# Groundwater Quality and Quantity Annual Report 2021

Prepared to meet the Requirements of CRC214226

## Christchurch City Council

June 2022

Christchurch City Council

## Internal Document Review

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# 1. Introduction

Christchurch City Council is required to review an annual groundwater monitoring data from various sites within the territorial boundary of CCC. A combination of CCC hydrometric network data currently managed by NIWA (NIWA, 2021), and CCC's water supply wells results have been reviewed.

This work pertains to the groundwater aspect of the Comprehensive Stormwater Network Discharge Consent, CRC 190445, issued by ECan to CCC on 20 December 2019. The work has been completed in accordance with the Christchurch City Council's Environmental Monitoring Programme (EMP).

## 1.1. Background

In December 2019 the Comprehensive Stormwater Network Discharge Consent, CRC190445 (the CSNDC) was issued by ECan to CCC. The CSNDC serves as a global consent enabling CCC to discharge water and contaminants to land and water from the stormwater network. A portion of this consent (conditions 49 – 55) requires the preparation and implementation of the EMP produced by CCC. The EMP serves to assess the effects of stormwater discharges from the CCC stormwater network on the receiving environment. In particular, to groundwater, the purpose of the EMP is "to (1) measure whether stormwater discharges are causing adverse effects on groundwater quality and quantity, (2) determine compliance with the conditions of consent, and (3) inform stormwater mitigation."

## 1.2. Objective

Section 3.4 of the EMP, details CCC's annual groundwater reporting requirements. The objective of this report is to address the requirements specified in the EMP as follows:

- Groundwater level patterns in CCC water level monitoring sites
- *E. coli* detections in CCC water supply wells;
- Groundwater quality patterns for copper, lead and zinc from CCC water supply wells;
- Any information from spring monitoring that could be attributed to stormwater impacts on groundwater;
- Statistical analyses of change for *E. coli* (daily data from pumping stations) and electrical conductivity (quarterly data at ECan monitoring wells; used as an indicator of changes in metals levels) shall be undertaken using Time Trends or other robust analysis, using a statistical level of significance of 5% (i.e. $p \leq 0.05$);

    - A minimum of three years is required before trends analysis can be undertaken (NIWA, 2014);
    - Trends analysis shall be conducted on data since the beginning of the dataset;
- Any groundwater related issues that affect the performance of stormwater management systems; and
- An assessment as to whether the Receiving Environment Objectives and Attribute Target Levels specified in Schedule 9 (Groundwater and Springs) of the consent conditions are being met at each site for copper, lead and zinc.

## 2. Scope of Work

In order to meet the objectives of this report, CCC undertook the following scope of work:

- Obtained all groundwater level monitoring data from CCC Hydrometric Network currently managed by NIWA from 27 sites
- CCC water supply well monitoring data
- Trend analysis of change for electrical conductivity (EC) using Mann- Kendall time trend analysis with a statistical significance of 5%. The analysis was undertaken using Time Trend (NIWA version 7, 2021).
- No trend analysis was undertaken for *E.Coli* as the majority (above 99%) of the data was expressed as being above or below the limit of reporting (LOR). Confirm with NZ drinking water MAV is not exceeded more than 5% of the time in accordance with the DWSNZ.
- Review of water quality trends for, dissolved copper, dissolved lead, and dissolved zinc in aquifer 1 and aquifer 2
- Comparison of analytical results (Cu, Pb, Zn) to the attribute target levels.

# 3. Methodology

## 3.1. Data Source

### 3.1.1. CCC Hydrometric Data

Groundwater level data was retrieved from the CCC Hydrometric Network as specified in Figure 1 of the EMP.

# 4. Assessment Criteria

Groundwater data for copper, lead, zinc, electrical conductivity and *E.coli* have been compared to the attribute target levels specified in Schedule 9 of the CSNDC, in accordance with section 3.4 of the EMP. The attribute target levels are presented in Table 1.

**Table 1. Receiving Environment Objectives and Attribute Target Levels for Groundwater (Schedule 9, CRC190445)**

| Objective | Attribute | Attribute target Level |
|---|---|---|
| Protect drinking water quality | Copper, lead, zinc and *Escherichia coli* concentrations in drinking water | Concentrations to not exceed: Dissolved Copper: 0.5 mg/L Dissolved Lead: 0.0025 mg/L Dissolved Zinc: 0.375 mg/L No statistically significant increase in the concentration of *Escherichia coli* at drinking water supply wells. |
| Avoid widespread adverse effects on shallow groundwater quality | Electrical conductivity in groundwater | No statistically significant increase in electrical conductivity. |

# 5. Results and Discussion

## 5.1. Groundwater level patterns in CCC water level monitoring sites

The CCC groundwater network consists of 35 sites (24 permanent sites and 11 project sites). At the end of 2021, the Council groundwater network consists of 35 permanent sites. Three of the sites, Kruses Drain (66649), Richmond Hill Waterway (66676) and Creamery Stream (67809) were decommissioned in late January as requested by the Council's Stormwater and Waterways Operations Team. The Prestons Subdivision water-level and flow site (66446) showed no discharge record for the entire period, the sensor is functioning normally however sedimentation of the sensor continues to be an issue at this site. No significant change in water level was recorded for the 2021 calendar year (NIWA, 2021). The minimum, mean and maximum stage levels for January to December 2021 are presented in Appendix A.


**Figure 1. Location of CCC groundwater level sites during 2021. Telemetered sites are labelled with blue pins and manual sites with yellow pins.**

## 5.2. *E.coli* detections in CCC Water supply wells

There was no detection of *E.coli* equal to or above the laboratory limit of reporting (LOR) of 1 maximum probable number (MPN) per 100 ml at CCC water supply wells in 2021. In total there were, 529 samples taken from the various water supply wells in the city.

In total, 100% of *E.coli* results were qualitative data expressed as being above or below 1 MPN/100ml, Mann-Kendall analysis would not be appropriate to analyse the data. The results were compared against the number of *E.Coli* exceedances allowed for 95% confidence that the New Zealand drinking water MAV is not exceeded more than 5% of the time in accordance with the DWSNZ. No CCC water supply wells exceeded their respective allowable exceedances given the respective number of samples in the 2021 calendar year.

## 5.3. Copper in CCC Water supply wells

There were no exceedances recorded of the attribute target level for dissolved copper in the 2021 calendar year. There were no historical exceedances reported of the attribute target level for copper. In the 2020 annual report, one exceedance of the attribute target level for dissolved copper was reported in 2020 at the Lake Terrace Pump Station (well 5) which extracts from aquifer 3 (Burwood gravels). This reported result was incorrectly recoded due to some logistical issues and later clarified in the separate Memo (provided along with this annual report).

## 5.4. Zinc in CCC Water Supply wells

There were no exceedances of the dissolved zinc target level in the 2021 calendar year. In 2011, there have been three exceedances of the attribute target level for dissolved zinc in various wells and aquifers at the Brooklands (aquifer 2), Mays (aquifer 4) and Belfast Pump Stations (aquifer 1). The results appear to be a one off and none of the wells were recorded above the attribute target level. Over the last few years, CCC has introduced the programme of replacement of most of the shallower wells with deeper secure aquifer sources. Requirements for demonstrating that wells have a sanitary bore head mean that Stormwater should not affect the quality of the bores.

## 5.5. Lead in CCC Water Supply wells

There were no exceedances of the dissolved lead target level in the 2021 calendar year. Historically there have been exceedances of the dissolved lead target level in various wells and aquifers at the Addington (2011), Main Pump (2009), Spreydon (2009), Woolston (2009), Auburn (2010), Crosbie

(2011) and Parklands Pump Stations (2011). The results appear to be a one off and none of the wells were recorded above the attribute target level.

## 5.6. Heavy metals concentrations (Cu, Zn and Pb) Trend analysis

Heavy metal concentration trends in aquifer 1 and aquifer 2 monitoring wells were assessed from (2011 – 2021) monitoring years. The data are non-routine and there was an insufficient number of monitoring events completed at each monitoring well to determine any trends in each specific well. Hence, a citywide analysis was performed from the available data. Routine and continued monitoring of heavy metals is required to gain a dataset to allow for a detailed assessment of trends in each specific well.

### 5.6.1. Trend analysis for copper (aquifer 1)

The Statistical trend analysis of copper using the Mann - Kendal Trend Test analysis (Trend 7.1, NIWA) was performed for dissolved copper (mg/L) at aquifer 1 (n = 42). No significant trend was detected.

### 5.6.2. Trend analysis for copper (aquifer 2)

Mann- Kendall Trend Test analysis for dissolved copper (mg/L) at aquifer 2 (n = 48). No significant trend was detected.

### 5.6.3. Trend analysis for zinc (aquifer 1)

Mann- Kendall Trend Test analysis for dissolved zinc (mg/L) at aquifer 1 (n = 38). No significant trend was detected.

### 5.6.4. Trend analysis for zinc (aquifer 2)

Mann- Kendall Trend Test analysis for dissolved zinc (mg/L) at aquifer 2 (n = 45). No significant trend was detected.

### 5.6.5. Trend analysis for lead (aquifer 1)

Mann- Kendall Trend Test analysis for dissolved lead (mg/L) at aquifer 1 (n = 42). No significant trend was detected.

### 5.6.6. Trend analysis for lead (aquifer 2)

Mann- Kendall Trend Test analysis for dissolved lead (mg/L) at aquifer 2 (n = 48). No significant trend was detected.

### 5.6.7. Trend analysis for conductivity (aquifer 1)

Mann- Kendall Trend Test analysis for conductivity (mS/m) at aquifer 1 (n = 83) of different wells in Christchurch City. No significant trend was detected.

#### 5.6.8. Trend analysis for conductivity (aquifer 2)

Mann- Kendall Trend Test analysis for conductivity (mS/m) at aquifer 2 (n = 54) of different wells in Christchurch City. No significant trend was detected.

#### 5.6.9. Trend analysis for conductivity in Coastal and Estuary

Mann- Kendall Trend Test analysis for conductivity (mS/m) at aquifers 1 and 2 (n = 8) at coastal and estuary. No significant trend was detected.

# 6. Related research and ongoing investigation

Over the years, the Council is working on various research and monitoring projects related to Council's water supply assets to assess and manage risks to the safety of drinking water. Section 6.1 and 6.2 highlight the summary of some of the ongoing projects in groundwater space.

## 6.1. Drinking water supply security: Groundwater Bore Security Modelling (2021)

The Drinking Water Standards of New Zealand (DWSNZ) 2005 (revised 2018) allow secure bore water to be supplied untreated if the following criteria are met:

1. The bore water must not be directly affected by surface or climatic influences (i.e. the water is at least a year old, by which time any pathogens will have died)
2. The well head must provide satisfactory protection to prevent contamination of the water supply
3. *E. coli* must be absent in the bore water.

It is anticipated that CCC's upgrades to bore headworks (post-earthquakes) will satisfy bore head security Criterion 2 (bore head security). In addition, CCC continues to monitor and comply with Criterion 3. CCC has engaged Aqualinc Research Ltd (Aqualinc) to predict the likely presence of water younger than one year in CCC's supply bores in 2021. These assessments are model-based and provide one of several lines of evidence that CCC will use to assess bore security for Criterion 1.

This research work has been supported and guided by two independent panels. A Peer Review Panel has provided direction relating to DWSNZ compliance. A Technical Panel has also been commissioned by CCC to provide technical guidance.

In undertaking the assessments, a numerical model (a modified version of the existing Canterbury Groundwater Model 3; Weir, 2018) has been used to identify bores that comply with Criterion 1. Bores that failed these initial assessments were to be assessed in detail if it was possible that more detailed analyses could alter the assessments. Other bores that were clearly non-compliant were also identified.

The assessments included the use of measured field data as a check on model representativeness. They consider how the aquifer system might respond under extreme, yet plausible, conditions (such as high pump rates, leaky aquitards, vertical flow within abandoned bores). An overriding principle of the method is that the model is applied in a way that results in predictions of travel times that are conservative (shorter travel times than actual). Therefore, if, given these assessments, water less than one year old is not predicted to reach the bore. In this scenario, the risk of microbial contamination is acceptably low. If modelling suggests that some water reaching the bores may be younger than one year, then there is less confidence in the security of the bore, and more detailed (future) analyses may be needed. Alternatively, some bores cannot be classified as secure.

Multiple decision criteria have been applied to assess the likelihood of supply security for each supply bore. These are:

- The direction of any vertical hydraulic gradient (including pumping drawdown);
- Vertical hydraulic connections to overlying layers (as might be determined by aquifer tests); and
- One-year backward particle tracking under the following modelling scenarios:
    - Baseline (a modified version of the calibrated model with high-yet-plausible continuous pumping from all of CCC's supply bores);
    - Local aquitard punctures (such as might occur from seismic fractures, old lamp posts, building piles, old river incisions, local areas of higher (than elsewhere) vertical connection, etc.);
    - Leaky bores (such as old unsealed or multi-screened bores that may vertically transmit water rapidly); and
    - Reduced spatial extent of the coastal confining layers.

A scoring system has been applied to the above criteria for assessing the supply security of each bore. A separate comparison of modelled water age has also been made against age estimates derived by GNS Science.

**Summary of Results**

In total, 55 well fields were modelled, comprising a total of 153 bores. Of these bores, 20 are listed as being abandoned (or out of service). Overall, the conservative analyses have concluded that most bores meet the DWSNZ Criterion 1; that is, it is very unlikely that water younger than one year is present in the abstracted water. This is largely due to the upward hydraulic gradients present at most locations, and the comparatively large depth of most bores. Most bores either pass clearly, or fail convincingly. Only a few are uncertain.

Of the 153 bores assessed:

- 139 are very unlikely to have young water (including 8 abandoned bores);
- 12 are very likely to have young water (including 2 abandoned bores); and
- 2 are uncertain (including one abandoned bore). These bores have modelled ages greater than one year, but the paths pass through the uppermost layer (under one or more scenarios). Hence, the water cannot be considered safe.

Of the 55 well fields assessed:

- 49 have all bores that pass
- 4 have operational bores that fail:
    - Grassmere - 1 bore uncertain, 3 pass
    - Main Pumps - all 6 fail
    - Spreydon - 1 bore fails, 4 pass
    - Dunbars - 4 bores fail (1 abandoned), 1 pass

*Currently, the report is sent to the external consultants for a peer-review process.*

## 6.2. Site-specific risk assessment (2019-2020)

In 2019 – 2020, Beca Limited (Beca) has been commissioned by the Council to undertake a high-level desk-based contamination screen for the CCC pump station sites. During the assessment, Beca has undertaken a high-level desk-based screen of the contamination risk from the wider area (400m radius from the pump station) to an individual wellhead site and to the groundwater supply to the pump station.

This assessment has been undertaken and reported in general accordance with the Ministry for the Environment (MfE) Contaminated Land Management Guidelines No. 1 – Reporting on Contaminated Sites in New Zealand (2011) and MfE Contaminated Land Management Guidelines No. 5 – Site Investigation and Analysis (2011).

Based on the reports, each pump station is categorised into the existing risk that affects the quality of water that include:

- Pump stations that have either fuel storage tanks or service stations in the vicinity
- Pump stations that are at risk due to past and present landfills activities
- Pump stations that are prone to extreme wet weather conditions
- Pump stations that are at risk with existing land use activities
- Pump stations that are recommended to have monitoring bores installed

In 2021, based on the findings, the Council has engaged PDP Ltd (PDP) to prepare a risk-specific sampling schedule including sites, timeline, and the nature of the determinanads in Christchurch City.

# 7. Stormwater Management Issues

This section is contrary to the purpose of monitoring under CSNDC EMP Chapter 3 (Groundwater). Monitoring under this chapter is for the purposes of determining whether stormwater discharges are having an adverse effect on groundwater, not the reverse. While such analysis may provide value to Christchurch City Council, it does not provide any useful information for evaluating the achievement of the Receiving Environment Objectives and Attribute Target Levels under Schedule 9.

# 8. Conclusions

An annual review of the 2021 groundwater results using CCC data has been completed. The results from the review have demonstrated CCC's general compliance with the CSNDC through the assessment against the receiving environment objectives and the corresponding attribute target levels. A summary of the results is as follows:

**Water Levels:**

No anomalies in the water level at all CCC monitoring network was observed. There are no assessment criteria specified in schedule 9 of the CSNDC for groundwater levels.

**Dissolved Metals and EC**

- There were no exceedances recorded of the attribute target level for dissolved copper
- There were no exceedances of the dissolved zinc target level in the 2021 calendar year.
- There were no exceedances of the dissolved lead target level in the 2021 calendar year.
- Mann- Kendall Trend Test analysis for conductivity (mS/m) at aquifer 1 (n = 83) of different wells in Christchurch City. No significant trend was detected.
- Mann- Kendall Trend Test analysis for conductivity (mS/m) at aquifer 2 (n = 54) of different wells in Christchurch City. No significant trend was detected.
- Mann- Kendall Trend Test analysis for conductivity (mS/m) at aquifers 1 and 2 (n = 8) at Coastal and Estuary wells. No significant trend was detected.
- Overall, there was an insufficient amount of data to draw any conclusions.

***E.Coli***

- There were no exceedances of *E.Coli* equal to or above the laboratory limit of reporting (LOR) of 1 maximum probable number (MPN) per 100 ml at CCC water supply wells in 2021. In total there were, 529 samples taken from the various water supply wells in the city. Due to the nature of CCC *E.coli* data, statistical analyses on *E.coli* was unable to be completed.

# 9. Recommendations

- Historical trend analysis are produced for the CCC water level data.
- A compilation of all relevant data is produced by both ECan and CCC that includes the full set of monitoring wells to be evaluated under the CSNDC and correct analysis is completed. Where there is a lack of information it is recommended that routine monitoring is completed in line with the EMP recommendations to analyse trends in the future.

- Trace element analysis is continued (or started) at the CCC monitoring wells where a statistically increasing electrical conductivity trend was observed

## 10. References

Christchurch City Council (August 2020). Environmental Monitoring Programme for Comprehensive Stormwater Network Discharge Consent for Ōtautahi/Christchurch City and Te Pātaka o Rākaihautū/Banks Peninsula

Environment Canterbury (20 December 2019). Resource Consent CRC190445, A DISCHARGE PERMIT (S15): to discharge water and contaminants to land and water from the stormwater network.

Ministry of Health (2005, revised 2018). Drinking-water Standards for New Zealand. 19 December 2018.

NIWA (2021). Christchurch City Council hydrometric network annual report: 1 January to 31 December 2021. April 2022.

## 11. Appendix

## APPENDIX A

Table 6-1: Groundwater site statistics summary 2021 comparison with full record

| Station details | | | Full record | | | 1-January-2021 - 31-December-2021 | | |
|---|---|---|---|---|---|---|---|---|
| Number | Name | Start of record | Minimum (m) | Maximum (m) | Mean (m) | Minimum (m) | Maximum (m) | Mean (m) |
| 3245014 | Roydvale Ave | 06-Oct-77 | 26.195 | 29.795 | 27.588 | 26.195 | 27.673 | 26.861 |
| 3245015 | Fairford St (opp Oldwood) | 19-Dec-88 | 24.975 | 26.525 | 25.787 | 24.975 | 25.950 | 25.502 |
| 3246004 | PS62, Tyrone Street | 05-Jun-84 | 11.745 | 14.935 | 13.715 | 13.025 | 14.770 | 13.975 |
| 3246005 | Dartford St, Brooklands | 21-Jul-81 | 8.498 | 10.873 | 9.635 | 9.565 | 10.873 | *9.802 |
| 3246006 | Lower Styx Track Burwood Forest | 11-Mar-91 | 10.400 | 12.775 | 11.051 | 10.635 | 11.240 | 10.897 |
| 3246007 | Mairehau Rd, near Greenhaven | 07-Mar-97 | 10.040 | 11.450 | 10.934 | 10.630 | 11.330 | 10.849 |
| 3246016 | Marshland Domain | 07-Mar-97 | 10.590 | 13.110 | 12.365 | 12.110 | 12.880 | *12.286 |
| 3246018 | QEII Drive (away) #2 Drain | 24-May-99 | 10.750 | 12.214 | 11.103 | 10.994 | 11.524 | 11.119 |
| 3247004 | No.134 Inwoods Road | 12-Nov-84 | 11.320 | 12.990 | 12.235 | 12.090 | 12.650 | 12.326 |
| 3255007 | Kirkwood Intermediate School | 06-Jan-67 | 20.350 | 22.395 | 21.462 | 20.445 | 21.690 | 21.067 |
| 3255009 | Halswell Ret.Basin, Halswell Jnt | 11-Oct-77 | 23.701 | 29.585 | 25.588 | 23.821 | 25.524 | *24.766 |
| 3255011 | Cashmere/Kennedys Road | 11-Sep-00 | 19.825 | 21.610 | 20.624 | 19.880 | 21.335 | *20.543 |
| 3255012 | Cashmere Road | 11-Sep-00 | 15.665 | 19.360 | 17.803 | 16.945 | 19.096 | 18.221 |
| 3255013 | Halswell Road PS | 05-Jun-84 | 20.390 | 22.970 | 21.767 | 21.040 | 22.170 | 21.531 |
| 3255015 | Hendersons Road | 11-Sep-00 | 14.985 | 18.310 | 17.224 | 15.535 | 18.045 | 17.053 |
| 3255016 | Milns/Sparks Road | 13-Apr-92 | 18.700 | 20.940 | 19.552 | 19.320 | 20.033 | 19.642 |
| 3255017 | Whincops Road | 13-Apr-92 | 22.135 | 23.210 | 22.650 | 22.250 | 22.841 | 22.558 |
| 3255018 | Hodgens Road | 13-Apr-92 | 24.265 | 26.775 | 24.720 | 24.275 | 24.885 | 24.297 |
| 3255019 | Quarry Carpark No.2 | 16-Jun-98 | 18.320 | 22.710 | 19.574 | 18.320 | 18.875 | *18.600 |
| 3255042 | Wigram Road near Haytons | 10-Dec-13 | 23.836 | 25.146 | 24.457 | 24.026 | 24.871 | 24.503 |
| 3256014 | Fisher Ave/Norwood Street | 20-Apr-92 | 13.050 | 15.250 | 14.355 | 13.070 | 15.200 | 14.209 |
| 3256016 | Gould Crescent, Woolston | 07-Aug-78 | 8.145 | 10.145 | 9.455 | 9.055 | 9.685 | 9.310 |
| 3256017 | PS42, Sparks Road | 07-Jul-69 | 15.860 | 18.850 | 17.376 | 15.880 | 17.890 | 17.040 |
| 3256018 | PS20, Locarno Street | 03-Jun-59 | 15.860 | 18.850 | 17.371 | 15.880 | 18.080 | 17.134 |
| 3256034 | PS1, Woodham Road | 03-Jun-59 | 11.095 | 12.695 | 11.936 | 11.435 | 12.275 | *11.598 |
| 3257024 | Ruru Road, Bexley | 10-Mar-86 | 7.635 | 12.380 | 11.098 | 10.980 | 11.520 | 11.193 |
| 3257031 | Cnr Wakefield and Nayland, Sumner | 08-Aug-19 | 12.520 | 13.835 | 13.130 | 13.190 | 13.820 | 13.377 |

Notes: * indicates gap percentage of 2.5% exceeded