Journal of Hydrology (NZ) 64 (1): 175-181

NOTE

Nitrate-N concentrations in the Christchurch-West Melton Zone, Canterbury: an update based on newly available historical groundwater quality data

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Purpose of this note

This note is presented to reiterate some of the earlier groundwater nitrate-nitrogen results presented by Rutter and Rutter (2019) and highlight some of the changes that can be observed with the addition of the newly available historical groundwater quality data reported by Aitchison-Earl and Knottenbelt (2024). It is also an opportunity to assess in more detail the spatial distribution of nitrate concentrations across the Christchurch-West Melton groundwater management zone. This is not a rigorous assessment but aims to highlight the data and briefly explore the previously observed differences between groundwater in 'north' and 'south' Christchurch, which may warrant further analysis.

Introduction

Human activities can contaminate groundwater, posing risks to public health and to the environment. As stated by Aitchison-Earl and Knottenbelt (2024), in order to better predict groundwater quality into the future we need to know what it was in the past, which may then allow us to understand relationships between land use and groundwater quality over time. The network of long-term monitoring wells was initiated in North Canterbury in 1986 and in South Canterbury in 1991. However, there is a much longer record of data, collected for many different reasons, as described in Aitchison-Earl and Knottenbelt (2024).

Current state and trends in groundwater quality in Canterbury are monitored through an annual survey of wells undertaken by Environment Canterbury in the spring, supplemented by more frequent (quarterly) monitoring at a subset of sites. The latest (2023) current state is summarised in Knottenbelt (2024) and is contained in the New Zealand national-level LAWA (2025) dataset. Knottenbelt (2024) reports that nearly 60% of Canterbury wells show a 'very likely increasing' or 'likely increasing' trend in nitrate-N, and that 36% are above 5.65 mg/L (equivalent to half of the maximum acceptable value (MAV) of 11.3 mg/L specified in the New Zealand drinking water standard).

Background

Rutter and Rutter (2019) observed that the Christchurch-West Melton groundwater zone had relatively low nitrate-N concentrations compared with other areas of Canterbury. The monitoring wells were divided into three depth categories (less than 40 m, 40–80 m and greater than 80 m). For each well, all the data for a decade were averaged, and

the average of all the wells within the depth category was calculated for each decade. This was not a rigorous statistical approach, but a way of using all the (often) limited data to assess broad patterns.

Rutter and Rutter (2019) assessed concentrations across the Christchurch-West Melton, Selwyn-Waihora and Ashburton groundwater zones and suggested that the Christchurch-West Melton zone had lower nitrate-N concentrations than the other zones assessed. The low concentrations across much of the zone were attributed to several reasons:

- land use controls enforced to protect groundwater supply;
- recharge from Waimakariri River, particularly in the north and east of the zone;
- the effects of land use intensification have not yet become apparent due to long travel times; and
- some denitrification may have occurred, particularly in the deeper, confined aquifers.

There was found to be a very clear depth limit above which higher nitrate-N concentrations are observed, with bores deeper than 80 m showing concentrations consistently below 0.5 mg/L.

Spatially, Rutter and Rutter (2019) suggested there was a distinct pattern in nitrate-N concentrations within the Christchurch-West Melton zone, with the zone appearing to be divided into two areas. The northern and eastern part of the zone was dominated by groundwater with nitrate-N concentrations of less than 2 mg/L, these low concentrations persisting across the seven decades assessed. South of approximately the Hagley Park area, and west of Yaldhurst Road, nitrate-N concentrations in groundwater could be much higher, some exceeding the drinking water standard MAV of 11.3 mg/L nitrate-N. Figure 1 shows average nitrate-N concentrations across the zone. It appears that the northern part of the zone is dominated by river recharge from the Waimakariri River: the river is known to lose water to groundwater from Halketts Corner (approximately the western point of the groundwater allocation zone). It may also be an area that is more affected by increased denitrification in some of the deeper confined aquifers (Aitchison-Earl and Knottenbelt, 2024), although the mapped extent of the coastal confined system does not match the pattern of low nitrate-N groundwater at first glance. The south-western part of the zone is more vulnerable to contamination from the surface and shows quite different (higher) concentrations. The area is more dominated by land surface recharge, with a large part of the area having a downward hydraulic gradient and/or limited confining layers. Current or historical sources of nitrate-N contamination in this area include landfill leachate, industrial discharges and agricultural activities (Rosado and Scott, 2020).

New data and updated analyses

The newly available historical data described by Aitchison-Earl and Knottenbelt (2024) adds significantly to the temporal nitrate-N data. Over the whole of Canterbury, the new data contributes all or most of the data available for pre-1960, 27% of available data for the 1960s and 39% of data for the 1970s. This adds substantially to the available data for the Christchurch-West Melton groundwater zone, particularly during the earlier decades.

The basic analysis carried out by Rutter and Rutter (2019) was repeated making use of the newly digitised data (Figure 2). Relative to the previous analyses, the additional data resulted in an increase in average concentrations in the shallower well group, with maximum (average) concentration occurring in the

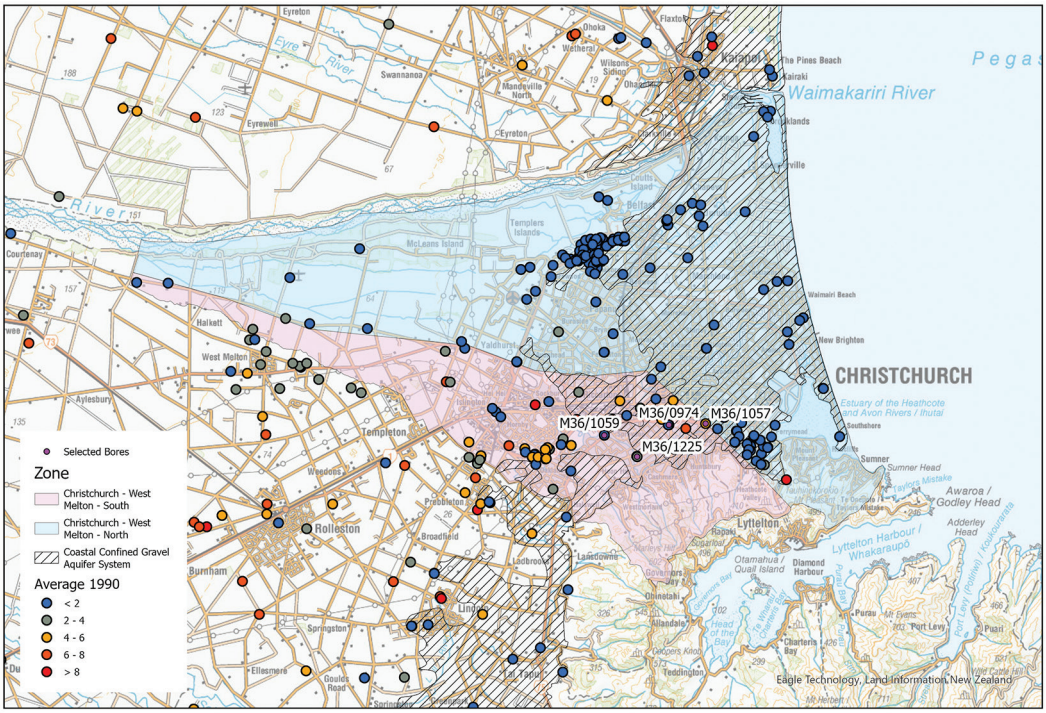

Figure 1 – Groundwater nitrate-N concentrations (mg/L, as an average for the 1990s) in north and south Christchurch illustrating the low concentrations across much of northern Christchurch. The specific bores referred to in this paper are labelled by their well identification numbers.

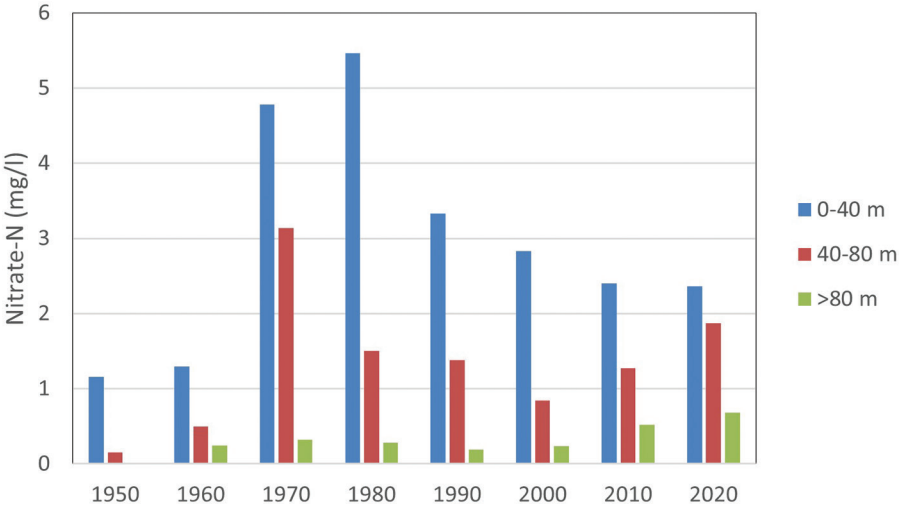

Figure 2 – Average nitrate-N concentration for bores in three depth categories, classed by decade (updated data, following Aitchison-Earl and Knottenbelt, 2024).

1980s (rather than the 1970s, as reported by Rutter and Rutter, 2019), peaking at over 5 mg/L nitrate-N. In contrast, the additional data lowered the average nitrate-N concentration for deeper well groups.

In addition, this time the data were split into the two subzones previously discussed. For the northern part of the zone, Figure 3 shows the decadal nitrate-N pattern observed previously, with a marked increase in concentration in the 1970s and 1980s, declining to a relative low in the 1990s before increasing again through the following decades. The shallow wells show average concentrations at or only slightly above 2 mg/L nitrate-N in the 1970s and 1980s, which declines to closer to 1 mg/L nitrate-N in the following decades. Figure 4 shows a very different pattern for wells in the southern part of the zone. Here the shallow average nitrate-N concentrations are substantially higher than in the northern part of the zone, peaking at around 6 mg/L nitrate-N in the 1970s and 1980s. The decline to a low in the 1990s does not occur: instead, a relative low (of around 4 mg/L nitrate-N) occurs by the 2010s. The reason for the long 'tail' from the peak concentrations in the 1970s is unknown and merits further investigation. Concentrations in the deeper wells are also substantially higher than in the northern part of the zone.

Rosado and Scott (2020) observed that concentrations within the southern part of Christchurch were higher in the west, decreasing towards the east. They attributed the distribution to the higher permeability of near-surface sediments further west, more industrial discharges and nutrient sources in the west, and the possibility that organic carbon in the swampy eastern parts of the city could be contributing to denitrification. Interestingly, nitrate-N concentrations in surface water through the city follow a similar pattern, with concentrations decreasing from west to east.

The analysis presented is not statistically robust, but by assessing the broad patterns in the data we can start to make observations that merit further investigation. As is typical

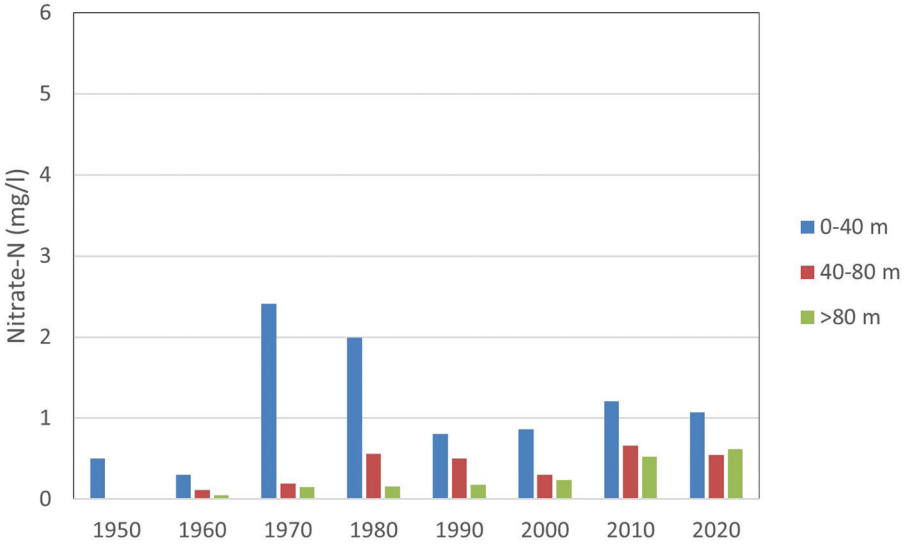

Figure 3 – Average nitrate-N concentration for bores in three depth categories, classed by decade, in the northern, river recharge-dominated part of the Christchurch-West Melton groundwater zone.

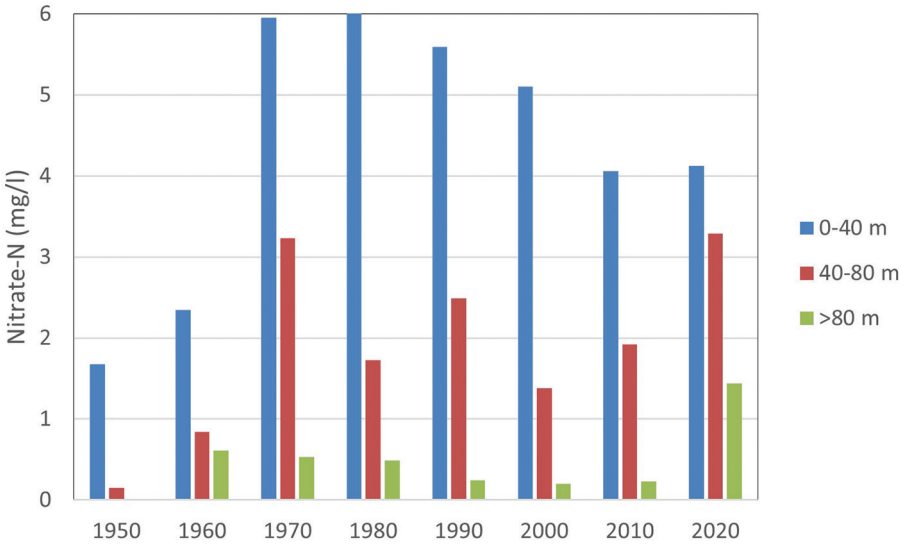

Figure 4 – Average nitrate-N concentration for bores in three depth categories, classed by decade, in the southern, land surface recharge-dominated part of the Christchurch-West Melton groundwater zone.

with long-term data analysis, there are very few wells that have sufficient data to draw definitive conclusions. The apparent increase in concentrations in the 1970s and 1980s is thought to be a consequence of higher than usual rainfall recharge (and hence, leaching) in the mid- to late 1970s. Aitchison-Earl and Knottenbelt (2024), Adams (1981) and Curtis (1982) describe a nitrate-N peak in 1978 in west Christchurch groundwater during an 'unusual succession of very wet winters' from 1973 to 1979, which flushed several years of nitrate-N accumulated in the soil over the preceding relatively dry period (Scott, 2019). This was further explored by Close *et al.* (1995).

Rutter and Rutter (2019) noted there are very few wells that have sufficient data to explore the rise in nitrate-N concentrations in groundwater in the 1970s. They identified four wells in the area (M36/1225, M36/1057, M36/0974 and M36/1059) that had data spanning the seven decades (1950s to 2010s) (Figure 5 of Rutter and Rutter, 2019); these are all between 32 and 41 m deep and located in the south side of Christchurch (see Figure 1). M36/1225 and M36/1059 showed a nitrate-N concentration peak around 1982; the other two showed maximum values around 1990/91. M36/1059 showed a gradual decline in the following decades. Updating the Rutter and Rutter (2019) analysis for the four wells with new (historical) data as well as more recent data (Figure 5) confirms the peak in some wells in the early 1980s but still suggests that M36/1057 and M36/0974 peaked in the 1990s, though the lack of data in the 1970s does not enable us to assess the impacts of the high recharge event through the mid- to late 1970s. However, it is possible to surmise that, in general, nitrate-N concentrations have decreased from higher concentrations that were observed in the 1980s and 1990s through to now.

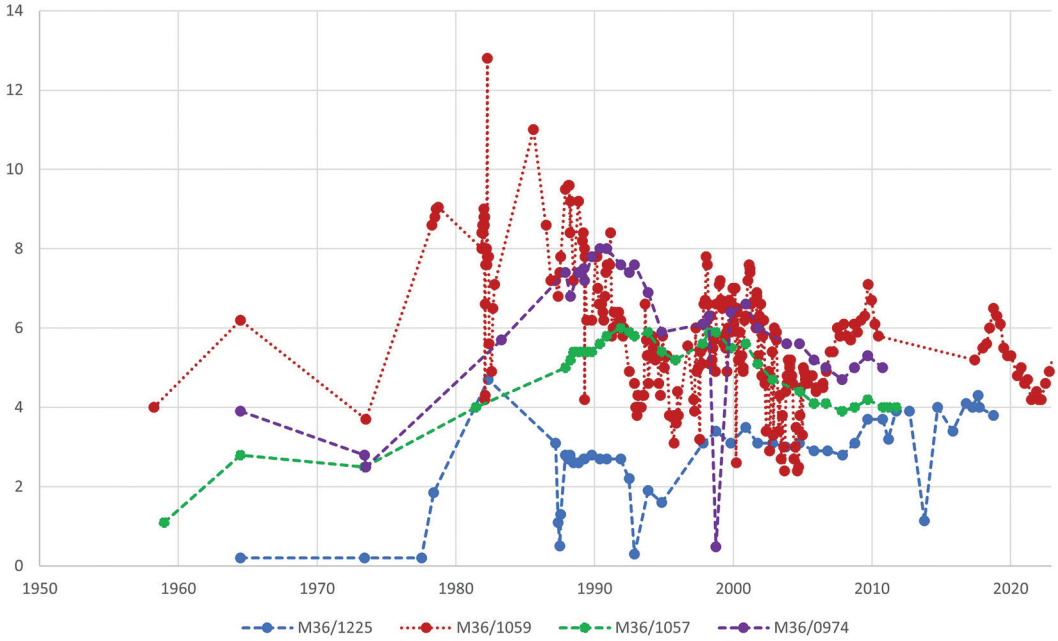

Figure 5 – Nitrate-N concentrations in selected wells in southern Christchurch, 1950s to present.

Summary

The newly acquired data start to fill in some of the gaps in our historic groundwater nitrate concentration record but frustratingly fail to fill the gap in the early 1970s that would provide background to the peak that occurred in many bores in the late 1970s and early 1980s. The additional data do add to the record, and for the Christchurch-West Melton zone suggest that the response to the high recharge years may have occurred slightly later than previously suggested, with the peak actually occurring in the 1980s. Dividing the Christchurch-West Melton zone into the river-recharge dominated northern zone and the land surface recharge-dominated southern zone show very different distributions in terms of the nitrate concentrations, likely due to a combination of recharge sources, land use activities and, possibly, denitrification. There are a number of further avenues to explore, including potentially investigating whether there is any evidence for denitrification being responsible for the lower concentrations in some areas, as well as assessing the reasons for the long tail observed in average nitrate-N concentrations in the southern part of the zone following the peak in the 1970s/1980s.

Acknowledgements

Many thanks to Environment Canterbury for data and input into this paper, especially Philippa Aitchison-Earl, Lisa Scott and Melanie Knottenbelt.

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