National Groundwater Quality Indicators Update: State and Trends 1995-2008

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EXECUTIVE SUMMARY

This report provides a summary of groundwater quality state and trends in New Zealand based on data collected from 973 sites over the period 1995 to 2008. The dataset includes sites in State of the Environment (SOE) monitoring programmes operated by regional councils and the National Groundwater Monitoring Programme operated by GNS Science. This report updates a previous report on groundwater quality at the same sites and based on data collected from 1995 to 2006 (Daughney and Wall, 2007).

This report focuses on ambient groundwater quality. Some of the monitoring sites considered in this report are used to supply single dwellings or small communities with water supply, but many other monitoring sites considered in this report have non-potable uses (e.g. irrigation, stock drinking water). Drinking water guidelines are used in this report to provide context for assessment of ambient groundwater quality, but for focused assessment of drinking water quality in New Zealand, readers are directed to the Annual Review of Drinking Water Quality reports produced by the Ministry of Health (e.g. Ministry of Health, 2009).

Median values and trend magnitudes for key groundwater quality indicators reported here are very similar to those reported previously (Daughney and Wall, 2007). Nationally, ambient groundwater quality in New Zealand is similar to other countries such as Finland, Canada and the Netherlands. New Zealand has two main groundwater quality issues:

- Contamination with nitrate and/or microbial pathogens (of presumably human or agricultural origin) occurs in many regions, particularly for shallow wells in unconfined aquifers. Nationally, median concentrations of nitrate and *Escherichia coli* exceed their respective health-related standards for human consumption at 5% and 23% of the monitoring sites considered in this report, respectively.
- Naturally elevated concentrations of ammonia, iron and/or manganese are found in many regions, especially for deeper wells in confined aquifers. Nationally, 4%, 21% and 27% of the sites considered in this report have median concentrations of ammonia, iron and manganese above their respective aesthetic guidelines for human consumption, and 10% of sites have median manganese concentration above the health-related standard (there are no health-related standards for ammonia or iron).

Groundwater quality is either constant over time or changing slowly (parameter values change less than 2-5% per year) at about three quarters of the sites considered in this report, probably due to the natural process of water-rock interaction. Changes in groundwater quality over time are more rapid at the remaining sites, with patterns that suggest human influence. With respect to nitrate, significant time trends are detectable at roughly one third of the monitoring sites considered in this report, and of these, roughly twice as many sites show increasing nitrate concentration over time compared to sites that show decreasing nitrate concentration over time. In general however, this report shows that attempts to identify and interpret time trends in groundwater quality are complicated by year-by-year changes in the structure of the various groundwater monitoring programmes operated by regional councils.

This report has revealed certain significant relationships between groundwater quality and well depth and/or aquifer characteristics. In contrast, this report has not revealed any systematic or significant relationships between groundwater quality (state or trends) and land use or land cover around the monitoring sites. This is in fact a common result that has been observed in several previous studies in New Zealand (e.g. Daughney and Wall, 2007) and overseas—it is hard to identify and understand relationships between groundwater quality

and land use unless the age and source of the groundwater being monitored are accurately known.

The main recommendation from this report is that similar studies should be conducted at a regular interval in the future, in order to identify changes in the status of groundwater quality in New Zealand. Future studies will require national and regional commitment to regular (quarterly) monitoring of key groundwater quality indicators (nitrate, *Escherichia coli*, ammonia, iron, manganese, electrical conductivity) via standardised sampling and analytical methods, on an on-going basis, and at a consistent network of monitoring sites, all having adequate well-head protection.

The main sources of bias in the aggregated regional and national statistics are, in order of influence:

- changes in sampling procedure, such as collection of field-filtered instead of unfiltered samples;
- addition or removal of a large proportion of sites from an SOE network; and
- changes in analytical procedure, such as replacement of total coliform counts with *Escherichia coli* counts.

In order to elucidate the drivers of groundwater quality, there is also a need to determine the age and origin of the groundwater that is actually being sampled at each monitoring site, to permit meaningful comparison to current and past land use.

1.0 INTRODUCTION

The Ministry for the Environment is committed to routinely updating groundwater quality indicator data for New Zealand, as part of its National Environmental Reporting Programme. The Ministry for the Environment contracted GNS Science to collect and groom groundwater quality data from regional authorities, undertake state and trend analyses covering the period 1995 to 2008, and produce a brief technical report and summary statistics that can be used as the primary basis for national reporting.

1.1 Previous investigation

This report updates the report by Daughney and Wall (2007), which provided an assessment of state and trends in groundwater quality in New Zealand based on data collected from 1068 sites over the period 1995 to 2006 through State of the Environment (SOE) monitoring programmes operated by regional councils and through the National Groundwater Monitoring Programme (NGMP) operated by GNS Science. The main conclusions from the report of Daughney and Wall (2007) were as follows:

- Two major national-scale groundwater quality issues were identified: 1) contamination with nitrate and/or microbial pathogens and 2) naturally elevated concentrations of iron, manganese, arsenic and/or ammonia:
    - At 39% of the monitoring sites, the groundwater quality data revealed some level of human influence, with nitrate and/or sulphate concentrations above natural background levels. Such monitoring sites were found across New Zealand, especially in Waikato and Southland, and were usually situated in shallow unconfined aquifers.
    - At 30% of the monitoring sites, the groundwater quality data showed little or no evidence of human influence, but due to high levels of oxygen in the aquifer, any introduced nitrate or sulphate would likely persist and accumulate.
    - At 31% of monitoring sites, the groundwater was found to be oxygen-poor and hence was not likely to accumulate significant nitrate; however, the groundwater may accumulate high concentrations of iron, manganese, arsenic and/or ammonia due to natural processes. Such monitoring sites were found in many regions of New Zealand, particularly Gisborne, Auckland and Manawatu-Wanganui, and especially for deep wells in confined aquifers.
- At about two thirds of the monitoring sites, groundwater quality was found to be either constant over time or changing slowly (parameter values change less than 2-5% per year), probably due to the natural process of water-rock interaction. Changes in groundwater quality over time were more rapid at the remaining sites, with patterns that suggested human influence. Time trends in parameters such as nitrate and sulphate suggested either increasing or decreasing levels of human or agricultural impact at 12% and 10% of all sites, respectively.
- There were relationships between groundwater quality and well depth and aquifer characteristics, but no detectable relationships between groundwater quality (state or trends) and land use or land cover around the monitoring sites. This is a common result that has been observed in several previous studies in New Zealand and overseas—it is hard to identify and understand relationships between groundwater quality and land use unless the age and source of the groundwater being monitored are accurately known.

1.2 Scope of work

Following the methods of Daughney and Wall (2007) and in accordance with the scope of work detailed by Ministry for the Environment, this current project involved the following:

- Data analysis:
  - **State:** determine median and other percentile statistics for key indicators of groundwater quality (e.g. nitrate, *E. coli*) by region and nationally, with analyses conducted 1) for the entire period from 1995 to 2008, and 2) separately for each calendar year from 1995 to 2008;
  - **Trends:** identify and quantify time-trends for key indicators of groundwater quality for the entire period 1995 to 2008, by region and nationally; and
  - **Land use and aquifer confinement relationships:** evaluate relationships between land use, aquifer confinement and state and trends of key indicators of groundwater quality, by region and nationally;
- Outputs:
  - **Summary tables:** following the convention of Tables 7, 8, 11 and 12 in Daughney and Wall (2007), but 1) split statistics by year (for the state analyses) and region and 2) limit data presentation to key indicators of groundwater quality;
  - **Summary spreadsheets (for mapping):** tabulation of location details (eastings, northings) and site-specific median values of key indicators of groundwater quality for most recent year of record (2008) and for the entire period of data record (1995 to 2008); and
  - **Report:** brief explanation of methods, results and conclusions, including discussion of necessary caveats, for example, the extent to which regional differences or focuses in SOE monitoring network design might bias results for that region towards particular groundwater conditions, etc.

For the sake of brevity, this report does not reproduce background information provided by Daughney and Wall (2007). Readers are referred to the earlier report for the following:

- a detailed description of the SOE and NGMP datasets, including characterisation of land cover / land use, and associated data limitations;