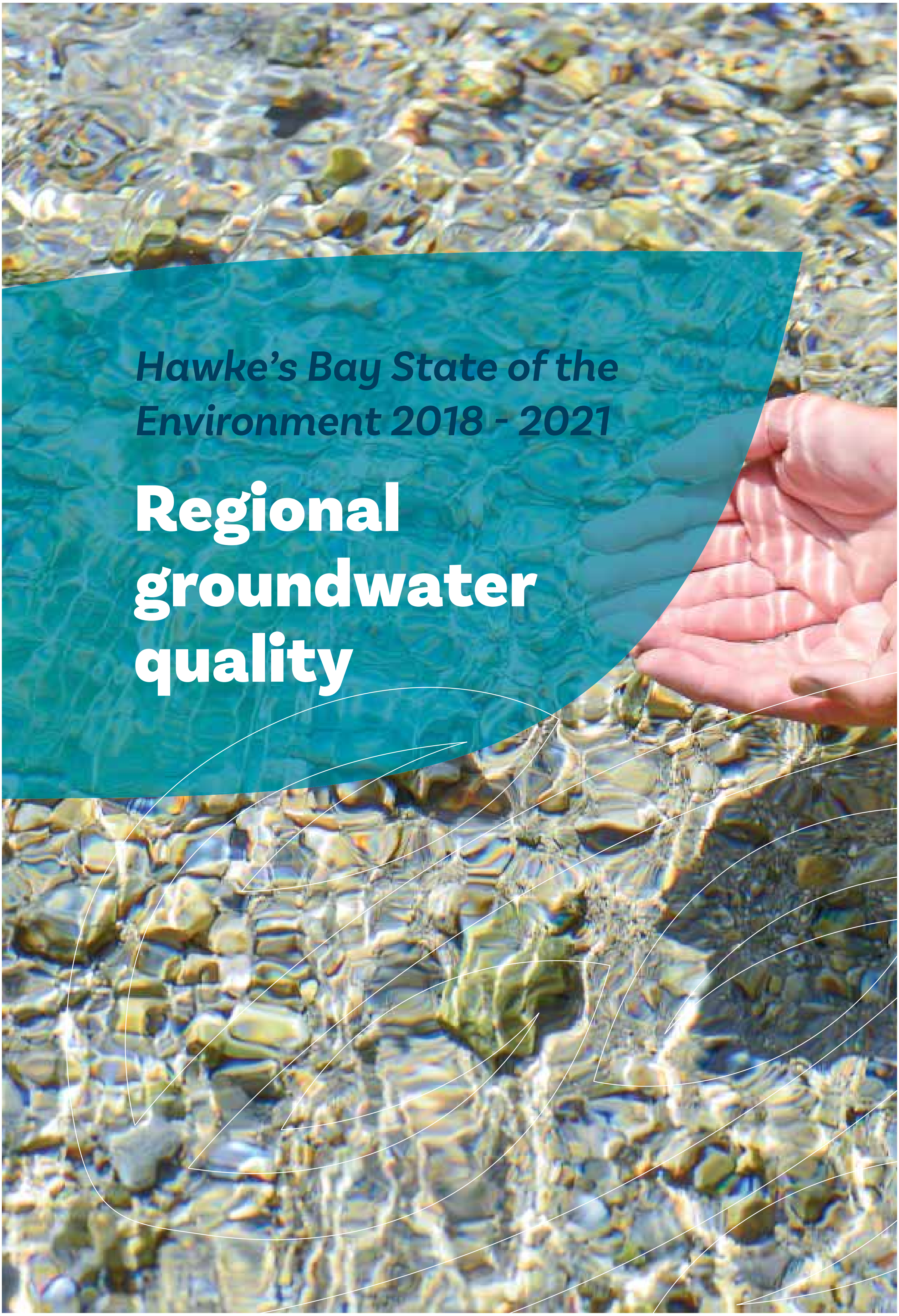


Hawke's Bay State of the Environment 2018 - 2021

Regional groundwater quality

7. Regional groundwater quality

Groundwater is the water stored in the voids of sediment and rock materials, where it can reside for anywhere from days to centuries before being abstracted or discharged. The quality of regional groundwater is largely dictated by the length of time that groundwater is in contact with rock material. The geographic location, depth, and the material type that the groundwater is sitting in can also influence the baseline quality of the groundwater.

Hawke's Bay groundwater systems are replenished through both rainfall and from the bottom of rivers and streams (Figure 7-1). Water from rain and/or surface waters typically contains relatively low concentrations of dissolved solids such as calcium, magnesium, potassium, sodium, bicarbonates, chlorides, sulphates, and nutrients.

Groundwater quality in some locations can deteriorate naturally over time as oxygen is depleted from the aquifer. This results in poorer quality water, known as 'reduced' conditions, that are typically elevated in iron and manganese. This type of groundwater has higher concentrations of soluble minerals and progressively poorer water quality for potable water supply, irrigation, and commercial/industrial activities. Under reducing groundwater conditions, concentrations of iron, manganese, and arsenic can be elevated and exceed water quality limits or guidelines. This is due to natural environmental conditions rather than the presence of human activities.

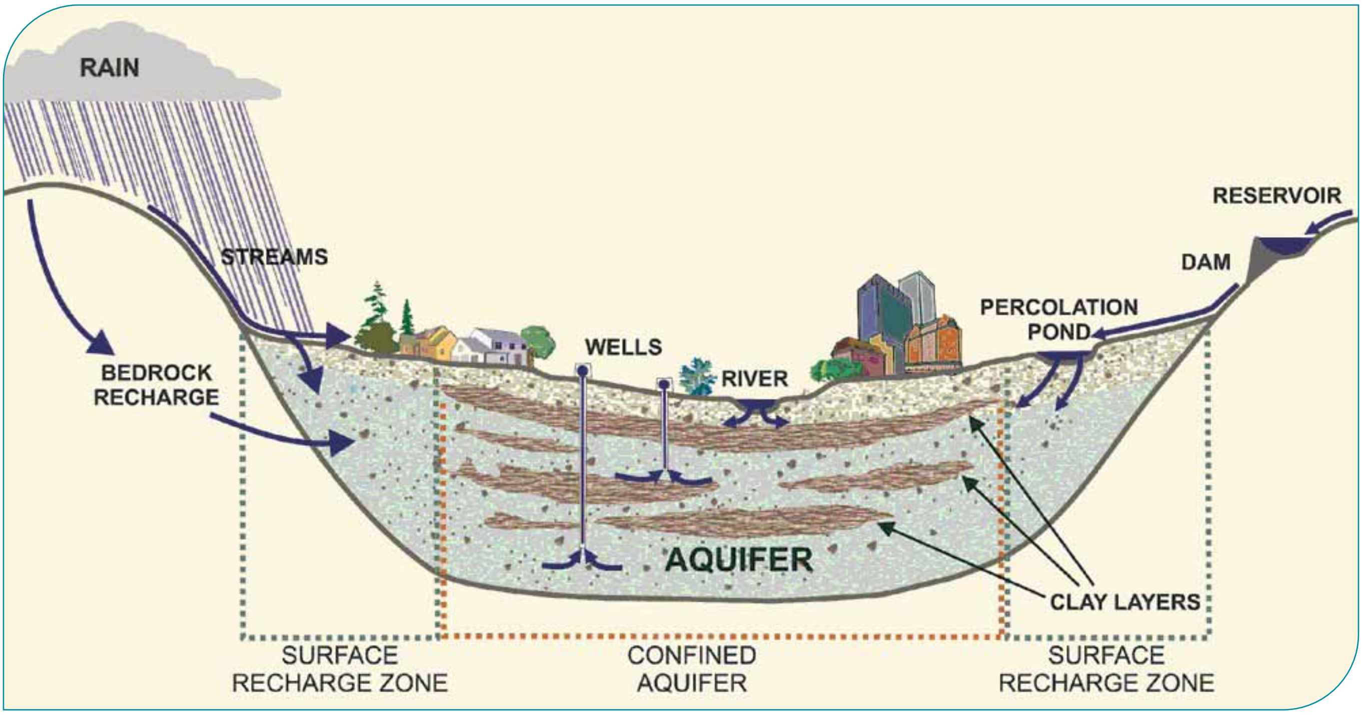


Figure 7-1. Groundwater systems are replenished from rainfall and riverbeds. What happens on the land can have a direct impact on the quality of groundwater.

Land-use impacts on groundwater

Land-use activities can influence groundwater quality, particularly in unconfined aquifers, or what is commonly known as the water table (Figure 7-2). Rainfall not retained in the soil or taken up by plants may pass through into the water table and into the groundwater. Similarly, seepage from riverbeds also replenishes the groundwater system. The dissolved materials that rain and river seepage contain (e.g., nitrates, phosphates, and microbes) can pass into groundwater and increase contamination.

Different types of land-use activities can generate either 'point' or 'diffuse' contaminant discharges. For example, septic tanks, offal holes, silage pits, landfills, effluent ponds, wastewater ponds, and underground storage tanks may lead to point source discharges if not managed correctly. Fertiliser, sprays, and animal excrement spread across paddocks are examples of diffuse contaminant sources.

Activities that discharge contaminants to land or water can also result in cumulative adverse effects on groundwater quality. For example, the impacts of irrigation and discharges to land can be amplified by urban, commercial, and industrial discharges, and sewage, and stormwater. The magnitude of groundwater contamination from diffuse sources is dependent on the type and intensity of land use.

For shallow groundwater systems that are at the coast or near estuaries (e.g., Wairoa flats), groundwater quality can be influenced by saltwater from the sea and freshwater from the land. At this interface the water quality is brackish. Freshwater can also sit as a layer above brackish (salt) water. This typically occurs in the Mahia tombolo (the sandy areas connecting Mahia Peninsula to the mainland) and other coastal settlements like the Bay View area.

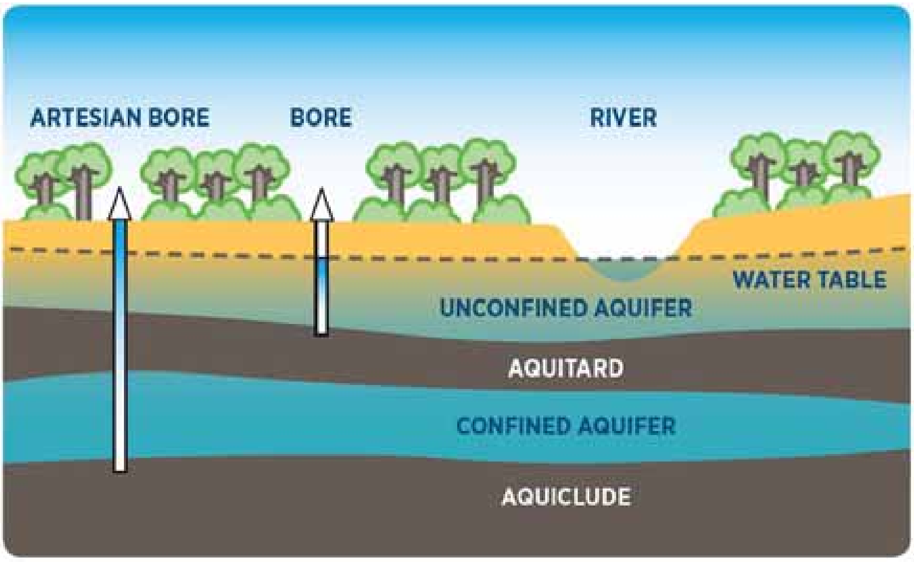


Figure 7-2. A groundwater system includes productive water flow layers (aquifer) where water is stored. This water can be accessed by wells and pumped easily for use. The aquifer can be either unconfined (water table), confined (artesian), or a combination of both. The sediment layers of a groundwater system can include aquitards, which store water but do not release it easily. Accessing water from aquitards requires a change in hydraulic pressure (pumping an aquifer). An aquiclude releases no water to the aquifer layer when hydraulic pressures change in the groundwater system (source Bay of Plenty Regional Council).

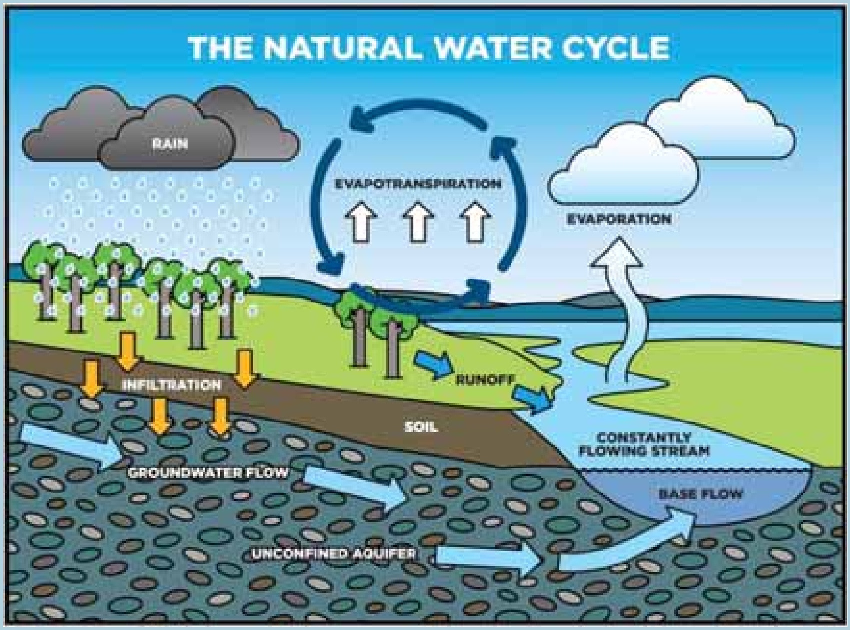


Figure 7-3. The natural water cycle includes the groundwater system. Surface water and groundwater resources need to be considered as one resource (source Bay of Plenty Regional Council).

Groundwater systems within basins (Papanui and Poukawa) and low-lying areas of the Heretaunga and Ruataniwha Plains support wetlands and peat soils. Groundwater that occurs in sediments high in organic matter such as these, typically support microbial activity that can break down this organic matter, causing the minerals and organic matter to be dissolved and released into the groundwater. These reactions typically increase the concentration of iron, manganese, and in some cases arsenic, which can adversely affect human health, as well as clogging water infrastructure and affecting the taste of drinking-water.

In gravel river systems (Taharua) and on the plains (Heretaunga and Ruataniwha), the shallow groundwater is typically oxygenated. These systems are replenished from rainfall and by their connection to streams and riverbeds. Drainage from land surfaces percolates down to the water table, and any contaminants that are not captured in the soil layer pass through to the groundwater. This makes shallow groundwater systems vulnerable to contamination from land-use activities.

Regional groundwater systems can support surface water flow throughout the year via springs and seeps. Groundwater that is hydraulically connected to lakes, rivers, streams or wetlands may provide pathways for nutrient discharge to surface water bodies (Figure 7-3). Nitrogen and phosphate are used in fertilisers to enable intensive agriculture and horticulture, and their use in areas with high permeability may lead to elevated concentrations in groundwater.

HBRC's groundwater monitoring shows that intensive land-use activities over shallow groundwater systems can strongly influence the quality of the groundwater, particularly increasing *Escherichia coli (E. coli)* and nitrate-nitrogen (NO_3-N). Changes in land-use activities can be reflected in changes in groundwater quality, and land-use management may be needed to protect groundwater quality.

As landowners become aware of the effects of certain land-use activities on groundwater quality, better land-use practices are being implemented, and the expectation is that groundwater quality will improve. Better mapping and monitoring of land-use activities and groundwater quality will help determine appropriate management practices by assessing changes in groundwater quality.

In deeper groundwater systems that are confined, land-use activities typically have less impact on water quality. However, over time oxygen is depleted in deeper groundwater systems, which can cause the release of minerals into the groundwater. This can negatively affect the natural quality of the groundwater simply as a result of the time the water has been retained in the groundwater system.

Groundwater quality monitoring

HBRC monitors groundwater quality in wells at various depths, within unconfined and confined aquifer systems (Figure 7-4). Samples are collected every three months for analysis against water quality standards set by the Hawke's Bay Regional Resource Management Plan (RRMP).

Our groundwater monitoring programme does not include assessment of groundwater quality results from compliance monitoring for resource consents for point discharges. The aim of the monitoring programme is instead to cover a variety of land-use types, across as much of the region and at as many depths as possible to provide a balanced overview of the state of groundwater quality in the region.

We have identified and are monitoring local groundwater systems in five of the six catchments in the Hawke's Bay region. The large alluvial (gravel and sand) aquifer systems of the Heretaunga and Ruataniwha Plains are the most highly productive and the most used groundwater systems in Hawke's Bay. Smaller localised aquifer systems are found along river valleys, inland basins, and coastal margins.

HBRC monitors the following groundwater systems:

- Mahia tombolo and Wairoa valley flats (Mahia-Northern Coast, Nūhaka, Wairoa)
- Taharua valley flats (Mohaka, Waihua)
- Esk valley flats (Central Coast, Esk)
- Heretaunga Plains and Poukawa basin (TANK)
- Ruataniwha Plains and Papanui basin (Tukituki)

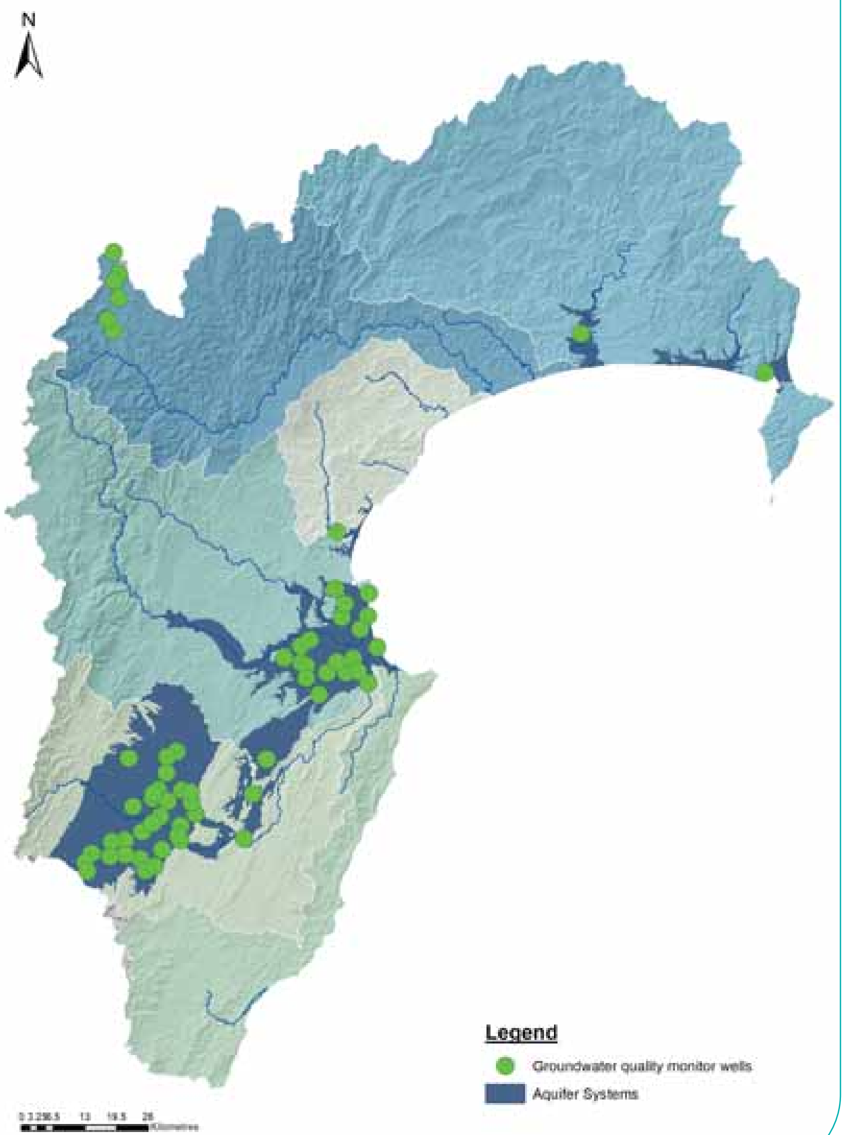
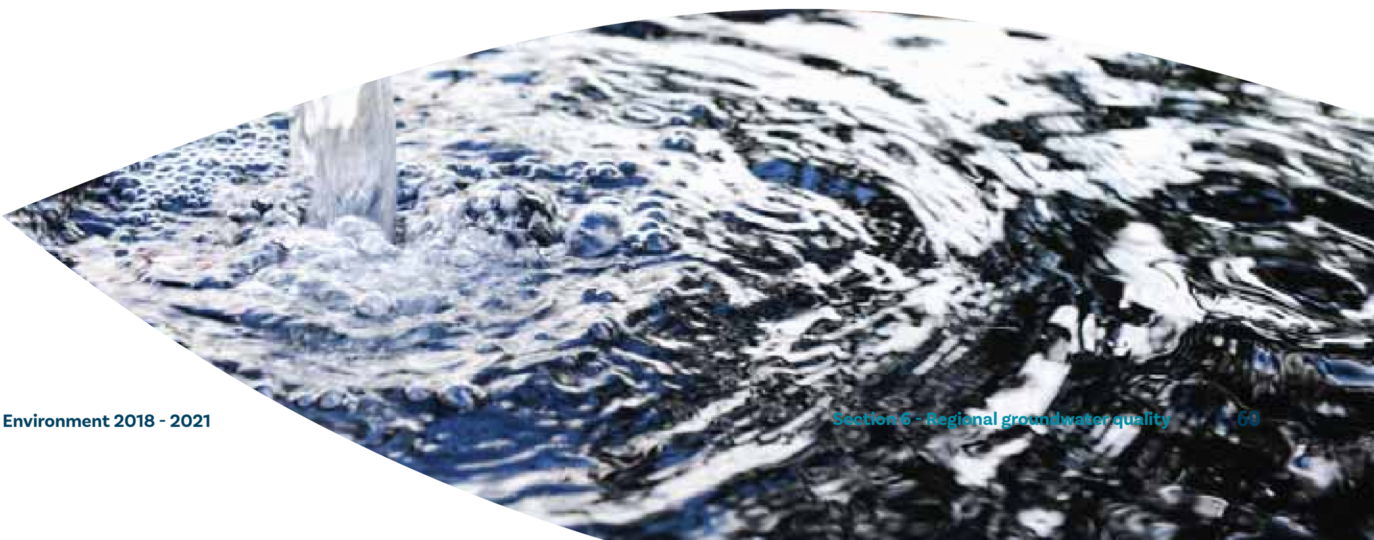


Figure 7-4. Groundwater quality monitoring wells within the groundwater systems of each catchment in Hawke's Bay.



These systems are discussed in more detail in the Land and Water sections of this report. Within each catchment, the extent of the groundwater system can be relatively small, but the depth of these systems means considerable amounts of water can be stored within them.

The monitoring results are assessed against limits and/or guideline values to identify issues with groundwater quality at specific locations and depths (Table 7-1 and Table 7-2).

The fundamental determinands analysed to understand water type and chemical properties of groundwater are Bicarbonate (HCO_3), Calcium (Ca), Chloride (Cl), Electrical conductivity (EC), Iron (Fe), THD (Total hardness), Potassium (K), Magnesium (Mg), Manganese (Mn), Sodium (Na), pH, Si (Silica), SO_4 (sulfate), alkalinity, temperature, and anion/cation balance. The main determinands analysed for human health are *E. coli* (a microbiological indicator of faecal contamination), nitrate-nitrogen and nitrite-nitrogen (nutrients), along with trace metals arsenic, chromium, copper, nickel, lead, and zinc.

Determinand	DWSNZ Health Limit MAV* (g/m3)	ANZ irrigation guidelines (g/m3)	ANZ irrigation guidelines comment
Arsenic (As)	0.010		
Chromium (Cr)	0.050		
Copper (Cu)	2.000		
E. coli (cfu/100ml)	<1		
Lead (Pb)	0.010		
Manganese (soluble) (Mn)	0.400		
Nickel (Ni)	0.080		
Nitrate-Nitrogen (NO_3 -N)	11.30		
Nitrite-Nitrogen (NO_2 -N) long-term	0.061		
Nitrite-Nitrogen (NO_2 -N) short-term	0.913		
Chloride (Cl) (mg/L)		175	Crop sensitivity
Total Hardness (Ca+Mg) as $CaCO_3$		>350 <60	Clogs irrigation equipment. Corrosion risk
Iron (Fe) (mg/L)		0.2	Clogs irrigation equipment. Crop sensitivity
Manganese (soluble) (Mn)		0.2	Clogs irrigation equipment. Crop sensitivity
pH		<6 or >8.5	Corrosion risk
Sodium (Na)		115	Crop sensitivity
Electrical Conductivity (µS/cm)		1000	Crop sensitivity

*Maximum Acceptable Value

Table 7-1. Criteria set by the Drinking Water Standards New Zealand (DWSNZ) and Australian and New Zealand Guidelines (ANZ) for groundwater quality.

Groundwater quality is assessed against criteria set by both the Drinking Water Standards of New Zealand (DWSNZ) and the Australian and New Zealand (ANZ) Guidelines for fresh and marine water quality (Table 7-1).

HBRC has also set groundwater quality limits and indicators for the Tukituki catchment in the RRMP. These include DWSNZ guidelines for human consumption (aesthetic determinands) and an indicator value for nitrate-nitrogen (Table 7-2). The proposed plan change for the TANK catchments has set a lower nitrate-nitrogen limit for groundwater quality than for the Tukituki catchment, based on aquatic ecosystem health rather than the DWSNZ (MAV 11.g/m^3).

Nutrient concentrations in groundwater may influence surface water quality where groundwater flows support surface water environments. This can encourage nuisance algae and aquatic plant growth, as well as being toxic to aquatic fauna if concentrations are high enough. Nutrients that can impact surface water quality include ammoniacal-nitrogen, nitrate-nitrogen (NO_3-N), and dissolved reactive phosphorus.

Determinand	Tukituki Indicator g/m^3	DWSNZ aesthetic guidelines g/m^3	DWSNZ aesthetic guidelines comment
Nitrate-Nitrogen (NO_3-N)	5.65		
Ammonia (NH_3-N)		1.5	Odour in alkaline conditions
Chloride (Cl)		250	Taste, corrosion
Copper (Cu)		1	Staining of laundry and sanitary ware
Total Hardness (Ca+Mg) as $CaCO_3$		200	Scale and scum formation (high hardness). Corrosive (low hardness <100)
Total Hardness (Ca+Mg) as $CaCO_3$		100-300	Taste
Iron (Fe)		0.2	Staining of laundry and sanitary ware (MAV 2 mg/L)
Manganese (soluble) (Mn)		0.04	Staining of laundry
Manganese (soluble) (Mn)		0.10	Taste
pH		7.0-8.5	Low pH high corrosion. High pH chlorine disinfection impeded
Sodium (Na)		200	Taste
Sulphate (SO_4)		250	Taste

Table 7-2. Determinands for groundwater quality set by the Hawke's Bay Regional Resource Management Plan for the Tukituki catchment.

Nitrogen in groundwater

Elevated concentrations of NO_3-N are an indicator of human influence on surface and groundwaters. The generally accepted limit for NO_3-N in a 'natural' system unimpacted by human activity is <1g/m3; levels above this indicate land-use activity that is low impact (1 g/m^3 to <5.65 g/m^3) or high impact but within DWSNZ (5.65 to <11.3 g/m^3).

Figure 7-5 shows the median NO_3-N concentrations recorded in monitored wells. One monitor well exceeded the DWSNZ limit. This shallow (15m depth) well is surrounded by land use activities for dairy, beef, and mixed sheep and beef on permeable gravel soils. Concentrations of nitrate (NO_3-N) are also considered relative to whether the groundwater system is oxidated or reduced. For oxidated groundwater conditions there may only be limited de-nitrification processes occurring, so NO_3-N concentrations remain in the groundwater. In reduced environments, NO_3-N is broken down into other compounds, (Nitrate-Nitrogen, Ammoniacal-Nitrogen, and Nitrogen gas) which means low NO_3-N concentrations may be detected even where intensive land-use activities are present.

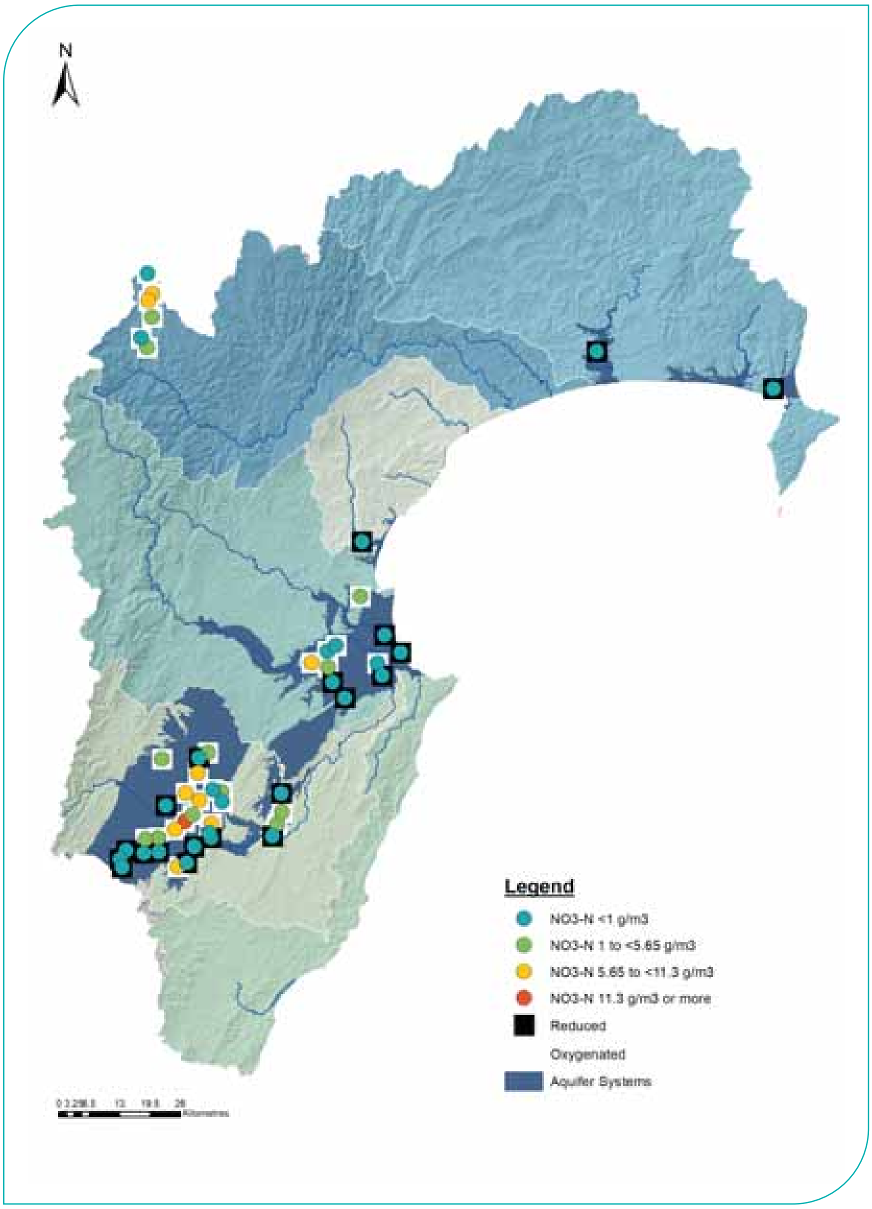


Figure 7-5. Median nitrate-nitrogen (NO3-N) concentrations at monitor wells. The concentrations are rated as natural background (<1 g/m3), low-impact land-use activities (1 to <5.65 g/m3), high-impact land-use but within the DWSNZ limits (5.65 to <11.3 g/m3) and exceeding the DWSNZ limit (11.3 g/m3or more). The white squares indicate oxygenated groundwater, and the black squares represent reduced groundwater.

Phosphorus in groundwater

The other nutrient within groundwater that can influence surface water quality is phosphorus. Phosphorus can occur naturally in some rocks, and therefore is a component of some soils and sediments. Weathering of rocks and minerals releases phosphorus in the form of Dissolved Reactive Phosphorus (DRP), which plants can absorb. DRP can occur naturally in groundwater depending on the aquifer geology and groundwater conditions. However, phosphorus is also used in fertiliser to promote agriculture and horticulture, and so high elevated levels in groundwater can indicate intensive land-use impacts.

Figure 7-6 shows median DRP concentrations in monitored wells throughout the region. HBRC has only set a limit on DRP in surface water bodies in the Tukituki catchment. The DRP limit is either 0.010g/m^3 or 0.015g/m^3 depending on the type of water body. Because the groundwater in the Tukituki catchment supports surface water baseflow at several locations, elevated DRP levels in groundwater may have adverse impacts on the receiving surface water quality. Elevated phosphorus concentrations have been associated with undesirable growths of periphyton, algae, and vascular plants in surface water bodies.

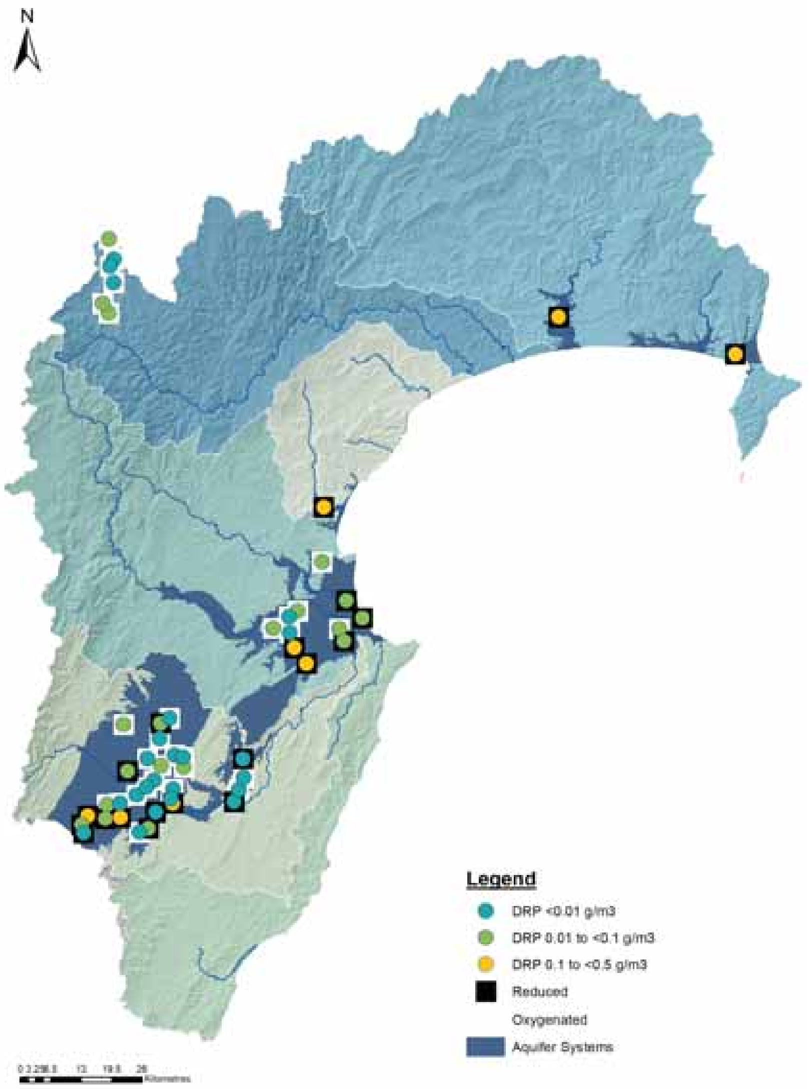


Figure 7-6. Median Dissolved Reactive Phosphorus (DRP) concentrations at monitor wells. DRP in groundwater can be influenced by land-use activities in both oxygenated (white square) and reduced (black square) groundwater conditions. However, in reduced groundwater, DRP could be partly natural due to the chemistry of the material the groundwater is stored within. There are currently no formal limits set for DRP outside of the Tukituki catchment.

Iron, manganese and arsenic in groundwater

Figure 7-7 shows median iron (Fe), manganese (Mn) and arsenic (As) concentrations in monitored wells throughout the region. Natural (background) concentrations of iron, manganese and arsenic can be attributed to the material the groundwater is stored within. Often, iron, manganese and arsenic concentrations are elevated in reduced groundwater environments, which release minerals from the surrounding sediment. However, just because the groundwater is reduced does not necessarily mean the concentrations of these minerals will be elevated.

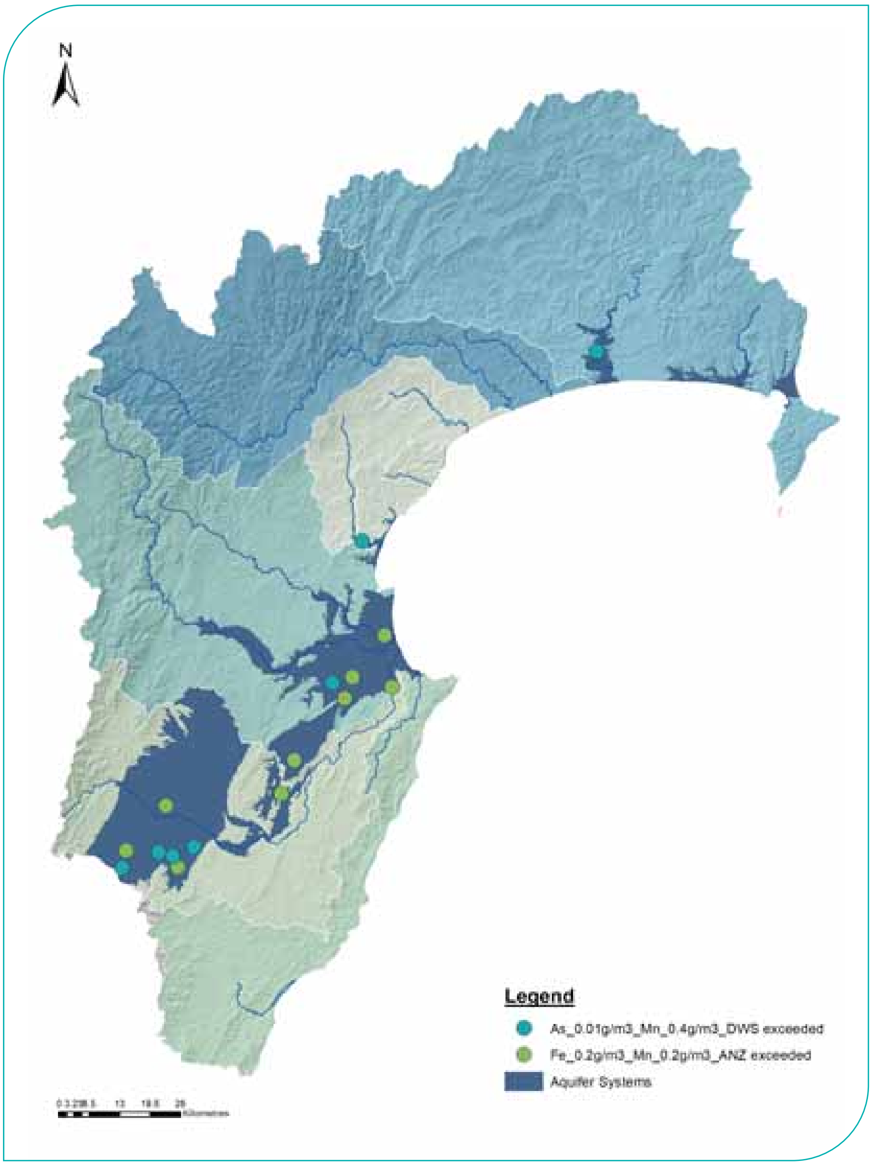
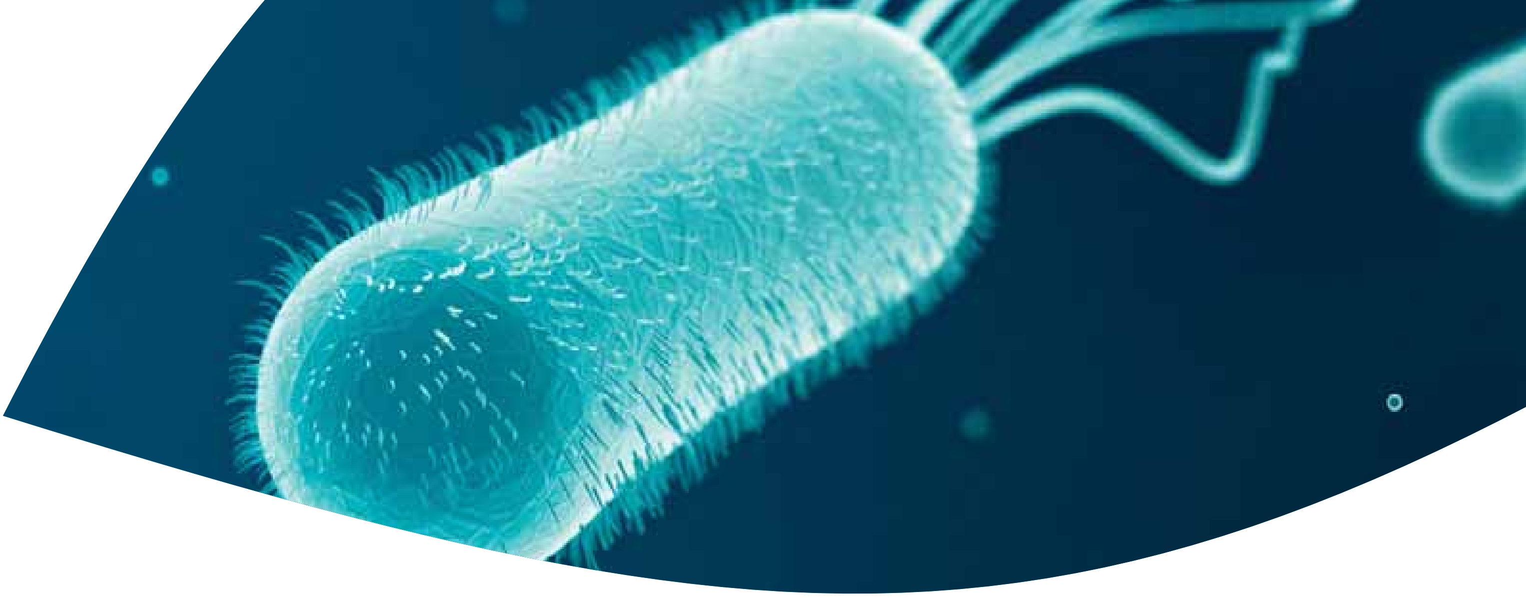


Figure 7 7. Iron (Fe), Manganese (Mn), and Arsenic (As) median concentrations at monitor wells. Blue dots are wells where DWSNZ were exceeded for Mn or As, or both. Green dots are wells where the ANZ Guidelines were exceeded for Fe or Mn, or both.



Esherichia coli (E. coli) in groundwater

The DWSNZ sets a maximum acceptable value for E. coli as an indicator bacteria for pathogenic contamination. This indicates drinking water that is suitable for human consumption without water treatment. The compliance limit is less than one E. coli bacterium in 100mL of water.

Figure 7-8 shows that six monitored wells have had *E. coli* contamination of groundwater at least once over the past five years. Four of these wells are shallow (<30m depth) and have exceeded *E. coli* two to three times. In unconfined groundwater systems, wells drawing groundwater from depths of greater than 30 metres are less likely to contain *E. coli* than at shallower depths. Shallow groundwater systems (<30m depth) are more likely to be influenced by land-use activities.

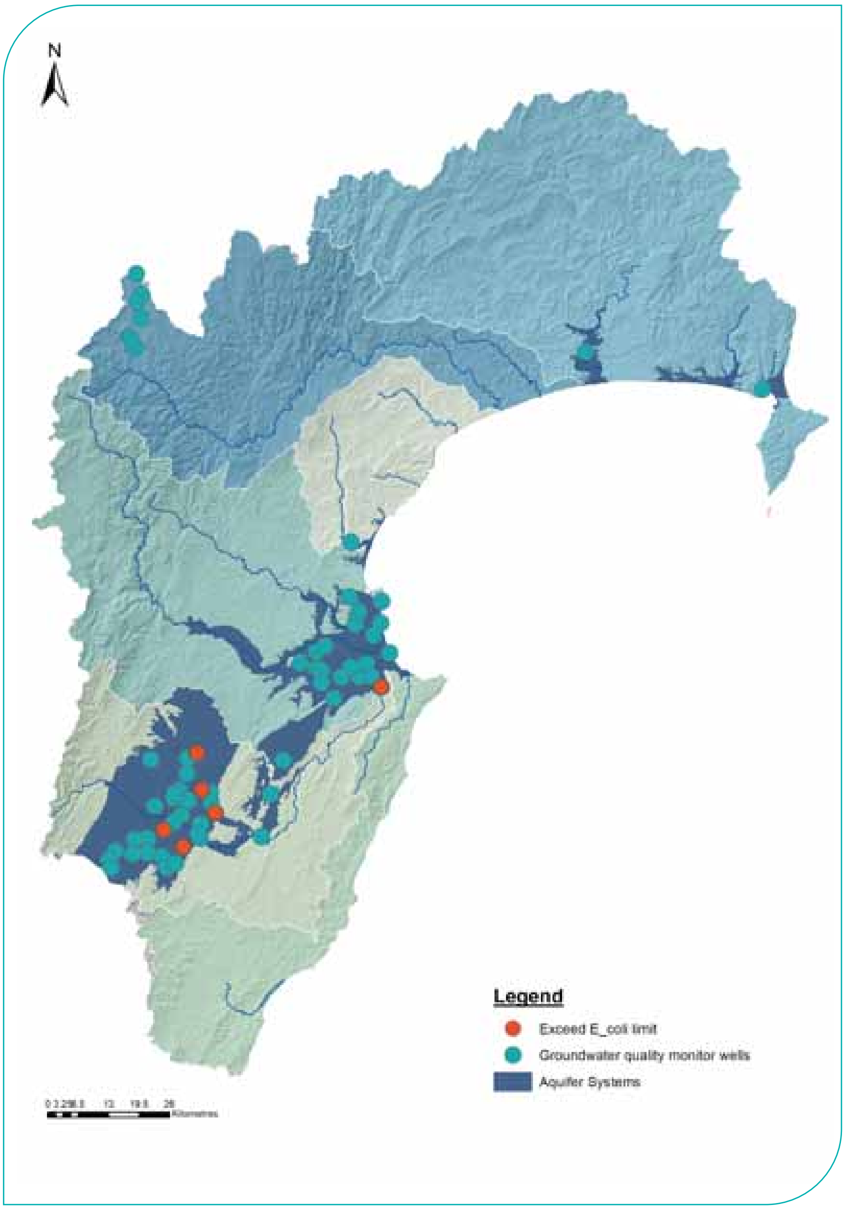


Figure 7-8. Well monitoring indicates E. coli *contamination of groundwater at least once over the past five years at six sites (red dots)*