GUIDING GROUNDWATER RESOURCE MANAGEMENT

GROUNDWATER FORUM

SCIENCE AND TECHNOLOGY STRATEGY **2021**

Guiding Groundwater Resource Management

Groundwater Forum

Science and Technology Strategy 2021

Prepared for Groundwater Special Interest Group (GW-SIG) on behalf of regional councils and unitary authorities of New Zealand Funded by Envirolink Advice Grant 2114-TSDC175

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Cover photo: Te Waikoropupū Springs (Pupu Springs), Golden Bay, South Island NZ.
Back cover: Te Waihou Walkway (Blue Springs), Waikato, North Island NZ

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Introduction

Who are we?

The Groundwater Forum members are scientists and technical staff from regional councils and unitary authorities who work on groundwater.

We are one of many Special Interest Groups (SIGs) under the overview of the Resource Managers Group, while the entire SIG network is overseen by the Regional Chief Executive Officers. The regional sector also has a Science Advisory Group who, with a view to the science funding framework, advise how Councils can pursue high quality, relevant research, and timely and appropriate knowledge transfer mechanisms.

The Groundwater Forum acts as a source of cross organisational collegial advice, able to network people to fill gaps, build knowledge and share experiences. The scope of our members' work includes monitoring, investigations, communication and input to policy and resource consents. We work closely with researchers (CRIs and other research agencies) and with government departments, particularly the Ministry for the Environment, Ministry of Primary Industries, and the Science and Technology section of the Ministry of Business, Innovation and Employment (MBIE). We can commission our own knowledge transfer and tool development through MBIE's Envirolink fund.

Purpose of this report

This report is our Groundwater Forum (Groundwater SIG) Science and Technology Research Strategy.

Its intent is to identify important science and technology priorities as well as factors that should be included in the research design.

This strategy builds on previous priorities developed in 2013 and 2017.

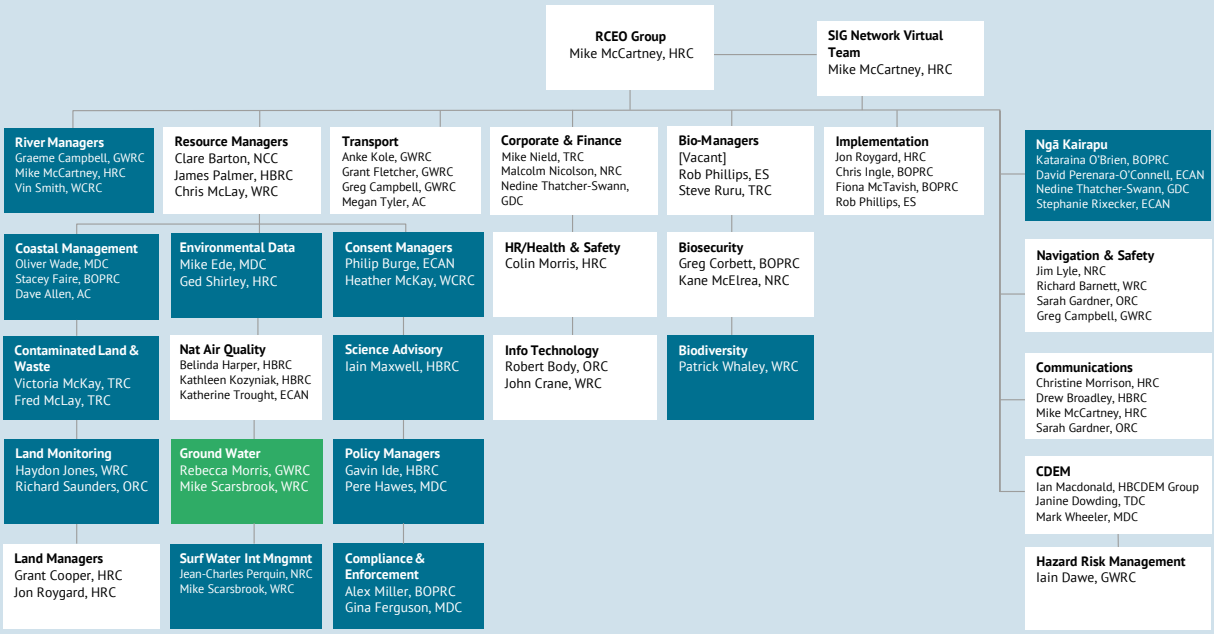

Figure 1: The place of the Groundwater Forum (Groundwater SIG, green box) within the SIG network and the SIGs that we connect mostly with through our research (blue boxes).

Photo: Environment Canterbury Regional Council

Our context – Science priorities in the regional sector

This strategy is under the umbrella of a broader science-related strategy by the collective regional councils. The Regional Council Research Science & Technology Strategy[1] has set a vision for regional council involvement in science (Science Advisory Group Strategy 2020)

The Regional Council vision is to be effectively involved in the identification, development, communication and implementation of research, science and technology that will undergird Regional and Unitary Councils' actions for the wider benefit of New Zealanders.

'Effective involvement' covers collaboration and coordination between councils and with research providers and funders; credible and timely engagement; clarity around current and future research priorities; meaningful partnerships; transfer and uptake of research and knowledge; and promoting the availability of RS&T capability and capacity.

Process for developing the Groundwater Strategy

This Groundwater Science and Technology Strategy was prepared through Envirolink Funding (Grant number 2114-TSDC175) to Manaaki Whenua Landcare Research. It was prepared by a working group of:

Rebecca Morris	Greater Wellington Regional Council and Convenor of the Groundwater Forum
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Christina Robb	Happen Consulting Limited

A workshop was held in November 2020 to seek input from all members of the Groundwater Forum. Research scientists from NIWA, GNS, ESR, Lincoln Agritech, Manaaki Whenua Landcare Research and Aqualinc also attended.

Members of the Groundwater Forum provided input to a draft strategy document.

1 https://www.envirolink.govt.nz/assets/Research-for-Resource-Management-2020.pdf (envirolink.govt.nz)

The Research Science and Technology Strategy has four goals and 10 priorities

Goal 1
To provide timely, authoritative and respected direction to science research and funding.

Goal 2
To catalyse and enhance science delivery.

Goal 3
To facilitate science uptake.

Goal 4
To ensure an ongoing RS&T strategy process.

Priorities

1. Influencing government science direction
2. Incorporation of mātauranga Māori
3. Better science utilisation
4. Enhancing policy effectiveness
5. Integrating land and water science for enhanced sustainable production
6. Improving biosecurity and biodiversity
7. Better hazard risk management
8. Improving coastal management
9. Cross-cutting themes: Adaptation and mitigation to climate change and improving data management
10. Retaining and building science capability and capacity

This Groundwater Forum Science and Technology Strategy responds directly to Goal 1 and contributes to other goals and all the priorities.

The importance of groundwater to New Zealand

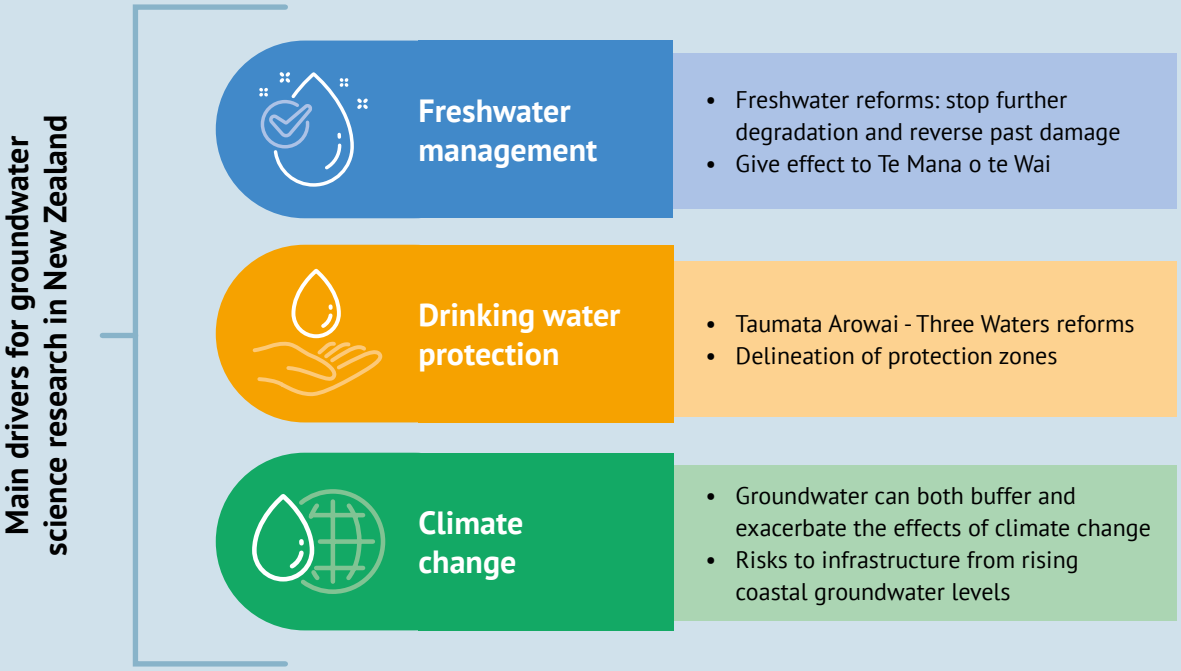


Figure 2: Main drivers for groundwater science and research in New Zealand, which also form the main drivers for the Groundwater Forum Science and Technology Strategy

Freshwater management

Freshwater ecosystems, flows and water quality are vital for the health of New Zealand's people, environment, and economy. Groundwater is a key part of the hydrological cycle and vital to the overall management of freshwater. Understanding groundwater, for itself and for its connections to surface water, is a critical part of designing and implementing actions to improve water quality and enhance freshwater ecosystems. Groundwater provides flows to and from rivers, lakes, wetlands, the coast and estuaries. It sustains baseflows and during summer will supply nearly all surface water.

Public concerns about freshwater ecosystems, water quality and water flows are growing. Scrutiny of regional councils' management of freshwater has increased significantly over the last five years. In September 2020, the Government released a reform package for freshwater to:

- stop further degradation of New Zealand's freshwater resources and start making immediate improvements so that water quality is materially improving within five years; and
- reverse past damage to bring New Zealand's freshwater resources, waterways and ecosystems to a healthy state within a generation.

Implementation of reforms via the National Policy Statement for Freshwater Management 2020 (NPS-FM) include requirements to:

- Manage freshwater in a way that 'gives effect' to Te Mana o te Wai:
    - through involving tangata whenua
    - working with tangata whenua and communities to set long-term visions and freshwater outcomes
    - prioritising the health and wellbeing of water bodies, then the essential needs of people, followed by other uses.
- Improve degraded water bodies and maintain or improve all others.

The NPS-FM requires the setting of freshwater outcomes and environmental flows and levels for groundwater. For surface water – lakes and rivers -the NPS-FM specifies attributes and attribute bands including national bottom lines which will inform freshwater outcomes for surface water. There are no national attributes for groundwater, however the requirement to maintain or improve water quality does apply to groundwater as do the requirements around setting environmental flows and levels, monitoring and freshwater accounting.

Regional and unitary councils have since 1991 developed regional plans under the Resource Management Act to manage water resources including groundwater. In order to set limits on water take and manage water quality, these plans require detailed knowledge of aquifer extent, groundwater flows/levels, water quality and vulnerabilities to exploitation. Groundwater science and technology are essential to implementing these national and regional directives for effective water and land management.

Drinking water protection
and the other Three Waters

As part of its ongoing Three Waters Reform, the Government is strengthening the regulatory framework for drinking water. A new entity - Taumata Arowai - administers New Zealand's drinking water regulatory system to achieve drinking water safety and public health outcomes. It also has an oversight role for wastewater and stormwater. Taumata Arowai must give effect to Te Mana o te Wai as set out in the National Policy Statement for Freshwater Management.

Risks to drinking water from its sources are managed under the RMA. The 2008 National Environmental Standard for Sources of Human Drinking Water applies to sources such as aquifers or springs, as well as rivers, lakes and other natural waters that are sources of human drinking water. Regional councils must manage activities in drinking water protection zones through RMA plans and resource consents. The National Environmental Standard for Sources of Human Drinking Water is scheduled to be strengthened in 2021.

Setting drinking water protection zones – identifying the land area over which risks to drinking water need to be managed - is a critical part of protecting drinking water. Drinking water suppliers need to prepare a water safety plan that identifies and manages risks to drinking water from its source. When drinking water is sourced from groundwater, drinking water protection zones are based on understanding groundwater flow paths, contaminant transport/transformation, and well-head dynamics. Understanding groundwater flow and contaminant transport dynamics is critical to the delineating and management of drinking water protection zones and hence to the safety of drinking water in New Zealand.

Ministry of Health data (2018-2019)[2] on the 490 registered drinking water supplies indicates that 20% of that population are totally dependent on groundwater as a drinking water source, and another 50% are supplied by a combination of ground and surface water. The data excludes any supply to less than 100 people including those who have individual bores. Even without data on small or individual supplies, it is clear that over two-thirds of New Zealand's population relies on groundwater for its drinking water.

Management of the other two waters - wastewater and stormwater – also requires groundwater understanding, particularly when these are discharged to land. The trend for wastewater to be discharged to land, rather than directly into rivers or the coast, is driving a need to understand risks to groundwater and consequential risks to surface water and to groundwater users.

2 Ministry of Health 2020. Annual report on Drinking Water Quality, Wellington Ministry of Health.

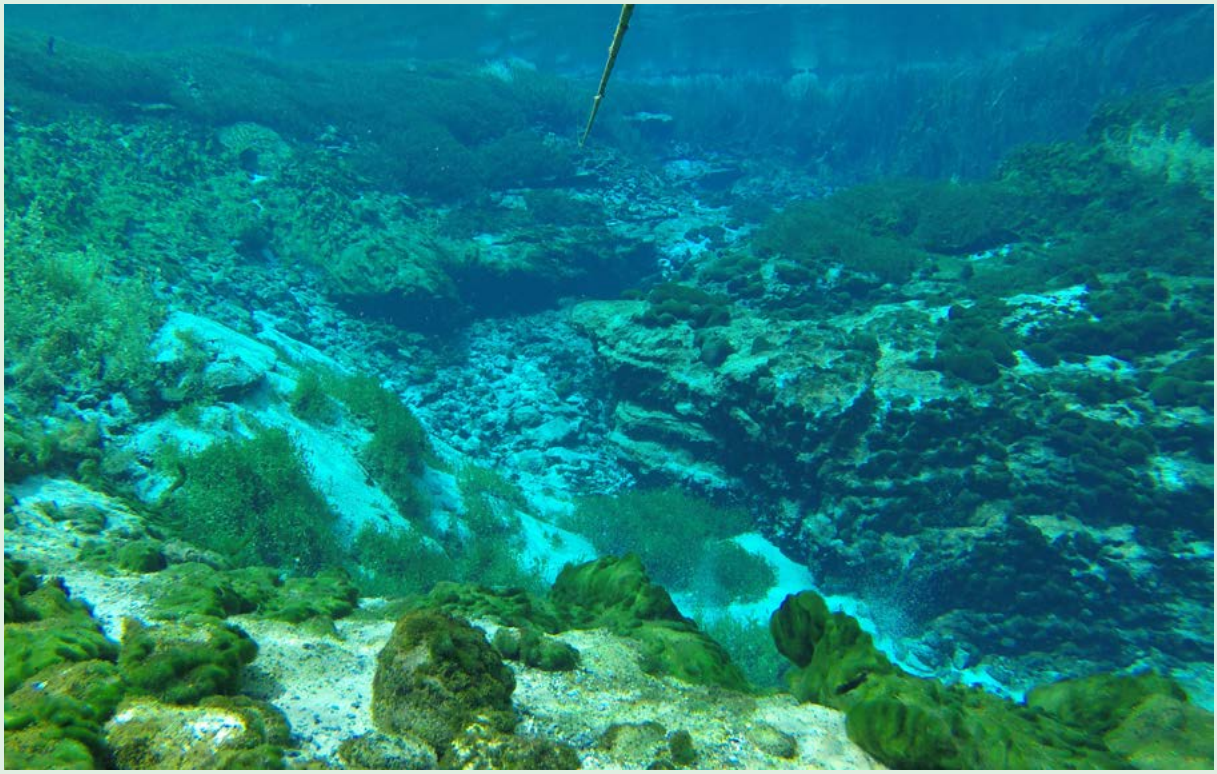
Climate change
and community resilience

Groundwater has the potential to both buffer and exacerbate the effects of climate change on freshwater- water quantity, water quality and freshwater ecosystems - and communities.

Groundwater systems will be affected by climate change. Groundwater flows are altered by changing rainfall patterns, changing temperatures, changes in surface water flows and sea level rise. Changing land use patterns also influence flow and contaminant input to groundwater. As sea level rises, the inland intrusion of salt water into or under groundwater systems will increase, and the depth to groundwater in coastal areas will reduce.

As part of a catchment ecosystem, groundwater is exchanged to and from surface water systems and the coast. Changes in groundwater systems therefore have implications for other freshwater in the catchment. In many situations, groundwater acts as a buffer providing baseflow to rivers. In summer, groundwater is often the only source of flow. The buffer capacity provides greater drought resilience. Changing flow patterns will alter the amount and timing of recharge into and out of groundwater, and potentially change the rate and location of contaminant flows. These will have effects on freshwater ecosystems, and on the reliability and availability of water for use.

The risk to infrastructure from rising coastal groundwater levels is acknowledged and beginning to be factored into climate change response. An important consideration is the intrusion of salt water into drinking water supply wells, and increased drainage risks from groundwater inundation.



Research design

At a workshop to develop and test groundwater science priorities, it became clear that the research design and the implementation pathways provided are critical to uptake of research by regional councils.

The way research is conceptualised, carried out and communicated is as important as the research questions. In this strategy, we have separated the research design (the "how") from the research questions (the "what"). Research design is discussed here and research questions (the"what") are in the following sections 1 to 7.

The Groundwater Forum has identified seven elements of research design that make groundwater research most useful to regional councils.

Figure 3: Seven essential elements to be included in research design that make groundwater research most useful to regional councils.

Incorporation of Te Ao Māori

Te Mana o te Wai is fundamental concept in the National Policy Statement on Freshwater Management (2020). This most recent version of the NPS-FM provides greater certainty that freshwater management in New Zealand must be informed by:

(a) *Mana whakahaere:* the power, authority, and obligations of tangata whenua to make decisions that maintain, protect, and sustain the health and well-being of, and their relationship with, freshwater

(b) *Kaitiakitanga:* the obligation of tangata whenua to preserve, restore, enhance, and sustainably use freshwater for the benefit of present and future generations

(c) *Manaakitanga:* the process by which tangata whenua show respect, generosity, and care for freshwater and for others

The Groundwater Forum encourages inclusion of research that can help us work with local tangata whenua to understand and provide for a Māori view of groundwater.

Ki uta ki tai - Integration across domains and disciplines

Groundwater is a fundamental contributor to catchment flows and water quality. The importance of groundwater is most obvious once it flows into rivers, lakes, wetlands, the coast and estuaries. It is a source of water to surface water ecosystems, can have a strong influence on surface water temperature, sustains baseflows especially in summer, and can be both a source and receptor of contaminants. It is important that groundwater research assists us to incorporate groundwater dynamics into catchment decision making by understanding and describing those connections. In particular, groundwater's connections to:

- Surface water ecosystems including wetlands
- Coastal environments
- Land use, land contamination and land management.

Groundwater expertise needs to be included in any research that seeks to advise on catchment-scale:

- Policy development and evaluation – how to set freshwater outcomes, limits and assess plan effectiveness over time.
- Economic and social assessments; and
- Integrated monitoring across surface water, groundwater and ecosystems, but also across cultural, social, economic and environmental outcomes.

Integration may be achieved by improving connections between research projects or through integrated research programmes, particularly at the level of conceptual or systems models. As well as integrated science, the Groundwater Forum is keen to work with other Special Interest Groups (SIG); we have identified in our priority research questions where we could link with other SIGs.

Adaptive approaches that give explicit recognition to uncertainties

Groundwater poses a peculiar set of uncertainties because the geology and flow paths are unseen and complex. It requires intensive, often three-dimensional, geological data, and spatial detail in recharge components to accurately describe aquifer properties and aquifer extent. Groundwater investigations and monitoring are often expensive, given the need to install wells or calibrate geophysical modelling. Further, understanding the temporal and spatial variation in flows, contaminant flows, attenuation and groundwater ecosystems requires monitoring data specific to the management scale. For example, there are different requirements for accuracy when understanding an entire system to manage overall abstraction, versus local data to manage how pumping from a well induces drawdown in a neighbouring well. Often, groundwater is managed using only a fraction of data compared to what is ideal.

Groundwater research should allow us to understand and communicate the implications of uncertainties at various scales. We encourage research that prioritises those uncertainties that are feasible and most beneficial to resolve at various scales and identifies what management or monitoring options could help reduce uncertainty.

Essentially, we encourage research that assists us to take an adaptive approach to improving understanding and management of groundwater which includes recognising and, if possible, reducing uncertainties.

Increased public communication on groundwater

Regional councils must engage with communities and tangata whenua when implementing the National Policy Statement on Freshwater Management (2020), and in determining freshwater outcomes as part of regional plans. In addition, Councils publicly report groundwater monitoring information (e.g., via the LAWA site at *Land, Air, Water Aotearoa (LAWA) - Groundwater Quality*). The Groundwater Forum encourages research, researchers and technologies that assist us in communicating groundwater science to multiple audiences including:

- Scientists from other disciplines
- RMA planners
- Landowners and land managers
- Councillors and the public.

Importantly, we need to explain the implications of research and management for each audience, including uncertainties.

Provision of toolboxes that reflect values, risks and costs

Groundwater scale, complexity and use varies across New Zealand. Similarly, the priority and funding given to groundwater monitoring and investigations varies across Councils. There are some groundwater systems with hundreds of monitored bores and extensive modelling, and many groundwater systems monitored with a single monitoring well. Often the degree to which monitoring exists within each groundwater system is relative to the pressure on the resource.

When research outputs include models and decision support systems for groundwater management, we would like to see a toolbox of options that respond to the scale and importance of the issue that has to be addressed. Options should reflect a realistic range in:

- data availability,
- scale of analysis
- type of aquifer including heterogeneity
- connection to other waterbodies and sensitivity of the receiving environment
- values and risks and the type of activities occurring in the catchment
- resourcing costs (people and time), and
- timeframes for decision-making.

Research could be structured to help establish the value of increased monitoring or modelling through providing additional management options or to reducing uncertainty.

Standardised monitoring and reporting protocols, and consistent databases

The Research and Technology Strategy[3] (SAG 2020) identifies that Managing the increasing quantities of data becoming available is a major challenge not only for Regional Councils but for all organisations involved in environmental data collection as new technologies make it easier and less expensive to collect information. There are currently a number of projects underway to improve both the standardisation of data collection across the sector but also investigate new technologies for data collection.

Database development is an essential component of the research process and has an important role in the facilitation of groundwater research, analysis, and communication. The move toward centralised databases for environmental data shows promise for better data management, quality control, and national consistency.

The Groundwater Forum supports the need for standard methodologies for monitoring, storing and reporting groundwater data including analysis techniques and tools that are repeatable and automated, and the capture of historic data to better evaluate trends. We strongly support industry standards like the New Zealand Standard for Drilling of Rock and Soil. We will continue to develop National Environmental Monitoring standards for groundwater and welcome research that accelerates and supports this work.

Reporting from science projects

It is difficult to get a snapshot of funded groundwater research. We welcome the provision of updates by research agencies, opportunities to participate in research, and the active participation by researchers with the Groundwater Forum. We participate in the setting of research objectives and outcomes, and while we get updates on research, it is not always mapped to the initial objectives and outcomes (for example, those in this Strategy). We would like to see a report against these, which could be co-ordinated from MBIE.

3 Research for Resource Management Regional Council Research, Science & Technology Strategy 2020. Science Advisory Group https://www.envirolink.govt.nz/assets/Research-for-Resource-Management-2020.pdf

Photo: Environment Canterbury Regional Council

Priority research questions

This chapter contains a set of research questions that are the "what" and complement the previous chapter on the "how" research is undertaken, and implementation tools provided. This chapter outlines a set of 16 priority research questions grouped into 7 sections as follows.

Improved understanding fundamental research

Research priorities 1 and 2 relate to improving understanding (fundamental research) on groundwater itself (research priority 1) and groundwater interactions with other parts of a catchment (research priority 2).

Applied research and implementation tools

Research priorities 3 to 5 are more applied research questions arising as regional councils respond to three important drivers – drinking water (research priority 3), freshwater management and the NPS-FM (research priority 4) and climate change (research priority 5).

Technologies

The final two research priorities move more towards technologies: research priority 6 concentrates on mitigation and restoration options and research priority 1 on technologies for monitoring and investigations.

Some of the priority questions have been the subject of past research and understanding continues to evolve. As research progresses, we are able to answer questions at a greater range of temporal and spatial scales and appropriate to more risks. The new questions we have identified are research into Māori values for freshwater, more tools for incorporating connections between groundwater and other waterbodies in a catchment, and incorporation of groundwater into climate change risk assessment and adaptation.

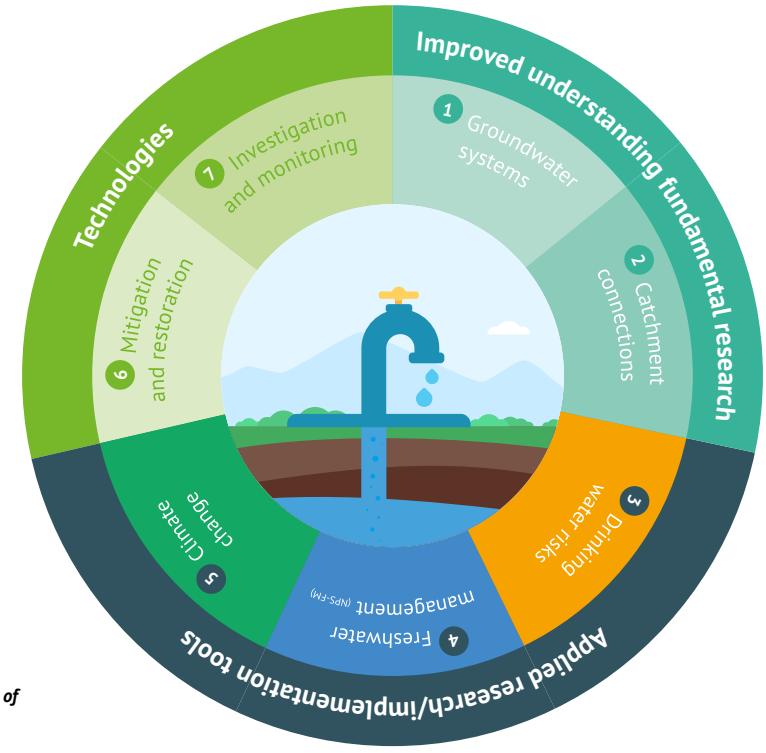


Figure 4: Main areas of research that form the background of our priority research questions

Timing

Our sets of priority questions all have immediate, short (up to 5 years) and long-term aspects. Rather than identify timeframes for each, we have sought to describe our immediate implementation needs and the ones needed over the next five years which are driven by legislative deadlines.

While there are legislative deadlines, the needs to continually improve understanding, anticipate future issues and develop innovative technologies and solutions are just as critical. We want to emphasise that these **short-term needs do not replace the importance of starting longer term research on priority questions.**

We consider that the groundwater research community can assist immediately, in the short term (next five years) and through longer and ongoing research programmes with the priority questions. The immediate needs are most likely to be addressed through work with Councils or the Ministry for the Environment.

Immediate implementation needs:

- **Research and tools that improve understanding and management of drinking water risks**
- **Tools and approaches for tangata whenua on Māori outcomes for groundwater**
- **Tools that support the development of freshwater RMA plan provisions by 2024**
- **Communication of groundwater values and technical uncertainties to communities.**

Of necessity, these need to use existing monitoring data, apply completed research, and use system-level conceptual understanding.

In the short term, before 2026, we will need:

- **Consistent approaches to freshwater accounting – groundwater quality and quantity**
- **Ecosystem health monitoring for groundwater**
- **Incorporation of mātauranga and Māori freshwater outcomes into monitoring programme design**
- **Innovative approaches to water allocation and water supply resilience**

Improved understanding and fundamental research

1

Understanding groundwater systems – essential for protecting Te Mana o te Wai

Improving our understanding of groundwater systems and how they function by researching Te Ao Maori view of groundwater systems, groundwater ecosystems, geology, hydrogeology and contaminant movement.

A set of priority research questions about how we understand groundwater systems and how they function including:

- Te Ao Maori view of groundwater systems
- Groundwater ecosystems – what lives in groundwater?
- Geology and hydrogeology – structure, extent and properties of aquifers; groundwater volumes, flow paths, and residence times of groundwater
- Contaminant movement – paths, time lags, transformations, attenuation within groundwater

Research Question 1.1

How to provide for Māori outcomes for groundwater?

Understanding tangata whenua's cultural connections to springs (puna), cave systems and groundwater systems more broadly, would assist in better managing groundwaters to protect and restore these values but only if understanding is gathered in a way that respects cultural sensitivities and tikanga.

Focussing on:

- Tools and approaches for local tangata whenua to contribute knowledge on groundwater values and freshwater outcomes for groundwater and for associated surface water systems
- Understanding how Māori values and outcomes for groundwater are influenced by groundwater quantity and groundwater quality
- Understanding how Māori values and outcomes for groundwater can be protected and enhanced

SIG Connections:

- Ngā Kairapu
- Surface Water Integrated Management

Timing:
(Refer to page 15)

Research Question 1.2

What is the role and sensitivities of groundwater ecosystems?

Focussing on:

- Mapping and inventory tools for groundwater biota
- Understanding the role of groundwater biota in filtering or transforming contaminants in groundwater and in maintaining flow (pore spaces)
- Exploring the potential of using groundwater biota as an indicator of groundwater quality and ecosystem health (rather than compartmentalised contaminants)
- Understanding the sensitivity of groundwater biota to nitrogen, dissolved oxygen and other important constituents

Timing:
(Refer to page 15)

Research Question 1.3

How to improve assessment of groundwater geology and hydrogeology?

Focussing on:

- Understanding the most appropriate ways to assess aquifer parameters and how groundwater flows into and through aquifers at various scales. For example, how can aquifer test data be applied at a range of scales, or how to structure drilling information to describe aquifer properties
- Understanding flow in fractured systems, along preferential flow paths, and in shallow versus deep groundwater
- Improving accounting in groundwater budgets, particularly for flows to and from rivers, and to the coast
- Innovative methods to deduce groundwater flow and contaminant load from surface water monitoring data

SIG Connections:

- Environmental data
- Surface Water Integrated Management

Timing:
(Refer to page 15)

Research Question 1.4

How to predict the movement of contaminants within groundwater?

Focussing on:

- Understanding catchment scale attenuation., particularly denitrification. What is the magnitude of attenuation and over what timeframe? What is the role of anoxic conditions in contaminant attenuation
- Improving understanding of pathogen survival rates – e.g., viruses and protozoa in fractured and karst systems (systems other than alluvial aquifers)
- Improving prediction of contaminant flow paths, particularly in fractured systems and along preferential flow paths including shifts after earthquakes
- Understanding the role of temperature in groundwater contaminant flow, focussing on lower heat inputs rather than full geothermal

SIG Connections:

- Land monitoring
- Contaminated Land and Waste

Timing:
(Refer to page 15)

Improved understanding and fundamental research

2

Ki uta ki tai - Understanding catchment connections of groundwater

Improving our understanding of the contribution groundwater makes to the health of a catchment through its connections with other water bodies, land use and cultural use.

A set of priority research questions about the contribution groundwater makes to the health of a catchment through its connections with other water bodies, including:

- Dynamics of groundwater flows (quantity and quality) to and from other water bodies and its variation in time and spatially
- Influence of land use – urban and rural
- Outputs and inputs into wetlands, rivers, lakes, lagoons, coasts
- Te Mana o te Wai for all waters in a catchment
- Taking a ki uta ki tai – integrated approach – to catchment understanding

Research on these priority questions will contribute to answering priority questions in each of the following sections 3 and 4 – drinking water protection zones and the National Policy Statement on Freshwater Management.

Research question 2.1

How does groundwater contribute to the health of surface water ecosystems?

Focussing on:

- Improving understanding and methods for assessment of wetland hydrology and connections to the groundwater system.
- Tools for quantifying groundwater flows into lakes, wetlands, estuaries, other aquifers, coasts and transitional waters
- Improving understanding of the importance of groundwater inflow dynamics to the ecosystem health of rivers, lakes, wetlands, estuaries and other aquifers at different spatial and temporal scales
- Understanding the role of offshore groundwater flows on estuaries and coastal ecosystem health
- Improving methods for assessing and managing stream depletion both from pumping and from regional water table variability

SIG Connections:

- Surface Water Integrated Management
- Coastal Management
- Biodiversity (wetlands)

Timing:
(Refer to page 15)

Research question 2.2

How to bring groundwater knowledge into ki uta ki tai catchment assessments?

Focussing on:

- Providing conceptual approaches to catchment system assessment that factor in groundwater quality and quantity (groundwater in an integrated catchment management approach)
- Providing a tiered toolbox of catchment system models which:
    - include groundwater
    - cater for a variety of data availability, resourcing costs (people and time), and timeframes for decision-making, and
    - are clear on where and how they are applied - the type of catchment, the scale and the freshwater outcomes
- Providing tools for economic and social assessment that adequately reflect the dynamic nature of groundwater flows and quality (e.g., assessment of supply reliability)

SIG Connections:

- Surface Water Integrated Management
- Policy Managers

Timing:
(Refer to page 15)

Applied research and implementation tools

3

Groundwater and the influence on drinking water risks

Developing guidelines on protection zone delineation for drinking water supply bores and management of land use and risks within those zones.

An applied research question on the delineation and management of drinking water protection zones.

The Science Advisory Group has identified an opportunity for Regional Councils to align with the Health Research Council in the area of environmental health (i.e., those aspects of the environment that have effects upon human health and wellbeing) and is investigating an opportunity to develop a research partnership. Environmental health research on drinking water and groundwater would complement our work.

Drinking water protection zones are a key part of drinking water safety plans and requirements under the National Environmental Standard for Sources of Human Drinking Water[4]. There are accepted methods and practice is continually improving.

Research question 3.1

How to continually improve the delineation and management of drinking water protection zones and risks?

Focussing on:

- Continued development of guidance on level of information and analysis needed to delineate source protection zones for groundwater-sourced drinking water across multiple situations depending on aquifer type, scale, particulars of drinking water supply and treatment, and potential risks
- Guidance on the on-going management of land and activities within a groundwater source protection zone depending on aquifer type, scale, particulars of drinking water supply and treatment, and potential risks
- Continued review of well head and drilling integrity standards
- Understanding the risks to drinking water safety from emerging contaminants
- Identifying and then prioritising uncertainties that are feasible to resolve and if resolved have the greatest potential to reduce risk, including developing options for monitoring and/or research that could progressively reduce those uncertainties.

SIG Connections:

- Surface Water Integrated Management
- Land Monitoring
- Policy Managers
- Compliance and Enforcement
- Consent managers
- Contaminated Land and Waste

Timing:
(Refer to page 15)

4 We are aware of ongoing research on the links between nitrate levels and colorectal cancer. – environmental health research. If any consequential change in the drinking water standards for New Zealand arise from the nitrate research, there will be subsequent implications for drinking water source management and we will stay connected to the nitrate work.

Applied research and implementation tools

4

Groundwater and the National Policy Statement on Freshwater Management

Identifying how our existing data and research aligns with the National Policy Statement on Freshwater Management and the requirements on maintaining or improving water quality, setting environmental flows and levels, monitoring and freshwater accounting and how we can improve groundwater resource management to align better with these requirements.

An applied set of research questions relating to the National Policy Statement on Freshwater Management 2020 (NPS-FM). The NPS-FM does not prescribe attributes for groundwater, however the requirement to maintain or improve water quality does apply to groundwater as do the requirements around setting environmental flows and levels, monitoring and freshwater accounting.

There are some immediate needs driven by legislative deadlines, and beyond those timeframes a need to continually improve approaches. Councils are required to notify a Resource Management Plan to give effect to the latest NPS-FM (2020) by December 2024. RMA processes of consultation and council approval mean that there are less than 2 years to finalise technical input. Of necessity, this input needs to use existing monitoring data, apply completed research, and use system-level conceptual understanding. Monitoring and freshwater accounting requirements of the NPS-FM do not have timeframes set but are unlikely to be far behind the plan notification. While the 2024 deadline is important, it will not be the end point and approaches to technical assessment, RMA plan provisions, monitoring and reporting on groundwater will continue to improve beyond 2024.

Research question 4.1

How should groundwater be considered in the setting of freshwater outcomes and environmental flows?

The NPS-FM requires the setting of freshwater outcomes and environmental flow and levels for groundwater. For surface water it requires the setting of target attribute states for surface water some of which will depend on the water quality of groundwater inflows.

Focussing on:

- Providing ways to bring together and communicate existing knowledge including Māori values for groundwater (see Research question 1.1)
- Guidance on applying conceptual approaches and catchment system models which include groundwater (See Research question 2.2) to the setting of freshwater outcomes, attribute states and limits for rivers, lakes, groundwater, and estuaries.
- Improving approaches to setting and evaluating groundwater outcomes and groundwater flows and levels
- Developing innovative approaches to groundwater flows and levels and allocation that reflect the dynamic nature of groundwater flows, often over multiple years
- Developing innovative approaches to groundwater flows and levels and allocation that integrate groundwater quality with groundwater quantity

SIG Connections:

- Surface Water Integrated Management
- Ngā Kairapu
- Policy Managers

Timing:
(Refer to page 15)

Research question 4.2

How to consistently describe the current state of groundwater quality?

The NPS-FM has an objective of maintaining or improving water quality and thus requires that the current state of water quality is consistently and robustly described against a 2017 baseline.

A protocol is needed:

- For reporting current state (2017 baseline) of groundwater quality ranging from situations with no or very little data, to those with multiple measuring points over many years.

SIG Connections:

- Surface Water Integrated Management
- Environmental Data (NEMS)

Timing:
(Refer to page 15)

Research question 4.3

How to integrate groundwater into ki uta ki tai monitoring?

The NPS-FM requires councils to monitor the achievement of environmental outcomes, trends and the cause of any deteriorating trend. Monitoring methods must include measurement of Mātauranga Maori and the health of indigenous flora and fauna.

Focussing on:

- Approaches to working locally with tangata whenua to incorporate matauranga monitoring of groundwater and associated surface water systems
- Protocols for the design of monitoring networks that integrate across land, surface water, groundwater and coastal waters
- Approaches to designing groundwater monitoring to evaluate the effectiveness of policy

SIG Connections:

- Surface Water Integrated Management
- Ngā Kairapu
- Policy Managers
- Environmental data
- Coastal Management
- Land Monitoring
- Biodiversity

Timing:
(Refer to page 15)

Research question 4.4

How to incorporate groundwater into freshwater accounting?

The NPS-FM requires councils to have freshwater quality and quantity accounting systems that record information on the measured, modelled, or estimated flows, loads and concentrations of relevant contaminants; sources of relevant contaminants; and the amount of each contaminant attributable to each source.

Focussing on:

- Developing freshwater accounting systems for groundwater quality and quantity using information from conceptual approaches, catchment system models, consenting and compliance data (see research question 2.2)
- Developing a tiered approach to catchment accounting that allows for variability in data availability, scale, complexity, and risk to freshwater outcomes.

SIG Connections:

- Surface Water Integrated Management
- Environmental data

Timing:
(Refer to page 15)

Applied research and implementation tools

5 Groundwater and climate change

Improving our understanding of how groundwater systems will be affected by climatic change and sea level rise, when groundwater buffers or exacerbates the effects of climate change and what the implications are for other freshwater sources and users in the catchment.

Groundwater systems will be affected by climatic changes and sea level rise which has implications for other freshwater in a catchment, for coastal infrastructure and for groundwater users. Groundwater has the potential to both buffer and exacerbate the effects of climate change on freshwater- water quantity, water quality and freshwater ecosystems - and communities. Rising coastal groundwater levels pose a risk to coastal infrastructure including drinking water supply wells near the coast.

Research question 5.1

How will climate change alter groundwater flows and groundwater quality?

Focussing on:

- How rising sea level will change groundwater flows and levels, inflows and outflows
- How changing climate patterns will influence groundwater inflows and outflows
- How changing groundwater inflows and outflows will influence contaminant pathways, contaminant concentrations and contaminant flows to and from surface water
- The connection between urban/residential development patterns including wastewater and stormwater needs, and groundwater flows and water levels under climate change predictions

SIG Connections:

- Surface Water Integrated Management
- Coastal Management
- Biodiversity

Timing:
(Refer to page 15)

Research question 5.2

How might groundwater assist in climate change resilience?

Focussing on:

- Understanding and communicating the importance of groundwater as a natural storage buffer and its role in supporting baseflow under climate change scenarios.
- Developing guidance on opportunities, constraints and methods for using groundwater storage as part of increasing reliability of supply and in mitigating drought –e.g. integrated approaches to water use, storage options and managed aquifer recharge
- Testing approaches used overseas for appropriateness in New Zealand and evaluating any effects on freshwater outcomes including Māori freshwater outcomes.

SIG Connections:

- Surface Water Integrated Management
- Ngā Kairapu

Timing:
(Refer to page 15)

Research question 5.3

How does groundwater influence natural hazards under climate change?

Focussing on:

- Mapping groundwater-related hazards that are likely to occur within each region due to climate change
- Mapping risk to infrastructure posed by shallow groundwater and subsidence risk under sea level rise scenarios
- Developing and testing options for mitigation
- Protocols for monitoring to understand climate change hazards relating to changing groundwater flows and levels.

SIG Connections:

- Surface Water Integrated Management
- Coastal management
- River managers

Timing:
(Refer to page 15)

Technologies

6 Mitigation and restoration techniques for groundwater

Identifying techniques to restore groundwater flows and quality including techniques that adjust land use, make use of natural features of groundwater and restore surface water flows and quality.

A research question on techniques to restore groundwater flows and quality including those that adjust land use and other activities to make use of natural features of groundwater (e.g., natural denitrification). Restoring groundwater flows and quality is also part of restoring surface water flows and quality. Techniques include:

- For quantity - managed aquifer recharge, targeted stream augmentation, and using aquifer storage. These approaches can also influence groundwater quality.
- For quality - utilising the spatial variation of the natural groundwater denitrification, biogas induced denitrification, permeable reactive barriers, pump and treat, and bioreactors.

Research question 6.1

What options are available to mitigate and restore groundwater quantity and quality?

Focussing on:

- Assessing approaches used overseas for New Zealand conditions including variations in scale and lag time
- Trialling existing and developing new techniques for mitigation and restoration of groundwater, including those that improve Māori outcomes for groundwater
- Guidance describing effectiveness at-scale of available techniques including evaluation of effects on freshwater outcomes, and cost effectiveness.

SIG Connections:

- Surface Water Integrated Management
- Ngā Kairapu

Timing:
(Refer to page 15)

7

Technologies for groundwater investigation and monitoring

Identifying cost-effective techniques that improve our understanding of the groundwater resource in relation to aquifer types, isotopes, emerging contaminants, flow rates, recharge, denitrification and groundwater biota.

Research question 7.1

What cost-effective technologies could be used to better understand groundwater?

Focussing on:

- Faster interpretation – e.g., isotopes/ emerging contaminants, tritium
- New technologies to map aquifer extent (locally applied e.g., SkyTEM) – what is appropriate given aquifer type, values associated with the aquifer
- Higher resolution investigation techniques – e.g., tTEM,
- New technologies for measuring flow rates, velocities or direction in aquifers or in recharge and outflow locations
- Technologies and methods for measuring transformation of contaminants within groundwater (below the root zone, within the aquifer and in connections to surface water) to validate predictions. For example, measuring denitrification product (N2) in recharge water to detect actual for comparison with predicted denitrification.
- Ways to inventory groundwater biota – e.g., eDNA as a tool for groundwater biodiversity assessment

SIG Connections:

- Surface Water Integrated Management
- Environmental data

Timing:
(Refer to page 15)

Wider data and monitoring needs

We have identified a suite of wider data and monitoring needs which would improve groundwater understanding and assist freshwater decision making. In some cases, what is needed is simply investment in applying existing mapping tools across the country.

Consistent and historical information on land use and land management practices – Understanding trends in groundwater quality and quantity requires understanding historical land uses and land practices, especially snapshots at relevant catchment scales. Information may be needed for decades into the past given time-lag for contaminant movement in some groundwater systems.

Predicting and tracking the introduction of new land uses and technologies – Understanding innovations in land use, land management, crops, technologies (e.g., heat pumps) so research can be future focussed.

Wetland mapping – Wetland mapping will assist in groundwater characterisation and identify where groundwater needs to be managed to protect wetlands.

Extend coverage of LIDAR and S-map, and continually improve S-map – Understanding land contours and soil properties informs overland flow paths, relativity between river and groundwater levels, and understanding soil properties helps quantify groundwater inflows, outflows and contaminant fluxes.

Improve quality of water take data from metering – Accurate and consistent data on water abstraction both from groundwater and from surface water helps understand groundwater dynamics, inflows/outflows to rivers and delineating drinking water protection zones.

Effective rainfall data – Understanding aquifer boundaries (extent and depth) and groundwater flows would be assisted by greater understanding of the distribution of rainfall (more spatial differentiation), as would understanding of spatial variability of evapotranspiration.

Database and storage systems – The move toward centralised and connected databases for environmental data will assist with better data management, quality control, and national consistency. Such systems will enhance our ability to work across councils and connect in with surface water, coastal water and land use understanding.

We believe it is timely to look at the various types of groundwater monitoring traditionally carried out by regional councils, particularly state of the environment monitoring. How does SOE monitoring relate to assessing plan/policy effectiveness, monitoring attribute trends under the NPS-FM, and freshwater accounting? What is the role of citizen science and data gathered by others? Does the increased emphasis on ecological outcomes in the NPS-FM alter the requirements, frequency and reporting of groundwater data?

Further, we recognise the importance of a national view on data needs and our need to be aware of and connecting into that work. The Parliamentary Commissioner for the Environment[5] (2019) recognised the importance of consistent, well-curated data sets for national state of environment reporting. The report recommended a comprehensive, nationally consistent, co-ordinated environmental monitoring system with dedicated resourcing. A national system will connect with regional data systems that are important for regional plan development, implementation and evaluation.

5 Parliamentary Commissioner for the Environment (2019) Focussing Aotearoa New Zealand's Environmental Reporting System. PCE. Wellington

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GUIDING GROUNDWATER RESOURCE MANAGEMENT

GROUNDWATER FORUM

SCIENCE AND TECHNOLOGY STRATEGY **2021**