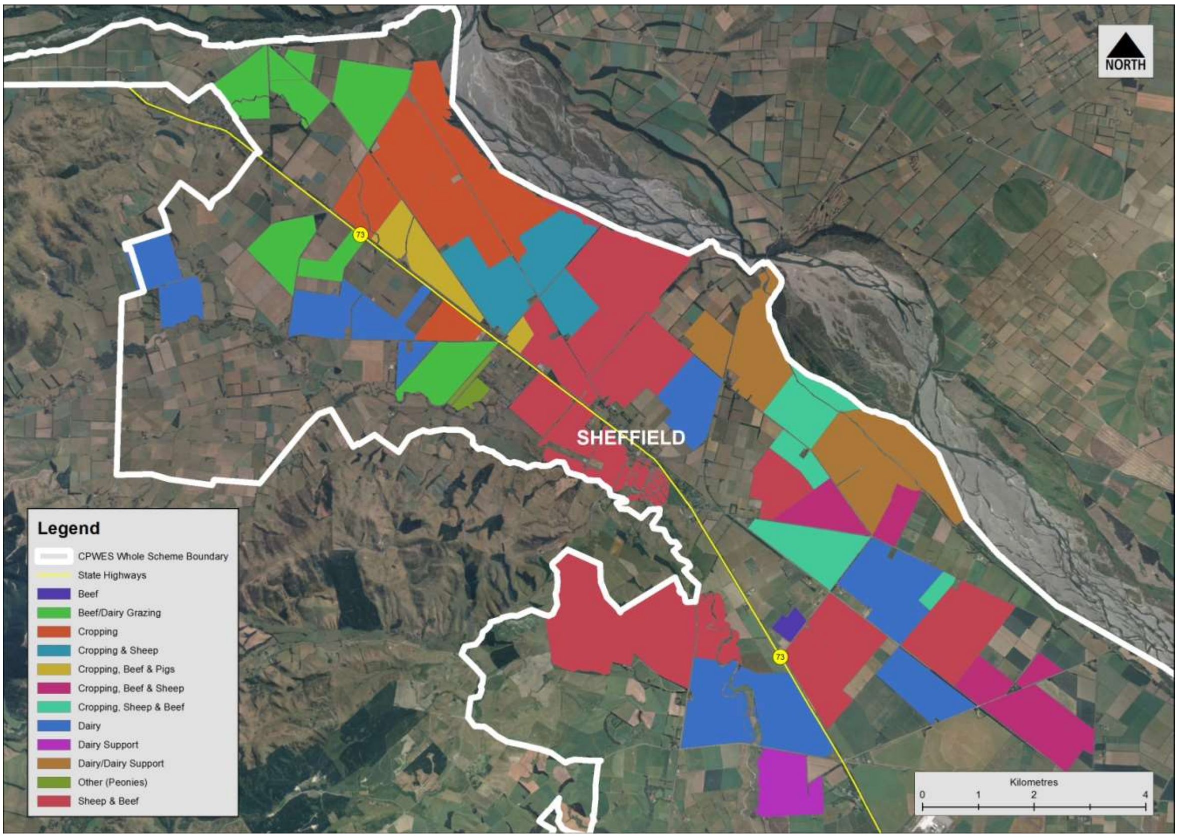

Figure 17. *Spatial distribution of land use types in CPW Sheffield Scheme area, 2017-18*

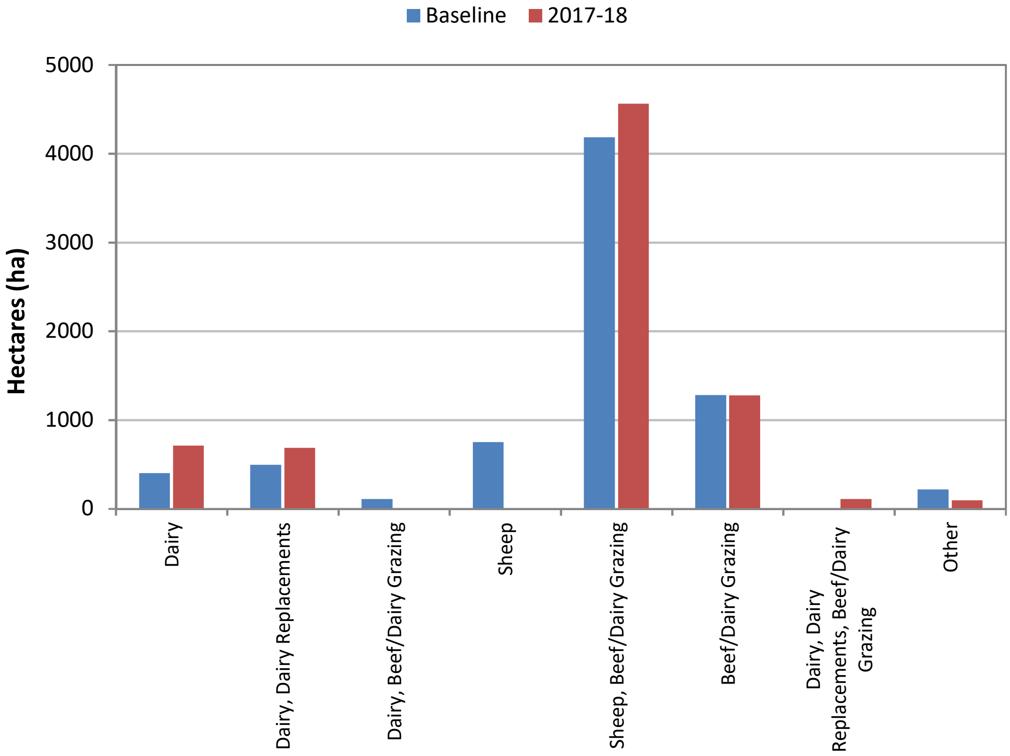

Figure 18. *Comparison of baseline (i.e. pre-CPW) and 2017-18 farm enterprise types in the CPW Sheffield Scheme area.*

3.4. Irrigation Water Use

The Scheme-wide average maximum application rate during the 2017-18 season was 2.42 mm/ha/day. As illustrated on Figure 19, no individual property exceeded a combined irrigation application rate (including CPW water and groundwater) of 5.18 mm/ha/day, which is the maximum limit specified in CPWs consent to take and use both Scheme water and groundwater[3].

Cumulative water use (across the CPW Stage 1 and Sheffield Scheme areas) area during the 2017-18 season totalled 4,518 m^3/ha (equivalent to a seasonal application depth of 451 mm), comprising 1,428 m^3/ha of groundwater and 3,090 m^3/ha of CPW water. Equivalent figures from the 2016-17 season were a scheme-wide seasonal application rate of 4,044 m^3/ha, comprising 1,245 m^3/ha groundwater and 2,798 m^3/ha CPW water. Irrigators who used CPW water only used an average of 2,486 m^3/ha during the 2017-18 season.

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

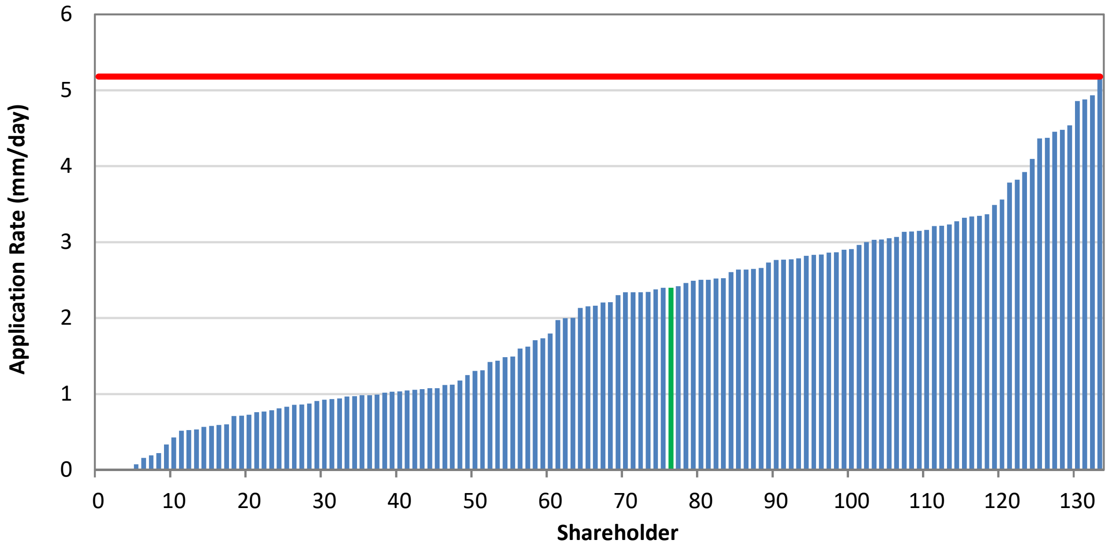

Figure 19. *Combined maximum daily groundwater and CPW irrigation application rate*

3.4.1. Groundwater Conversion to CPW Scheme

One of the key benefits associated with the Scheme identified in the Selwyn 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 the Rakaia, Waimakariri and Kowai Rivers (run-of-river and storage). The reduction in groundwater abstraction is 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-Selywn and Selwyn-Waimakariri allocation zones is identified in the Selwyn-Waihora Zone ZIP Addendum.

Figure 20 shows the percentage of total groundwater allocation utilised by farms in the Stage 1 and Sheffield Scheme areas between 2015-16 and 2017-18. The data show groundwater use in Stage 1 declined from 21.4% of total allocation in 2015-16 to less than 20% over the past two seasons. Cumulative groundwater use on properties in the Sheffield Scheme area was 24.4% of total allocation during 2017-18 and is expected to drop below 20% in future years (particularly given the delayed start to CPW operations during the 2017-18 season).

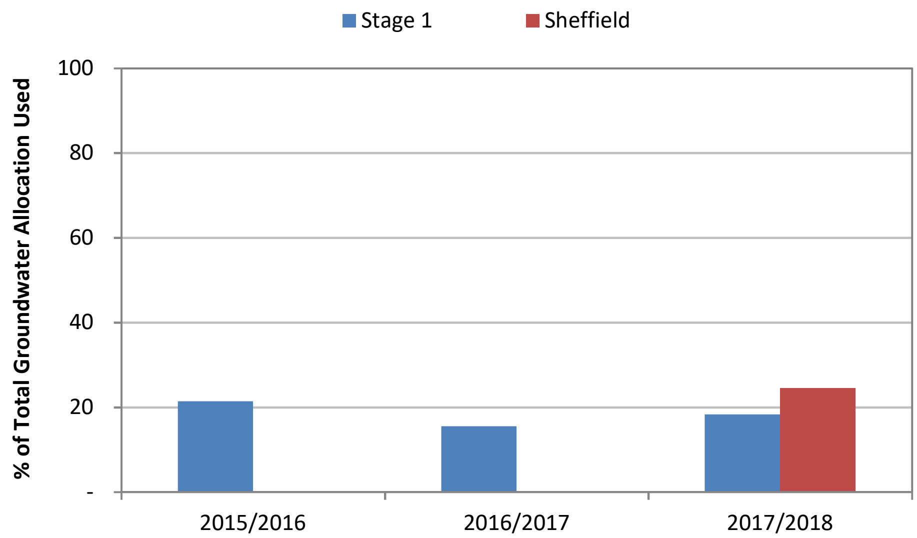

Figure 20. *Percentage of total groundwater allocation used by farms in the Stage 1 and Sheffield Scheme areas, 2015-16 to 2017-18*

Figure 21 provides a comparison of actual and consented groundwater use on properties within the Stage 1 area which hold existing groundwater abstraction consents. The figure shows that approximately 20 percent of properties holding existing groundwater consents used no groundwater during the 2017-18 (i.e. irrigation water was derived solely from the CPW Scheme). Across a majority of the remaining properties, groundwater usage was significantly below consented volumes, with cumulative usage less than 20% of the total volume allocated.

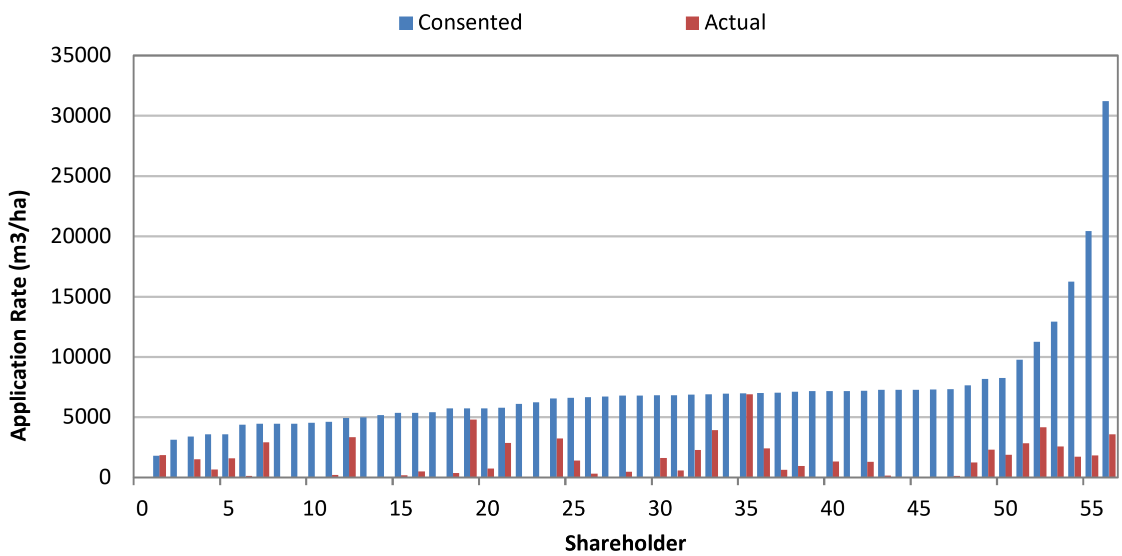

Figure 21. *Comparison of consented and actual groundwater use within the CPW Stage 1 area, 2017-18.*

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 a 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 all irrigators were required to have an FEP in place before they are able to take water from the Scheme. Following recent changes to the LWRP, these FEPs now form a key component of the overall environmental compliance requirements for the CPW Scheme. The FEP must be updated if anything on-farm changes e.g. a farm system or manager.

3.5.1. Stage 1 FEP Compliance Status

During the 2017-18 year a total of 106 FEPs were in place covering all properties located in the CPW Stage 1 area. Over this period an independent audit of all FEPs for properties in the Scheme was undertaken, in accordance with the standardised methodology developed by Environment Canterbury[4]. Each FEP was graded according to specified criteria from A (all objectives met) to D (objectives for one or more management areas not met). Of the FEPs audited during 2017-18, 56 received an A grade, 46 a B grade and 4 a C grade. No FEPs received a D grade. Of the properties receiving a C grade, two did not meet effluent management objectives, one due to a lack of records (associated with a farm sale process) and one due to wet areas identified on the farm.

Figure 22 shows a breakdown of the FEP audit grades by enterprise type. The figure shows dairy enterprises received the highest percentage of A grades (approximately 60% of plans audited). Properties receiving C grades were split between dairy, dairy support and other enterprise types.

Figure 23 compares audit grades received for CPW Stage 1 properties in the 2016-17 and 2017-18 seasons. The figure shows an overall improvement in FEP grades with fewer properties receiving C or D grades and more properties receiving A grades.

[4] http://files.ecan.govt.nz/public/pc5/MGM_Technical_Reports/Canterbury_FEP_Audit_Manual_Feb_2016.pdf

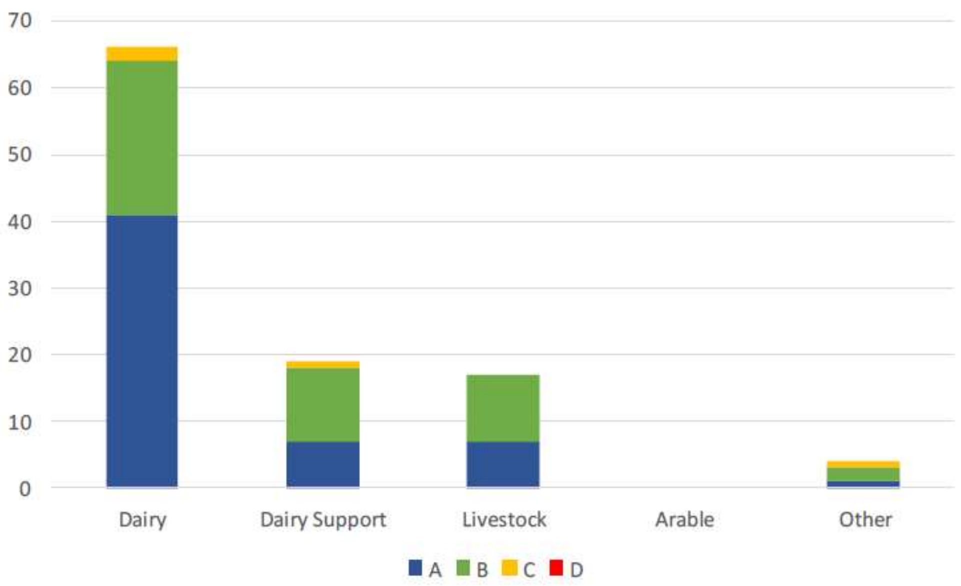

Figure 22. *Breakdown of FEP audit grades by enterprise type for the CPW Stage 1 area 2017-18*

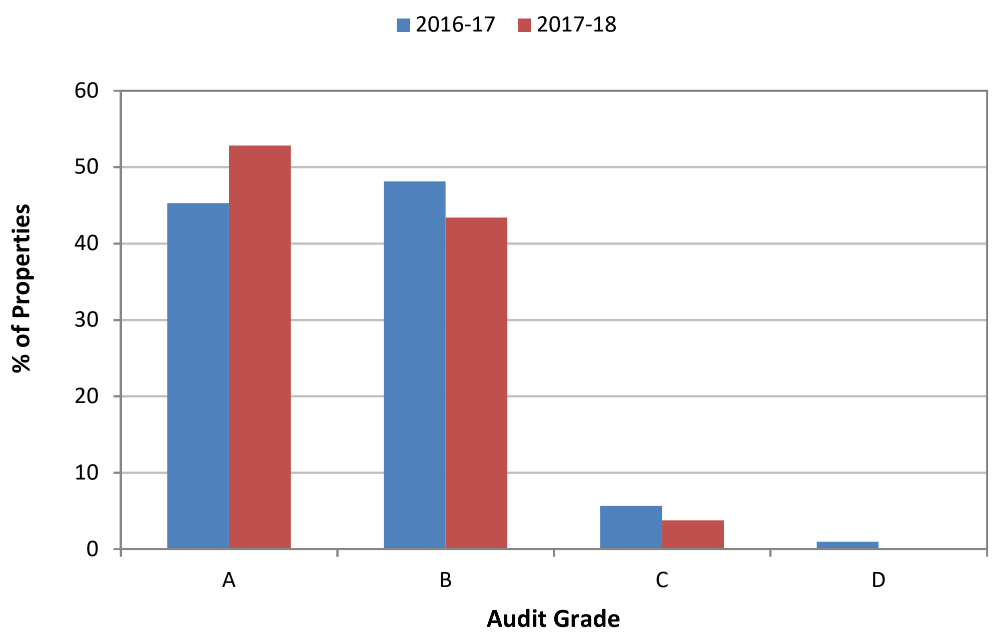

Figure 23. *Comparison of FEP audit grades for CPW Stage 1 properties, 2016-17 and 2017-18 enterprise type for the CPW Stage 1 area 2017-18*

From the 2017-18 FEP audits, key areas identified to continue improvements in audit gradings in future seasons include:

- Irrigation distribution uniformity and application depth testing
- Maintenance and record keeping
- Soil moisture monitoring

- Nutrient loss planning to achieve require reductions by 2022; and
- Maintenance of up-to-date nutrient budgets

No FEP audits were conducted for properties in the Sheffield Scheme during the 2017-18 year. These plans were in development and will be in place and audited during the 2018-19 irrigation season.

3.5.2. Nutrient Budgets and Nitrogen Allocation

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 (7% of the total under Overseer® version 6.1.3) has been allocated to CPW to provide for the conversion of dryland into irrigated land. This allocation is in addition to the assessed dryland nitrogen baseline of 621 tonnes (Overseer® 6.1.3), giving a total of N-loss limit for the CPW scheme of 979 tonnes (Overseer® 6.1.3), as specified in Table 11(j) of the LWRP. Under Overseer® version 6.2.3 this is equivalent to 1,755.8 tonnes N/year.

Nutrient Budgets and FEPs have been prepared for all Stage 1 and Sheffield properties. Comparison of N-losses with LWRP limits is complicated by changes in the definition of Good Management Practices (GMPs) for the Selwyn Te Waihora Zone and the change in the versions of Overseer®. Calculated cumulative nutrient losses from the Stage 1 area for existing and new irrigators during the baseline period was 1,643 tonnes N/year in Overseer® version 6.2.3. In 2017-18 estimates losses were 1,514 tonnes N/year in Overseer® version 6.2.3, an 8% reduction in N leaching (with the addition of approximately 7,000 hectares of new irrigation).

All the Stage 1 nutrient budgets need to be updated to the newly approved GMPs. This work has commenced and will be completed over the next year. Under the current version of Overseer®, 13 properties within Stage 1 converted to irrigation within their dryland baseline. The revised GMPs may see these properties requiring a nitrogen allocation. The Sheffield Scheme Nitrogen Discharge Allowance (NDA) in 2017-2018 was 344 tonnes N/year compared to a baseline of 287 T N/yr. Over both Stage 1 and Sheffield for the 2017-2018 irrigation season 9,382 hectares was provided a NDA.

3.6. On-Farm Training

CPW provides ongoing training and assistance to shareholders with regard to a range of irrigation and environmental management issues, including development and implementation of FEP requirements. Additional training is also being provided in terms of irrigation management and FEPs on an ongoing basis via a series of workshops for all users within the Scheme area (including Stage 1, Stage 2 and Sheffield).

4. Environmental Monitoring

Requirements for extensive monitoring of environmental effects resulting from operation of the Scheme are specified in resource consent conditions for the take and use of water. Details of this monitoring programme are outlined in a Ground and Surface Water Monitoring Plan (GSWMP)[5] which consists of two parts:

- Part I: an outline of the CPW monitoring programme (e.g. monitoring sites, parameters measured, monitoring frequency etc.); and
- 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 the *Annual Ground and Surface Water Monitoring Report*[6] (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 the 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 relating to ground and surface water quality and quantity, land drainage and cultural values.

4.1. Environmental Baseline

Development and ongoing operation of the Scheme is anticipated to result in changes to existing 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 receiving environments (groundwater, rivers and streams, and Te Waihora/Lake Ellesmere).

In terms of water quantity, increased recharge from irrigation using water from alpine rivers, coupled with a reduction in the volume of groundwater used for irrigation and targeted stream augmentation, are expected 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 can also result in higher water tables around the margins of Te Waihora.

Groundwater flowing through the Central Plains aquifer system is ultimately discharged to lowland rivers and streams around the margins of Te Waihora/Lake Ellesmere 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 takes significant time for water recharged on the Central Plains area to drain to Te Waihora/Lake Ellesmere. These variable time lags complicate

[5] http://www.cpwl.co.nz/environmental-management/ground-surface-water-monitoring-programme

[6] http://www.cpwl.co.nz/environmental-management/environmental-reports

interpretation of water level, flow and quality monitoring results, particularly when the period of historical information available is short, and these measures can also be influenced by factors external to the scheme (such as non-CPW land use).

Interpretation of monitoring results is also complicated by climate variability. For example, the increased rainfall occurring during the 2017-18 year contrasts with significantly below average rainfall during the 2014-15 and 2015-16 seasons. Consequent temporal variations in groundwater recharge and surface water flows can result in short-term effects that obscure longer-term underlying trends in groundwater levels, groundwater quality, streamflow and surface water quality.

Given the Scheme has recently commenced operations in an area with an extensive history of agricultural development, the existing state of water quality and quantity differs significantly from its 'natural' state. As a consequence, environmental effects arising from the Scheme are assessed in terms of the pre-Scheme baseline (i.e. the state of water quality and quantity in the absence of the Scheme). In order 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[7]. In addition, conditions of consents operated by CPW also required monitoring of groundwater and surface water quantity and quality 2 years prior to individual Scheme stages becoming operational.

4.2. Environmental Monitoring Programme

Full details of the CPW environmental monitoring programme are outlined in Part 1 of CPW's Ground and Surface Water Monitoring Plan (available at http://www.cpwl.co.nz/environmental-management/ground-surface-water-monitoring-programme)

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; and
4. 12 groundwater level monitoring sites.

As illustrated on Figure 13, 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 stockwater race system at the downstream boundary of the Scheme

[7] http://www.cpwl.co.nz/environmental-management/ground-surface-water-monitoring-programme

Surface water quality sites are monitored on a monthly basis 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.

The monitoring network also includes 5 sites located in Lake Ellesmere/Te Waihora (4 around the lake margins and one mid-lake site). These sites are monitored on a monthly basis by ECan for a range of parameters including total nutrients and Trophic Level Index (TLI_3).

As shown on Figure 25, 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), as well as 12 lowland groundwater level sites downstream of the scheme area that are monitored as part of the ECan State of the Environment groundwater monitoring network. Groundwater quality sites are sampled quarterly, while groundwater levels are measured monthly.

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. This aspect of construction is important with regard to interpretation of monitoring results as contaminants associated with overlying land use are typically concentrated near the water table, reducing in concentration with depth (in contrast typical water supply bores are screened at some depth below the water table). Collection of samples from close to the water table therefore provides a conservative (or ‘worst case’) assessment of groundwater quality at any given location.

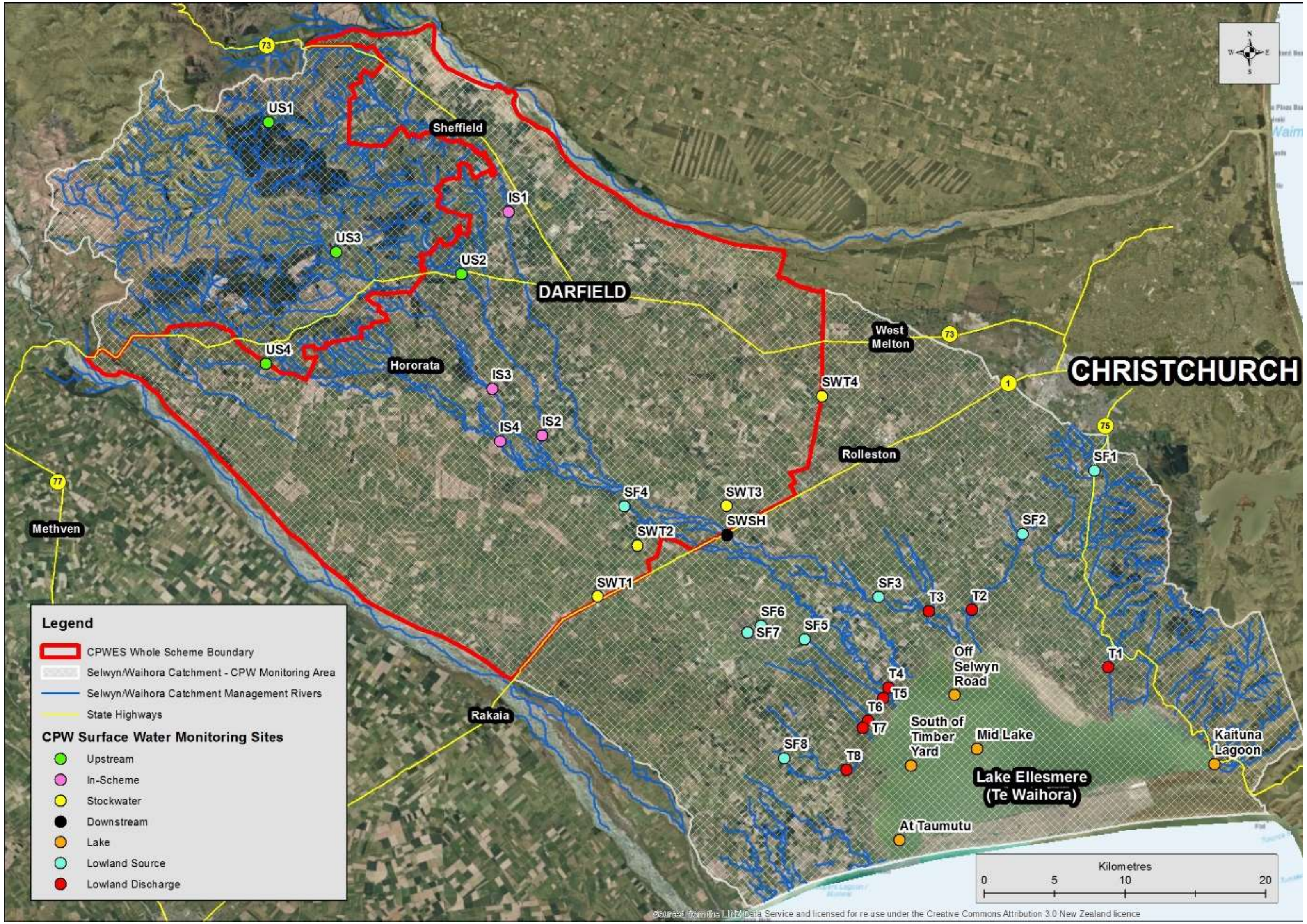

Figure 24. Surface water quality monitoring sites for the CPW scheme

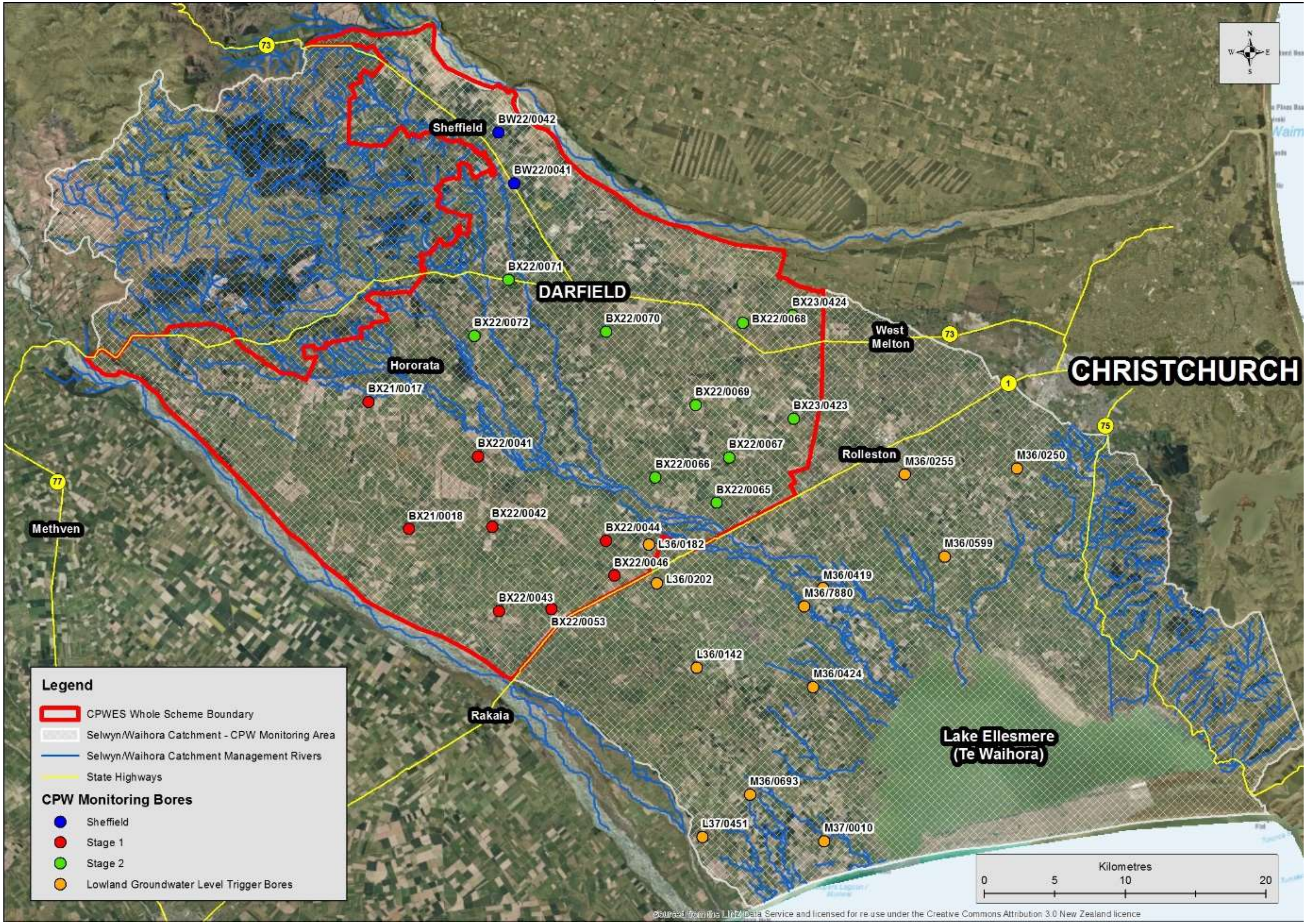

Figure 25. Groundwater quality and level monitoring sites for the CPW scheme

4.3. Environmental Management

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

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

The nominated trigger levels were established 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 or levels 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. 2017-18 Monitoring Results

Results from the CPW environmental monitoring programme are summarised in the *Annual Ground and Surface Water Monitoring Report 2017/18* which was reviewed and approved by GSWERP in November 2018.

As discussed in Section 2 above, climate conditions experienced during and immediately preceding the 2017-18 year were in contrast to those experienced over previous years since environmental monitoring for the Scheme commenced in the Stage 1 area in 2013. This variability is observed to have had a significant influence on surface water quality, groundwater quality and groundwater level monitoring results during the 2017/18 year in many parts of the Scheme, including areas within Stage 2 where operations did not commence until October 2018.

4.4.1. Surface Water Quality

Trigger levels for CPW surface water quality monitoring are summarised in Table 1 below. These triggers are equivalent to limits for surface water quality established in the LWRP. It is noted the trigger levels differentiate between hill-fed streams (i.e. 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 1. *Surface water quality triggers for Nitrate-Nitrogen (mg/L)*

River Type	CPWL Surface Water Monitoring	
	Annual Median	**Annual 95th Percentile**
Hill-fed Lower	1.8	2.6
Spring-fed Plains	5.2	7.4

Table 2 summarises trigger level exceedances for nitrate-nitrogen concentrations at CPW monitoring sites during the 2016-17 and 2017-18 years. The data show both the median and 95th percentile triggers were exceeded at 9 sites (2016-17, 6 sites), while two sites exceeded the 95th percentile trigger only (2016-17, 1 site) and no sites exceeded the median trigger only (2016-17, 2 sites).

Table 2. *Summary of surface water quality trigger level exceedances for CPW sites, 2016-17 and 2017-18*

River Type	Year	Sites	Samples*	Sites exceeding annual Nitrate median	Sites exceeding annual 95th percentile
Hill-fed Lower	2017-18	9	93	3	4
	2016-17	9	71	2	1
Spring-fed Plains	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

During the 2017-18 year surface water nitrate trigger level exceedances were recorded in six waterways including the Hawkins River, Waianiwaniwa River, Selwyn River, Hamner Road Drain, Boggy Creek and Harts Creek at the locations shown on Figure 26. While a majority of sites exceeding the trigger levels were located in spring-fed streams around the margins of Te Waihora/Lake Ellesmere, sites in the Hawkins River and Waianiwaniwa River within the Stage 2 area (i.e. where CPW operations had not commenced) also exceeded the trigger values. While trigger level exceedances in upstream and downstream sites in the Selwyn River and the Hamner Road Drain in 2016-17 were not repeated in 2017-18 year, other sites in the Hororata River, Doyleston Drain (upstream and downstream) and Boggy Creek (downstream) exceeded triggers during 2017-18.

It is noted that historical nitrate concentrations that would have exceeded CPW triggers were identified at sites in the Hawkins River, Selwyn River, Boggy Creek and Harts Creek in the GSWERP baseline water quality report. As illustrated in the examples from Boggy 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-dates Scheme operations. It is noted that both of the sites illustrated showing different temporal trends during 2017-18, with nitrate concentrations increasing significantly in Boggy Creek while declining in the Selwyn River. These differences may relate to the above average recharge and river flow conditions occurring during the 2017-18 year.

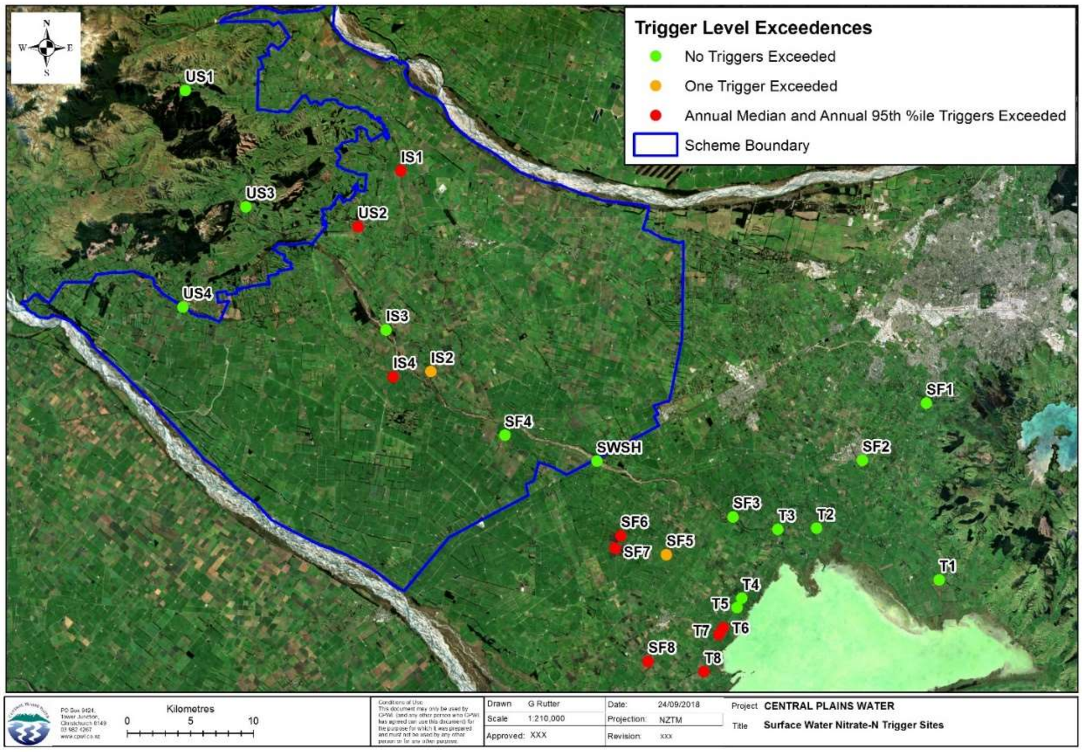

Figure 26. *Surface water nitrate trigger level exceedances during 2017-18*

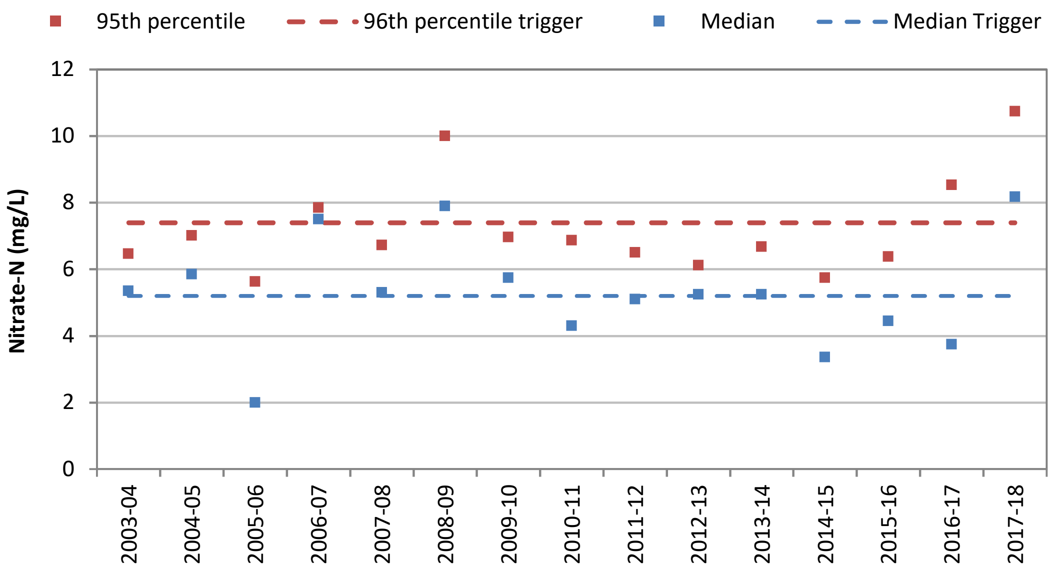

Figure 27. *Annual median and 95th percentile nitrate-nitrogen concentrations in Boggy Creek, 2003-04 to 2017-18*

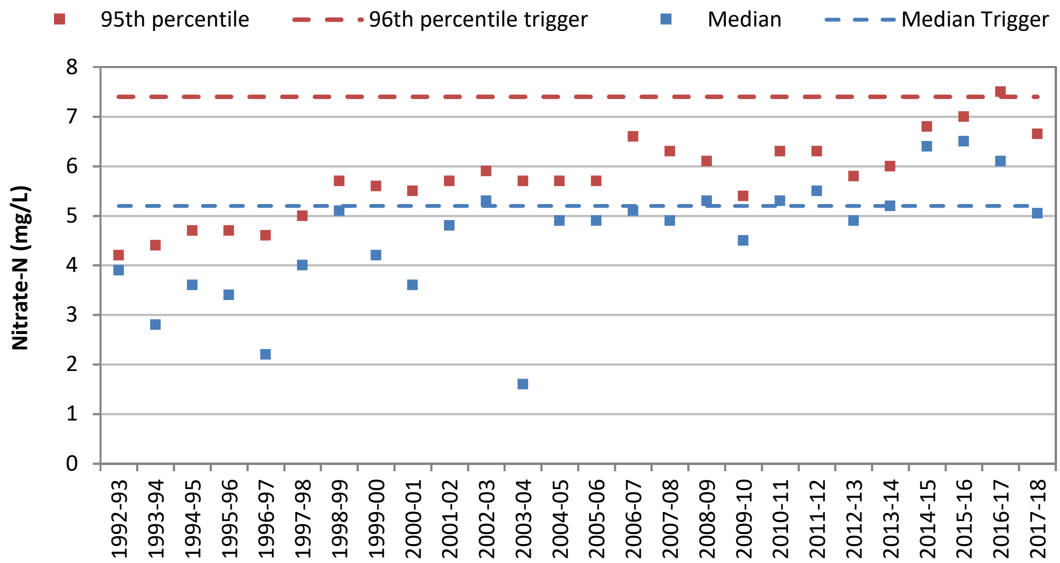

Figure 28. *Annual median and 95th percentile nitrate-nitrogen concentrations in the CPW Selwyn River downstream monitoring site (Coes Ford), 1992-93 to 2017-18*

Overall, although surface water triggers were exceeded at a number of sites in the CPW monitoring network during the 2017-18 year, observed concentrations are generally consistent with the historical baseline (either the observed range or historical trends). As a consequence, monitoring data collected to date does not show any discernible effects of the Scheme on surface water quality either within, or down-gradient, of the Scheme area. Monitoring results during the 2017-18 year are also likely to be influenced by the greater rainfall during 2017-18 and associated effects on groundwater recharge and river flows.

4.4.2. Lake Water Quality

The trigger levels for Lake Water Quality are listed in Table 2. The trigger levels are equivalent to water quality limits contained in Table (I) of the LWRP.

Table 3. 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.

For the mid-lake monitoring site, data collected during the 2017-18 year showed the annual average Total Phosphorus value of 0.19 mg/L exceeded the trigger value of 0.1 mg/L. However, as illustrated on Figure 29, the average Total Phosphorus concentration recorded at this site during 2017-18 was slightly below the long-term average, and significantly below the maximum values recorded at this site in previous years.

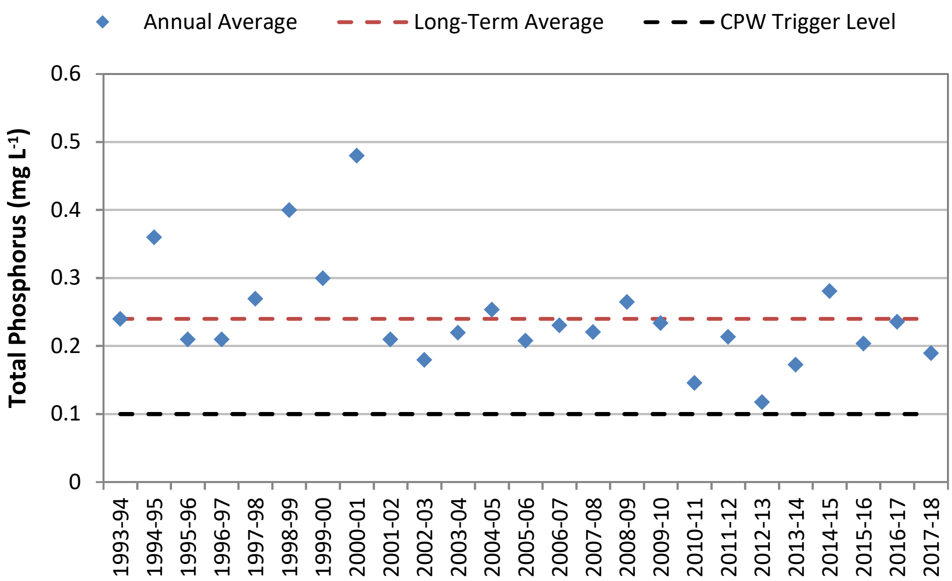

Figure 29. *Annual mean Total Phosphorus at the Lake Ellesmere/Te Waihora mid-lake monitoring site, 1993-94 to 2017-18*

The Trophic Level Index (TLI_3) is an indicator of lake water quality specifically developed for New Zealand lakes. The TLI_3 is derived from a number of water quality measures including total nitrogen, total phosphorus and chlorophyll *a* (found in algae). Triggers for TLI_3 were exceeded at all lake water monitoring sites during the 2017-18 year. However, again recorded TLI_3 values were close to the long-term average for these sites, and well below maximum recorded values, with no discernible influence that can be associated with operation of the CPW Scheme.

4.4.3. Groundwater Quality

Trigger levels for CPW groundwater monitoring are summarised in Table 3 below. It is noted that these triggers are equivalent to the limits for groundwater quality in the Selwyn-Waihora zone established in the LWRP.

Table 4. 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 groundwater level

(b) Measured over the length of record

Due to the limited period over which the CPW monitoring programme has been established, Nitrate-Nitrogen monitoring results from the CPW monitoring programme cannot be directly compared to the trigger level established in the GSWMP (based on a 5-year annual average concentration). However, as shown on Figure 30 below, comparing annual mean Nitrate-Nitrogen concentrations for individual monitoring sites against the trigger level shows concentrations exceeded 7.65 mg/L in:

- 5 of the 8 monitoring sites in the Stage 1 area; and
- 8 of the 10 sites in the Stage 2 area

No monitoring sites in the Sheffield Scheme area exceeded the groundwater nitrate trigger.

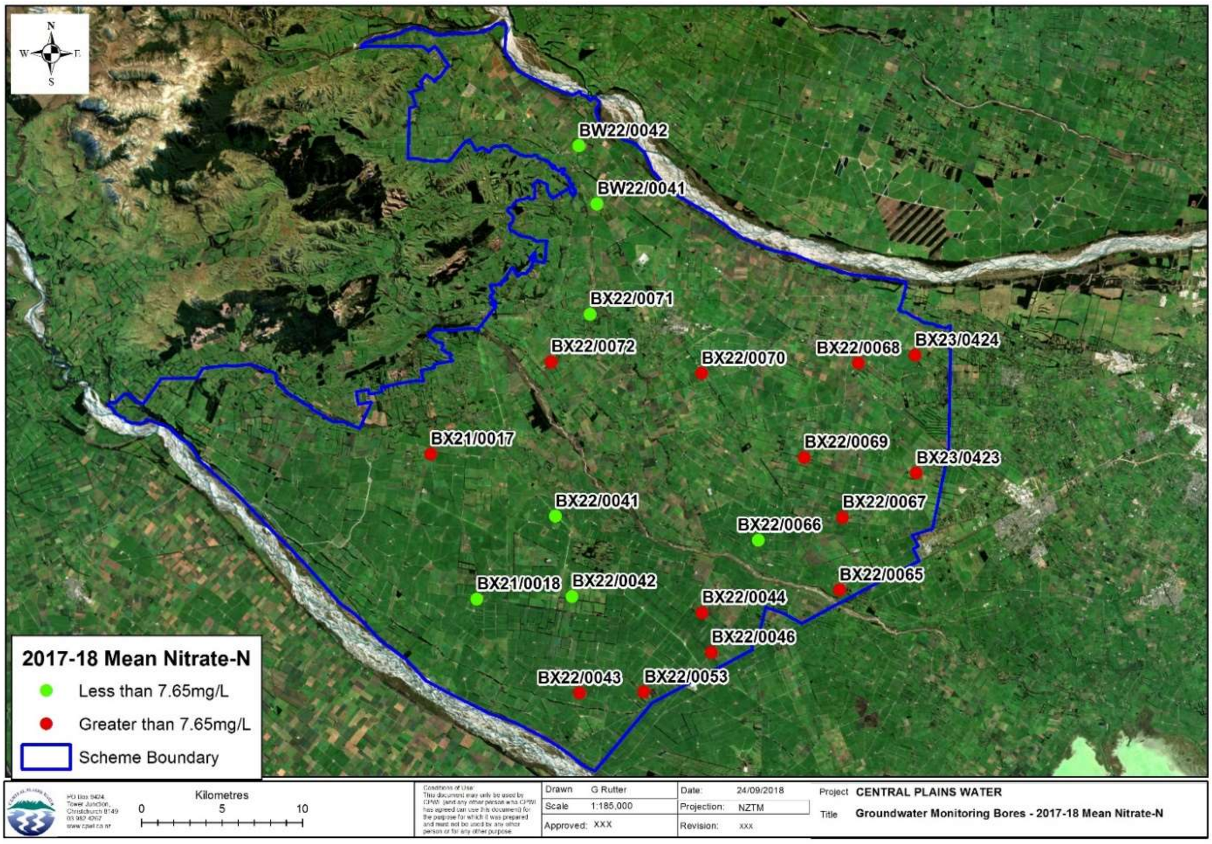

Figure 30. *Mean annual groundwater nitrate concentrations across the CPW Scheme area 2017-18*

Of particular note during the 2017-18 year was a significant increase in nitrate concentrations in many groundwater monitoring sites following heavy rainfall during the 2017 winter. As illustrated on Figure 31 below, nitrate concentrations in several (although not all) monitoring bores in the Stage 1 area exhibited a marked increase in nitrate concentrations in the September 2017 sample round, with several sites exhibiting the highest concentrations recorded to date. Similar variations were observed in data from the Sheffield Scheme area and in Stage 2 (where CPW operations had yet to commence).

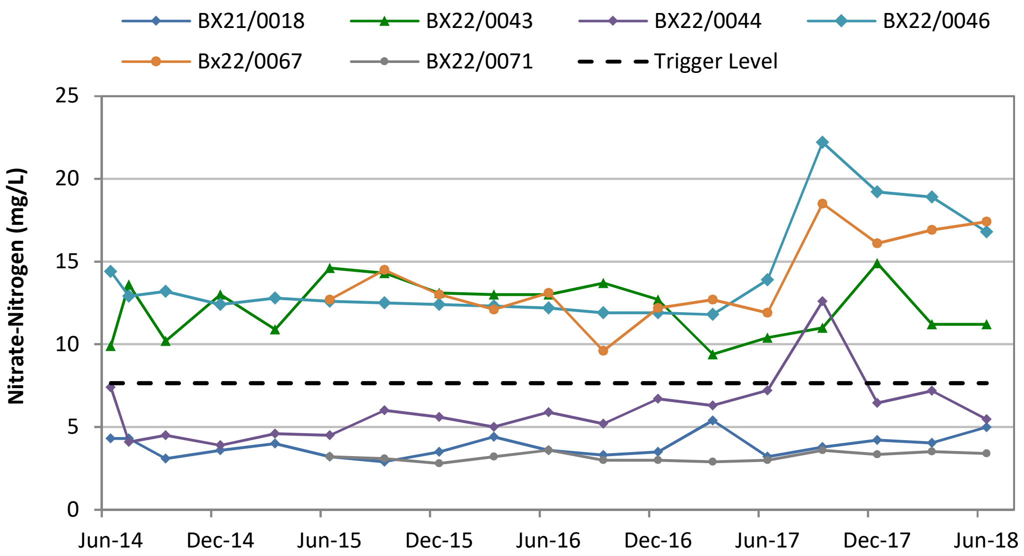

Figure 31. *Groundwater nitrate concentrations across the CPW Scheme area 2017-18*

The abrupt increase in nitrate concentrations in September 2017 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. As illustrated in Figure 32, monitoring data collected by ECan elsewhere in the Central Plains (outside of the CPW scheme area) exhibit a similar relationship with groundwater levels with large increases in groundwater levels (associated with significant recharge events) corresponding to significant increases in groundwater nitrate concentrations.

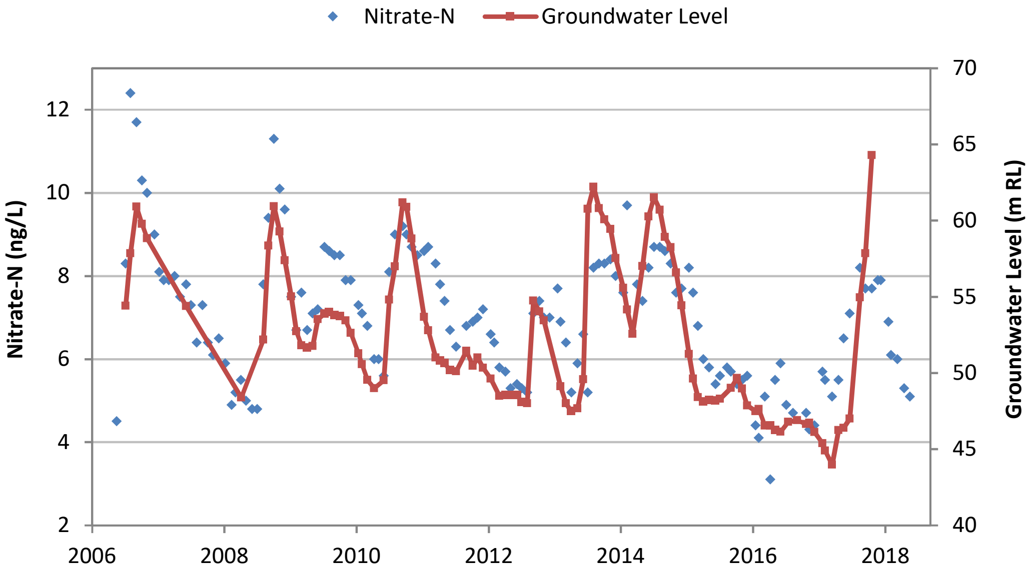

Figure 32. *Temporal variation in groundwater level and nitrate concentrations in M36/4126 near Rolleston (monitored by ECan), 2006 to 2018.*

The monitoring data indicate that baseline nitrate concentrations exceeding trigger levels were widespread across the Central Plains area both within the Stage 1 area as well as in the Sheffield Scheme and Stage 2 area (where CPW irrigation is yet to commence) during 2017-18. Temporal variations in nitrate concentrations, particularly in the long-screen CPW monitoring bores which sample immediately below the water table appear to be influenced by large recharge events (such as during winter 2017) which 'flush' nitrogen from the soil and underlying unsaturated zone to the underlying water table.

Overall, the 2017-18 groundwater quality data indicate groundwater nitrate concentrations are elevated in many areas of the Central Plains as a result of land use pre-dating operation of the Scheme. This observation is 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 between 2010 and 2013 exhibited nitrate concentrations in excess of the nominated trigger value, with approximately 40 percent of wells exhibiting statistically significant increasing trends in nitrate concentrations.

CPW groundwater monitoring also detected the intermittent presence of low levels of indicator bacteria in a number of monitoring wells sampled across the monitoring network. Rates of detection in the Stage 1 area were similar to those observed prior in baseline monitoring prior to Scheme operation (i.e. low level in between 10 to 15% of samples analysed). Positive detections of *E. Coli* were determined in approximately 25% of samples collected in the Stage 2 area (where CPW is yet to commence operations). No clear relationships were observed between surrounding land use or rainfall events and positive detections of indicator bacteria in CPW monitoring bores, although the relatively high frequency of detection may in part relate to the sampling methodology used (i.e. samples collected from the top of the water table in long-screen monitoring bores).

4.4.4. Groundwater Levels

Trigger levels for lowland groundwater levels are set at the 95th percentile of the (at least 40 year) historical record from individual monitoring sites[8]. During the 2017-18 year, groundwater level trigger exceedances were recorded in 5 of the 12 monitoring bores in the area down gradient of the CPW scheme area (Figure 33). As illustrated on Figure 34, these trigger level exceedances followed heavy rainfall during the 2017 winter and were of a similar magnitude to those occurring during previous wet winters (e.g. 2013 and 2014).

CPWL did not receive any complaints concerning elevated groundwater levels, or impacts on land drainage or on-site wastewater systems in the Lowland Plains area during the 2017-18 year.

[8] Denoted by orange dots on Figure 25 above

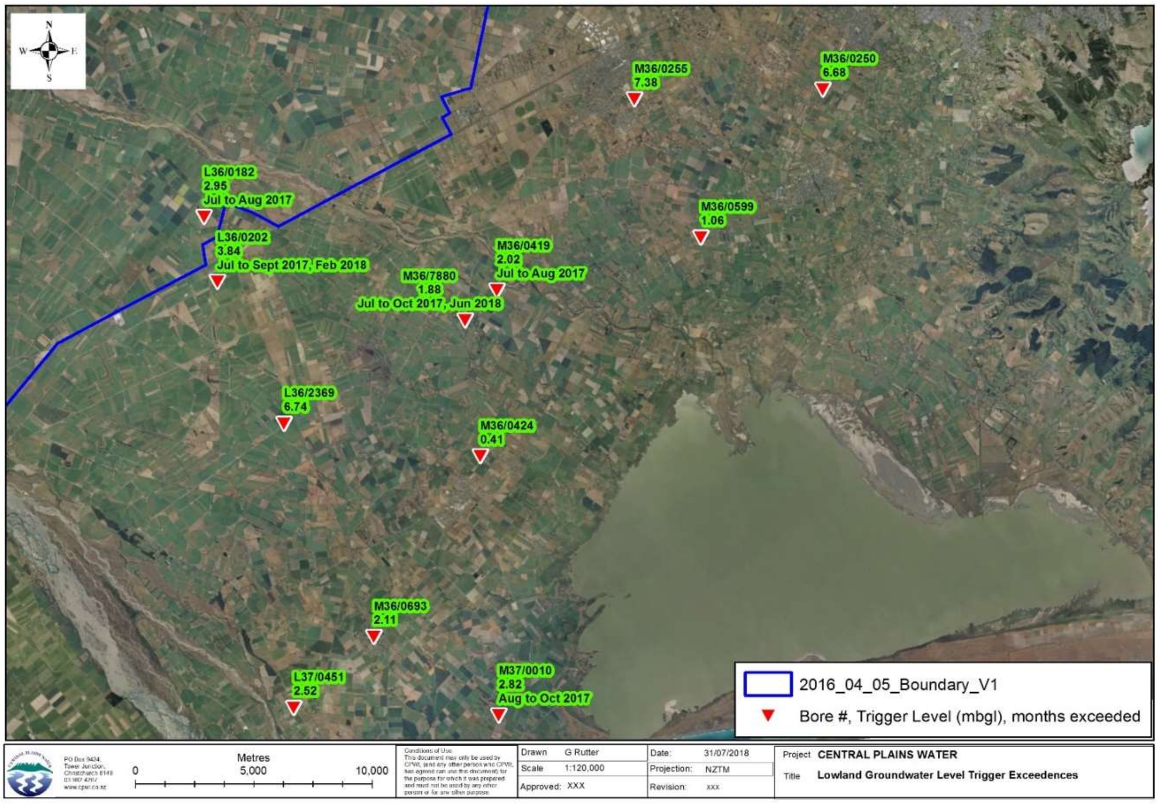

Figure 33. *Lowland groundwater levels monitoring sites and trigger level exceedances 2017-18*

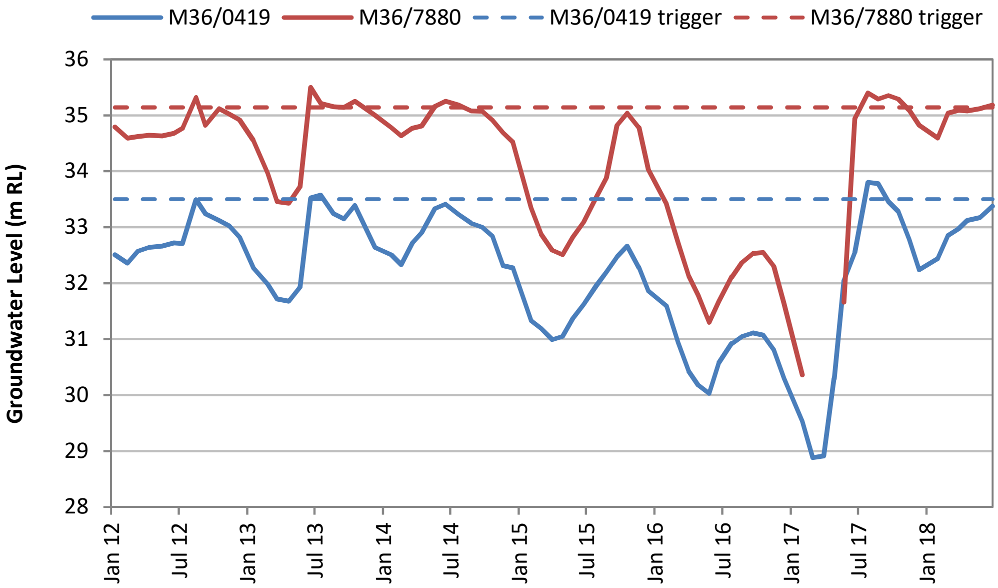

Figure 34. *Groundwater levels (and respective trigger levels) recorded in M36/0419 and M36/7880, 2012 to 2018*

4.4.5. Summary

Water quality monitoring results recorded in the CPW monitoring network during the 2017-18 year indicate surface water quality, groundwater quality and lake water quality exceeded trigger levels established in Part II of the CPW GSWMP[9] at a number of monitoring sites located both in Stage 1 and the Sheffield and Stage 2 areas of the scheme. Trigger level exceedances at many monitoring sites followed an extended period of high rainfall during the 2017 winter that resulted in significant groundwater recharge and maintained high flows in surface waterways. These short-term climate-related effects tend to obscure underlying background trends in water quality. The above average rainfall during the 2017-18 year also resulted in exceedances of lowland groundwater level triggers of similar magnitude and duration to those observed following previous wet winters.

The *Annual Ground and Surface Water Monitoring Report 2017/18* produced by CPW was approved by the GSWERP in November 2018 as providing a valid interpretation of monitoring results for the 2017-18 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 2017-18 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 Hearings process involved the establishment an Environmental Management Fund (EMF) and a Te Waihora Environmental Management Fund (TWEMF).

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 will increase as the area under irrigation increases. 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. By contrast, the TWEMF fund is provided directly to Ngai Tahu who manage allocation and annual reporting of fund expenditure.

Since its formation, the EMFC has allocated over $260,000 of funding to groups and individuals within the Selwyn Te Waihora catchment for environmental enhancement projects. 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 EMFC 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 34 shows the location of sites in the Selwyn Waihora catchment where EMF funding was utilised to support environmental enhancement and biodiversity projects during the 2017-18 year.

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

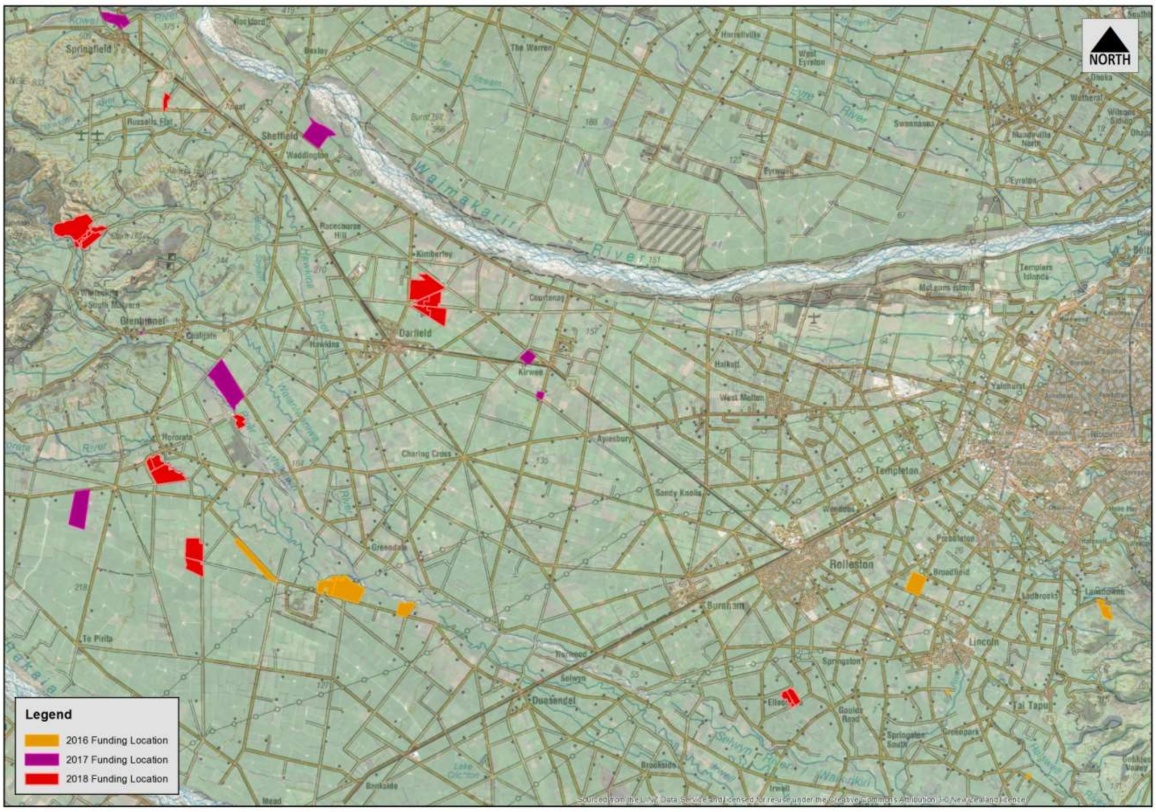

Figure 35. *Location of sites where CPW Environment Management Funds were utilised to support environmental enhancement and biodiversity projects during the 2017-18 year.*

4.5.2. Targeted Stream Augmentation

During the 2016-17 season CPW signed an agreement with ECan to make provision in the CPW Stage 2 infrastructure for a discharge point that will enable up to 3.5 cumecs of water to be released into the Selwyn River at times when the water is not required for irrigation, particularly during the fringes of the season. ECan have secured the land area required for construction of an energy dissipater, wetland soakage area and control system the will join onto the CPW Pipeline. Water will be utilised to augment natural flows in the Selwyn River in a manner that provides significant environmental benefits to the river system, while respecting cultural values associated with the mixing of waters. It is anticipated that targeted stream augmentation utilising CPW water will commence in 2019.