



Central Plains Water Limited

Baseline Water Quality Assessment

Liquid Earth
January 2014

Executive Summary

Central Plains Water Limited (CPWL) are currently in the process of developing an irrigation scheme which will encompass a command area of approximately 60,000 Ha extending between the Waimakariri and Rakaia Rivers, inland of SH1. The suite of consents granted to CPWL includes a range of conditions which require extensive monitoring and assessment of environmental effects associated with the project. This report is intended to provide information relating to 'baseline' groundwater, surface water and lake water quality to assist in the preparation of the Ground and Surface Water Plan and provide context to assist the Ground and Surface Water Expert Review Panel (GSWERP).

Development of the CPWL scheme will result in significant changes to existing land use and water abstraction patterns across the mid to upper sections of the Central Plains area. These changes have the potential to alter water quality in receiving waters, particularly in terms of Nitrate-N concentrations in underlying groundwater. Increases in Nitrate-N concentrations have the potential to result in wells exceeding recommended health guidelines for safe drinking water and, as a significant portion of groundwater flowing through the Central Plains aquifer system is ultimately discharged to lowland rivers and streams in the vicinity of Te Waihora/Lake Ellesmere, also impact on ecological and environmental values associated with these waterways and the lake itself.

Historical groundwater Nitrate-N concentrations recorded on the Environment Canterbury groundwater quality database indicate that:

- Groundwater Nitrate-N concentrations appear to have been elevated in some areas of the Central Plains since at least the 1970s;
- Wells less than 50 metres deep appear to show a relatively consistent increase in median Nitrate-N concentrations from the 1970s to the present day. The largest increases (>4 mg/L) over this period appear to have occurred across the mid-Plains with smaller increases noted in lowland areas;
- Nitrate-N concentrations in many shallow wells (<50 metres) exhibit significant short-term variability in response to land surface recharge flux. Periods of increased recharge due to high rainfall (with an unknown contribution from irrigation) tend to be associated with peaks in Nitrate-N concentrations. In many wells this short-term variability tends to be of a significantly greater magnitude than any underlying long-term trends;
- In deeper wells (>50 metres) the magnitude of changes in Nitrate-N concentrations tend to have been relatively minor prior to 2000 but appear to have accelerated in recent years, particularly across the mid to upper plains.

Analysis of land use scenarios for the CWMS Selwyn Waihora zone limit setting process indicate that even if future land use were to remain unchanged (from 2011), groundwater nitrate concentrations in the Central Plains area will continue to increase by approximately 30% over current levels due to the lag between land use and resulting changes in groundwater quality.

Consent conditions for the CPWL scheme require comparison of measured water quality against a 'baseline' representing its likely state in the absence of the scheme. However, groundwater quality at any point in an aquifer system reflects a complex interaction between a number of factors including land use, recharge flux and the nature of infiltration and flow through the unsaturated and saturated zones respectively so varies spatially, with depth and over time. As a consequence, there is no single measure available to determine 'baseline' groundwater quality. Any quantitative measure of groundwater quality is highly influenced by the location and depth of sample sites utilised which, Combined with inherent short-term variability, may make it difficult to distinguish effects associated with the CPWL scheme from the baseline. However, proposed modelling and management of farm-scale nutrient losses (via nutrient budgets and farm management plans) on properties serviced by CPWL may provide useful quantitative and qualitative data to assist interpretation of observed variation in groundwater quality.

Current water quality in Te Waihora/Lake Ellesmere surface water catchments is characterised by elevated levels of dissolved inorganic nitrogen (DIN), dissolved reactive phosphorus (DRP) and indicator bacteria. These elevated nutrient concentrations are also associated with macrophyte and filamentous algae growth which exceed targets established in the NRRP (and the proposed Land and Water Regional Plan (LWPR)) at many monitoring sites. These factors exert a significant influence on ecological, cultural and environmental values associated with these waterways.

Modelling of land use scenarios indicate that even if land use across the Central Plains were to remain unchanged (from 2011), DIN concentrations in these streams are likely to rise significantly (between 20 to 40 percent over current median concentrations) with a consequent increase in risk to associated ecological, cultural and environmental values.

Current water quality in Te Waihora/Lake Ellesmere is characterised in terms of high nutrient and suspended sediment concentrations, with consequent high phytoplankton (suspended algae) biomass and low clarity. Monitoring of key water quality parameters indicates water quality in the lake has remained relatively stable over the last 20 years with the overall water quality state consistently classified as hypertrophic (e.g. annual average Trophic Level Index (TLI) ~6.8)

Due to the influence of groundwater inputs to tributary streams modelling indicates that the overall total nitrogen (TN) loading to the lake is likely to increase by around 30 percent under current land use due to nutrient loadings already entrained in the groundwater system. Such increases in TN are likely to result in an overall decline in the overall trophic state of the lake with consequent adverse effects on several key indicators including TLI, cyanobacteria, colour and fisheries values.

Table of Contents

Executive Summary	1
1. Introduction	4
1.1. Central Plains Water Limited.....	4
1.2. Project Scope	5
1.3. Baseline Water Quality.....	5
1.4. Report Structure	6
2. Baseline Groundwater Quality	7
2.1. Hydrogeology and geochemistry of the Central Plains area.....	8
2.2. Factors influencing spatial and temporal variation in groundwater quality	10
2.3. Historical groundwater Nitrate-N concentrations	24
2.4. Baseline groundwater Nitrate-N concentrations	41
2.5. Summary	52
3. Baseline Surface Water Quality	54
3.1. Introduction.....	54
3.2. Current Surface Water Quality	56
3.3. Future Baseline Water Quality	71
3.4. Summary	74
4. Baseline Lake Water Quality	75
4.1. Current Water Quality	75
4.2. Biophysical state	82
4.3. Future Baseline Water Quality	85
4.4. Summary	88
5. Cultural Values.....	90
5.1. Overview	90
5.2. Wahi Tapu/Taonga.....	91
5.3. Summary	97
6. Summary.....	99
7. References.....	101
Appendix 1. Wells Exhibiting Nitrate Concentrations Exceeding 11.3 mg/L.....	105

1. Introduction

1.1. Central Plains Water Limited

Central Plains Water Limited (CPWL) are currently in the process of developing an irrigation scheme which will encompass a command area of approximately 60,000 Ha extending between the Waimakariri and Rakaia Rivers, inland of SH1. **Figure 1** shows the approximate extent of the scheme area.

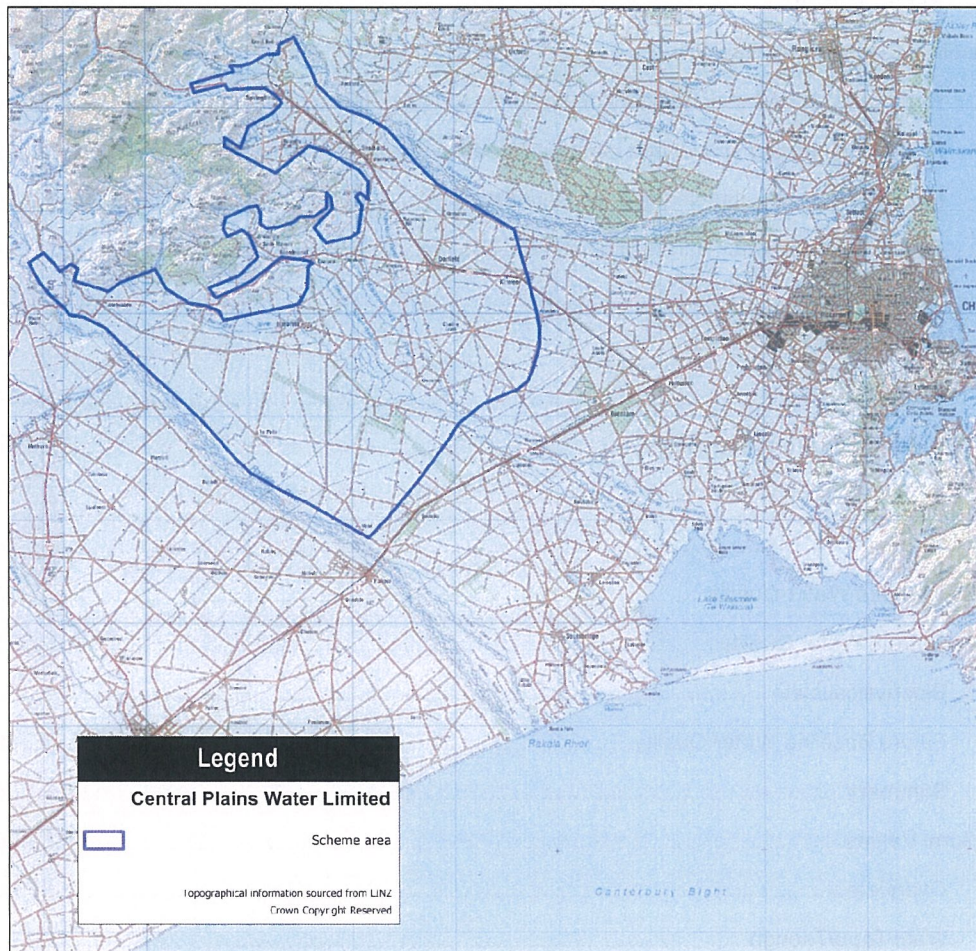


Figure 1. CPWL scheme area

Resource consents for the CPWL scheme were granted by a hearing panel appointed by Environment Canterbury and the Selwyn District Council in May 2010. The suite of consents granted to CPWL includes a range of conditions which require extensive monitoring and assessment of environmental effects associated with the project.

This report is intended to provide information relating to 'baseline' groundwater, surface water and lake water quality to assist in the preparation of the Ground and Surface Water Monitoring Plan required to be prepared by CPWL under Condition 21.

1.2. Project Scope

The primary objective of this report is to provide technical background to inform the Ground and Surface Water Expert Review Panel (GSWERP) and assist development of the Ground and Surface Water Plan. The scope of the report included assessment of:

- Historical nutrient levels;
- Baseline water quality for groundwater;
- Baseline water quality for surface water;
- Baseline water quality and biophysical state of Te Waihora/Lake Ellesmere
- An overview of cultural values that have been established in relation to water quantity and water quality.

The report draws on information from a variety of sources including:

- Assessment of groundwater quality data included on the Environment Canterbury groundwater quality database;
- Published technical reports describing the hydrogeology and geochemistry of the Central Plains area;
- Assessments of current and future water quality prepared for the Environment Canterbury Selwyn Waihora zone committee.

1.3. Baseline Water Quality

The CPWL scheme area overlies the Central Plains aquifer system which hosts an extensive groundwater resource which is extensively utilised for stock, domestic, municipal, industrial and irrigation water supply. Recharge to the aquifer system occurs via rainfall infiltration across the surface of the plains and seepage losses from the major river systems. Groundwater flows through the aquifer system in an easterly direction reflecting the overall topographic gradient across the plains toward the coast. Groundwater flowing through the aquifer system is ultimately discharged to lowland streams or via direct seepage to Lake Ellesmere or via relatively minor (but unquantified) discharge the offshore marine environment.

Within the CPWL scheme area, the permeable nature of the soils and underlying alluvial materials mean that the underlying groundwater resource is the ultimate receiving environment for a majority of nutrients and other contaminants lost from land use activities (including discharges to land). Due to the extensive utilisation of the groundwater resource as a water supply source and its contribution to flows in lowland streams around the margins of Lake Ellesmere/Te Waihora, management of groundwater quality is critical to ensure that community values associated with water, articulated in the Canterbury Water Management Strategy (including the Selwyn Waihora Zone Implementation Plan), can be achieved.

In order to quantify the effect of the CPWL scheme on water quality, the consent conditions utilise the concept of 'baseline' water quality. This refers to the current and future state of water quality in the absence of CPWL scheme development with an underlying assumption being that any departure from the water quality baseline is therefore attributable to the effects of scheme development.

For groundwater Nitrate-Nitrogen (Nitrate-N) is utilised in this report as the key indicator of baseline water quality. Although other parameters such as microbial contaminants and dissolved reactive phosphorus (DRP) may be of significant importance for particular uses or receiving environments (e.g. drinking water or stream baseflow), their occurrence in groundwater is either localised or not a major consideration for groundwater or surface water quality effects associated with CPWL scheme development. For example, Hanson *et al.* (2006) reviewed the occurrence of indicator bacteria in wells across Canterbury. The study concluded that although indicator bacteria are detected in between 5 to 16% of wells sampled in any given year, their occurrence is highly variable and in many cases appears to be associated with localised factors such as wellhead protection or location of the well down gradient of a point source (e.g. septic tank). Similarly, although many surface water environments in Canterbury are highly sensitive to phosphorus inputs, available data suggest a majority of the phosphorus loading in groundwater is associated with natural interaction between groundwater and the host aquifer materials rather than losses from land use activities (Hanson and Abraham, 2009).

Nitrate-N in groundwater is typically assessed in terms of the suitability of water for drinking. The Drinking Water Standards for New Zealand (MoH, 2008) specify a maximum acceptable value (MAV) of 11.3 mg/L Nitrate-N in water utilised for potable supply.

For surface water, dissolved inorganic nitrogen (DIN), dissolved reactive phosphorus (DRP) and microbial indicators (*E.coli*) are utilised to characterise existing water quality, with cyanobacteria and various physical indicators also utilised to describe the water quality and biophysical state of Te Waihora/Lake Ellesmere. These parameters affect a range of ecological and environmental values associated with surface waterbodies.

1.4. Report Structure

The report comprises the following sections:

- Section 2 - *Baseline Groundwater Quality*: An assessment spatial, depth and temporal variations in historical, current and future groundwater Nitrate-N concentrations in the Central Plains area.
- Section 3 - *Baseline Surface Water Quality*: An assessment of current and future surface water quality in Lake Ellesmere/Te Waihora catchments.
- Section 4 - *Baseline Lake Water Quality*: An assessment of current and future surface water quality and biophysical condition of Te Waihora/Lake Ellesmere catchments.
- Section 5 - *Cultural Values*. A summary of cultural values associated with the Waikirikiri/Selwyn-Te Waihora catchment.