CONFIDENTIAL

Weather Forecasting System Review

Final Report

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Contents

Appendices

Tables

Figures

Glossary

Abbreviation	Stands for
ACE	Autonomous Crown Entity
CRI	Crown Research Institute
DIA	Department of Internal Affairs
DPMC	Department of the Prime Minister and Cabinet
ECMWF	European Centre for Medium-Range Weather Forecasts
ERA5	The fifth generation European Centre for Medium-Range Weather Forecasts' atmospheric reanalysis
ICE	Independent Crown Entity
MBIE	Ministry of Business, Innovation and Employment
MetService	Meteorological Service of New Zealand Limited
MfE	Ministry for the Environment
MoT	Ministry of Transport
MoU	Memorandum of Understanding
NEMA	National Emergency Management Agency
NIWA	National Institute of Water and Atmospheric Research
PFAs4a	A Public Finance Act 1989 Schedule 4A company
RIA	Regulatory Impact Analysis
SOE	State Owned Enterprise
SQ	Status Quo

Acknowledgements

We acknowledge the input from the Ministry of Business, Innovation and Employment (MBIE); the Treasury; The Ministry of Transport (MoT); the Meteorological Service of New Zealand (MetService) and the National Institute of Water and Atmospheric Research (NIWA) as well as external experts we consulted and the stakeholders who provided their time and thoughts during interviews or in completing our online survey.

A list of those we have engaged with is provided in Appendix A to the appended interim report (Appendix F), with additions noted in section 1 below. These people were generous with their time and the discussions helped inform our thinking which has fed into this report. However, the views expressed in this report are those of the authors only and should not be taken as representing the views of any of the individuals met with during the process, nor any of the organisations they are associated with.

Executive summary

We were engaged by the Ministry of Business, Innovation and Employment (MBIE) and the Treasury to review the weather forecasting system (the system) in New Zealand, focusing on the following objectives:

1. Identify and recommend the optimal arrangements and responsibilities in the weather forecasting system that will best position New Zealand to meet future weather-related challenges and impacts in the context of climate change.
2. Consider the structural configuration of MetService and NIWA, based on the optimal system arrangements identified in point one above.
3. Identify if changes in access to weather data should be made and what these should be.

Having completed our analysis, we recommend a re-integration of meteorology services with climate science, hydrology, and oceanography. We believe this will best meet New Zealand's future needs for weather prediction and anticipation of the effects of weather events and address potential challenges to meeting these needs. In particular, the adjacency of weather with hydrology and the integration of the research to operations pipeline (and resulting implementation and outcomes), together with the removal of duplication in data management and back-office functions provides a compelling logic. We suggest other changes to funding and monitoring, data access and the integration across systems and uses to support the prioritisation of effort, take a long-term view of investments, and needs, and support the application of insights across different applications and improved understanding of impacts.

Below, we set out our reasoning for this.

The system performs as we might expect and delivers value, but there is a case for change to meet future needs. We surveyed knowledgeable stakeholders (receiving 145 responses) and ran interviews and an extensive workshop at the Meteorological Society meeting of 2023. Overwhelmingly, this knowledgeable group of stakeholders acknowledged the importance of systems-level change, while recognising New Zealand's weather prediction is doing a good job. The future challenges of extreme weather mean there is a compelling case for change.

The key findings from our interim report were that:

1. Public weather forecasting delivers value to society, and that value is likely increasing.
2. The government has a role in ensuring the provision of a "public good" weather forecast.
3. Prior changes to institutional arrangements delivered efficiencies and the system performs as should be expected at present.
4. To meet future (increasing) needs, there is a case for change in institutional arrangements.

After this, we considered options for change to best meet future needs and deliver net benefits to New Zealand which have led to our recommendation.

Future system needs are expected to increase, providing a compelling case for change

New Zealand's future system needs go beyond what existing arrangements are expected to deliver (with increasing risks and demands from the system in light of increasing prevalence and impacts of weather events as a result of climate change). Given this, there is a strong case for change to meet the needs of the future and make best use of capabilities and investment. These future needs are summarised in Table 1.

Table 1: Future needs for the weather forecasting system

	Access to **global** observations, modelling, and capabilities with an increased coverage of the South Pacific.
	Prioritised investment targeted at **New Zealand's highest value/needs.**
	Ability to **leverage computing** capabilities, artificial intelligence and machine learning and increasing data to better understand/**link** with: • risks **across hazards** (including with interactions and increasing extremes) • **impacts**, including understanding highly localised conditions and different uses/applications (safety and commercial) • research, operations, applications and consumer demands.
	Clear **communications and engagements** that are: • understood, insightful and trusted • accessible to relevant communities • clear on actions needed from different parties.
	Customer **choice**, input and engagement, and innovation in research provider, products/application, and advice that is supported by open data access.
	Changing role of the meteorologist, linking more with computer modelling and relevant environmental sciences.

Current institutional arrangements are associated with several potential barriers to the system meeting future needs

Our interviews, survey, workshops, and research highlighted several potential barriers to meeting future demands. These potential barriers largely stem from the current institutional arrangements. A summary of the root cause, themes that stem from this, and the implications and impacts is illustrated in Figure 1. Collectively, the impacts and effective elements of the case for change are as follows:

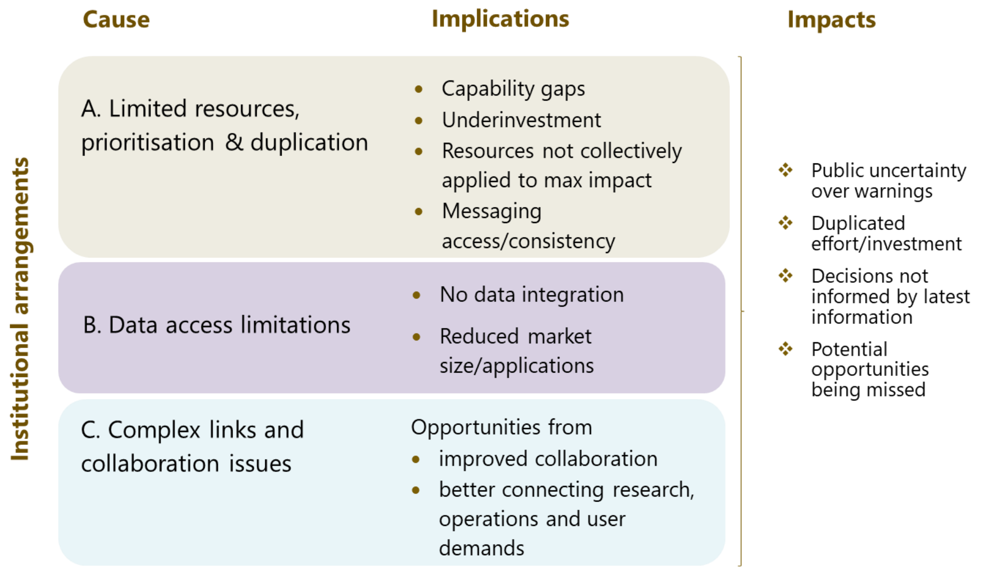
- **Public uncertainty over weather warnings** (or watches), which ultimately causes risk to lives and properties as well as economic activities. These risks increase with rising frequency of extreme weather and increasing duplication in weather forecasting (including exposure and number of parties publicly commenting, particularly where the parties are seen as parts of government). The costs associated with extreme weather events appears to have been growing, with a marked increase last year.

- **Duplicated efforts and investment**, which ultimately cost the Crown or customer and may lead to alternative activities not being undertaken. These risks increase with barriers/costs to accessing information and increasing duplication in weather forecasting (overlap in the scope of public providers). The former has been raised by stakeholders (and previously), and there is evidence of increasing overlap in scope of public providers. Overlaps appear present in both observation networks and associated costs, as well as different services or areas of development/investment.

- **Decisions not being informed by the latest information**, which also causes risks to lives and properties as well as economic activities. These risks increase with barriers/costs to accessing information and issues of coordination/collaboration or role clarity, both of which have been raised as part of our analysis.

- **Potential opportunities that may be missed.** This risk also increases with barriers/costs to accessing information and issues of coordination/collaboration or role clarity, as well as any challenges in making the case for resourcing and making best use of resources available, each of which have been raised as part of our analysis.

Figure 1: Potential barriers, implications and collective impacts



We analysed relevant options against principles for an optimised system, and assessed the two most promising options in terms of costs and benefits

We developed a long list of options based on future needs and addressing identified barriers (shown in Table 3 of the report). We then worked through the considerations set out in Figure 2 to identify and short-list options.

Figure 2: Roles and levers available to government and associated questions worked through

1. Funding
   i. Where does the **government** have a **role** in the weather forecasting system?
   ii. Which **agencies** have an **interest**?
   iii. **How** should public good weather forecasting services be **funded**?

2. Delivery
   i. What **needs to be delivered** by the Crown (scope)?
   ii. What are the **skills/requirements** needed for delivery?
   iii. Which **vehicle** should be used for delivery?

3. Other (regulatory) levers
   i. What **additional (regulatory levers)** should be considered?
   ii. Are such levers **needed**?

Our short-list included:

- The status quo: with the two entities operating as they do at present/are expected to evolve.
- Option 1: enhancements to the status quo to explicitly remove duplication.
- Option 2: integrating NIWA and MetService alongside NIWA's other functions.
- Option 3: a new public weather service entity that includes the components of MetService and NIWA that fall under the weather forecasting system.
- Option 4: integrating both capabilities in relation to the weather forecasting system as well as capabilities relating to other natural hazards.
- Option 5: integrating the weather forecasting capabilities with those held within NEMA in relation to emergency management.

The short-list is shown in Figure 3, noting that there are a number of common elements that are recommended across all options. We then assessed the short-list based on the degree to which an option would support the principles/objectives for an optimised system shown in Figure 4. Options 2-4 were assessed as likely to best meet these. We then undertook a cost-benefit analysis of the two options that were in scope and would best meet the objectives for the future system (options 2 and 3). As a result, our recommendation is based on addressing potential barriers to meeting future needs, optimising the system, and providing the greatest net benefits within the scope of our review.

Figure 3: Short-listed of options

	SQ	1 ESQ	2 Integrate	3 New	4 Broader	5. Linked to EM
Funding, monitoring	Existing	**Coordinated, prioritised,** w/ **long-term funding** agreement for delivery (core), **monitoring** system performance				
Data access		**Publicly funded** data and research is made **easily available** (and where funded/agreed, outputs too)				
Additional integration considerations		*Investment case* for **data integration** and **access** platform				
		Investment case for **interoperability** in IT **systems** across EM agencies				
Scope		**Enhanced SQ**	**Full integration**	**New** integrated prediction-focused entity	Expanded integration **across hazards**	**Integrated with NEMA**
Institutional form		SOE, CRI	CRI	PFAs4A	CRI	Departmental Agency
Checks		Check on pricing/access		N/A	Possible check	N/A

Figure 4: Principles for an optimised system

Optimises use of **resources** to ensure **fit-for-purpose** core forecasting, informing & warning services, including associated infrastructure & capability (public weather and climate forecasting)
Improves **understanding/prediction of impacts, risks and necessary actions** and drives more **effective** planning and emergency management
Reinforces **trust** in the weather forecasting system and builds **social capital** across diverse needs
Builds strong **international links** and alliances supporting access to relevant global systems, data, infrastructure/models, and expertise
Enables **innovation** within system, including through ensuring ready **access** to public/publicly funded information
Is realistic, **practical** and minimises service disruption

Options 4 and 5 were beyond the scope of our review, though we note option 4 scored as well as options 2 and 3 relative to our principles/objectives, and picks up on the concept of integrated hazard management as seen in Japan (discussed in the final appendix to our appended interim report). We therefore focused our model detailed assessment on options 2 and 3:

- **Option 2**: integrating NIWA and MetService alongside NIWA's other functions. This is likely to involve NIWA acquiring MetService and operating as a subsidiary, at least initially. Then there would be the ability to draw on different capabilities and systems across the two organisations, and to coordinate communications and messaging.
- **Option 3**: a new public weather service entity that includes the components of MetService and NIWA that fall under the weather forecasting system, and is less commercial than an SOE with the ability to design anew. This would involve combining weather and climate capabilities, with either close connection or incorporation of hydrology and oceanography as well. This would be set up as a Public Finance Act 1989 Schedule 4A (PFAs4A) company.

Merging capabilities and systems will best meet the principles for an optimised system and provide the greatest benefits

The preferred option requires the putting back of meteorology services with climate science, hydrology, and oceanographic services. Further, these combined capabilities would have direct access to NIWA's computing services and modelling. This integration would strengthen the social trust in weather forecasting (with internal coordination to support a single authoritative voice) and support greater estimation of effects of weather events. We expect considerable benefit in this integration of effort, as well as likely benefits from adjacency of research effort. At the same time, there will be modest but tangible savings in rationalisation of the observation network, savings in data collection and curation, reduction in the cost of purchasing computer processing, and reductions in executive team, human resources, and finance function costs.

We estimate net benefits in the order of $99.2 million- $139.0 million, noting some of the key benefits have not been quantified and acknowledging some of the transition risks to be managed. This closer integration makes New Zealand's institutional arrangements more aligned to several international arrangements, more integrated across hazards, and allows us to better facilitate our presence in the geo-political aspects of weather and climate change. Further, the opportunities from increased integration are expected to extend to the increasing work both agencies are undertaking in the Pacific (though we understand that collaboration is often already at its best in relation to efforts in the Pacific, so any transition risks will need to be specifically managed so as not to diminish this).

Figure 5: Overview of proposed arrangements

Funding, monitoring	Coordinated, prioritised, with long-term funding agreement for delivery (core), monitoring system performance
Data access	Publicly funded data, research and outputs made easily available Transparency over data available; clear policies for data provision that support a level playing field and clear principles and user-friendly systems for pricing and access with limited restrictions
Additional integration considerations	*Investment case* for data integration and access platform
	Investment case for interoperability in IT systems across EM agencies
Scope	Integrated meteorology, climate science, hydrology, oceanography and data science and modelling; integrated systems and observation network
Institutional form	CRI – NIWA evolved incorporating MetService's expertise, roles and systems
Checks	Monitoring agency to engage periodic assurance of data access and pricing arrangements

This option is considered to best leverage the capabilities available (within our scope of review), and existing structures and systems in place. It limits the risk to the elements of NIWA outside the weather forecasting system but where there are nevertheless links that are of value for those functions.

However, it will require detailed design (drawing on the knowledge and expertise of both MetService and NIWA) to make the most of the opportunity to think afresh about what is needed and how this is focused and organised. It will be extremely important to ensure continuity of services and bring together the relevant skills around a common purpose, considering the most appropriate timing for any changes, and ensuring operational weather forecasting receives sufficient focus and priority. The role of the combined entity will also need to be clear relative to, and support, the responsibilities of local government and other actors in the system. Further, in drawing together these components, it will be vital to ensure that there is transparency about what data exists, and ensure that data is made easily available to others based on clear principles around the nature of any charges and in a manner that supports a level playing field for value-added services.

Key components of recommended optimal arrangements

Our recommended option would include:

a) **enhancing funding and monitoring** of the system performance, prioritising across government purchasing interests for core services and taking a long-term view. This would involve a lead agency responsible for funding and contracting for core services, coordinating and prioritising across different demands, and monitoring performance of the system as a whole as well as against funding conditions.

b) **merging relevant capabilities** and systems to ensure that relevant insights can be drawn on and inform a greater understanding of impacts, coordinate communication in a way that reduces ambiguity and draws on different communication channels, supports efficiencies in the management of observations, data and modelling and removes duplication. This would involve integrating meteorology, climate science, hydrology, oceanography and data science expertise to draw on these complementary skills and provide better understanding across hazards and impacts. This would be achieved by NIWA acquiring the shares in MetService and initially operating it as a subsidiary and following detailed co-design, amalgamating where this makes sense to best meet New Zealand's needs (including ensuring a level playing field with other providers/applications). Under this approach NIWA's functions outside the weather forecasting system would likely be unaffected though would be able to draw on the broader combined capabilities.

c) **improving data access** to support the application of weather data and modelling by external parties. This would include reviewing data access policies and systems and moving as quickly as possible to ensure full transparency regarding what data exists, and that all publicly funded data is easily available and that any costs and access arrangements are justifiable. We suggest that the monitoring agency would also, every five years or so, commission assurance of the access and pricing of data, research and, where applicable, outputs, to determine whether these are consistent with a level playing field for downstream applications and make recommendations if necessary for changes in order to support this (which would then be priorities for funding and monitoring discussions).

d) **exploring investments in data access and interoperability** of systems to support the ease of sharing information and drawing together different insights by developing investment cases for each. This would include the systems to support data access and application, which for instance may also include the way the data is captured, and fields considered (such as whether data could capture and present breakdowns relevant to different Māori decision-makers and communities), as well as how this can be accessed and absorbed to support different applications. The second investment case would consider how different systems are able to share and incorporate information from others so that each is able to be informed by the relevant insights it captures and apply and combine these insights to greatest effect.

We recommend an immediate transition towards the preferred option

We recommend that officials seek Ministerial and then Cabinet agreement in principle to:

1. Incorporate the following **core elements** of the government's role in the future weather forecasting system:

    a) Enhanced funding and monitoring of the system performance, prioritising across government purchasing interests for core services and taking a long-term view.

    b) Merging relevant capabilities and systems to: ensure that relevant insights can be drawn on and inform a greater understanding of impacts; coordinate communication in a way that reduces ambiguity and draws on different communication channels; support efficiencies in the management of observations, data and modelling and remove duplication.

    c) Improve data access to support the application of weather data and modelling by external parties. This includes being transparent about what data exists (such as that illustrated in Appendix D) but with component information being set out publicly, that data is made easily available to others (user-friendly systems, with data easily downloadable, and in formats that support different uses), based on clear data policies and clear principles around the nature of any charges and in a manner that supports a level playing field for value-added services (including limiting any restrictions on the use and re-use of information).

    d) Explore investments in data access and interoperability of systems to support the ease of sharing information and drawing together different insights.

2. **Empower the funding and monitoring agency lead** to undertake long-term planning, funding and coordination. This will include determining where that lead best sits (e.g. MOT, MBIE, MfE or potentially DPMC or DIA), making any necessary changes to funding across votes and to roles and responsibilities, shifting funding agreements over time, and supporting periodic public independent assurance of data access and pricing.

3. **Improve coordination, implement detailed design and shift to the proposed delivery arrangements**, including:

    a) Requesting that NIWA coordinate with MetService on its communications and public messaging around severe weather to support a single authoritative voice informed by the best available information where the respective roles support clarity of understanding an insight and delivers on contractual commitments but avoids potential confusion while the detail of the future arrangements envisaged in this report are worked though and transitioned to.

    b) Consulting with NIWA and MetService regarding purpose and functions in the future weather forecasting system, review capabilities, systems, functions and needs, and co-design of a new amalgamated whole and appropriate operating model that supports future needs, delivering core services and supporting downstream applications on a level-playing field to other providers.

    c) Removing MetService from State Owned Enterprises Act (SOE Act).

d) NIWA acquiring the shares in MetService and incorporating initially as a subsidiary, and in the medium term requiring MetService be retained as a brand, as New Zealand's authorised meteorologist.

e) Shift to that model and cancel/novate/renew contracts under it as appropriate, including realising clear savings opportunities as early as possible.

4. **Review:**

a) Data access arrangements from the new entity periodically as part of wider system monitoring.

b) The effectiveness of the new arrangements once operationalised, considering the new entity's role in downstream markets (and gaps if it did not operate in them) and whether there is a need for any of the other regulatory measures flagged as possible further escalations to be considered to meet future needs and objectives for the system.

Benefits can begin as soon as early decisions are taken, with full implementation likely to take a year to 18 months (and with benefits even if things take longer)

We set out a recommendation implementation roadmap in our report, outlining a high-level set of steps from early decision-making based on this report, improvements in data access, co-design of the detailed arrangements, changes to funding and monitoring arrangements, investment cases being developed, MetService being removed from the SOE Act and NIWA acquiring the shares in MetService, and shifts in systems and structure to realise the full benefits of amalgamation, followed by reviews of data access and then the new arrangements. We recognise that it may take time to work through the future needs and there may be certain shifts that are worth making at points in the future, however we estimate that even if there are greater costs and delays in recognising some benefits, the changes recommended would still deliver net benefits.[1]

[1] Our cost benefit analysis directly engages with speed of benefit realisation as one of the key variables stress-tested with benefits accruing from the beginning of year: 1) two in the base case; and 2) three in the less optimistic case.

1. The Review seeks to address three key objectives

In September 2023, the Ministry of Business, Innovation and Employment (MBIE), together with the Treasury, engaged us to provide an independent review of New Zealand's weather forecasting system (the Review). The Review was termed Project Hau Nuku, meaning 'shifting winds', and has a steering group of members from the Ministry of Transport (MoT), MBIE and Treasury as well as terms of reference (MBIE, 2023). The terms of reference set out the following key objectives (with further detailed context and questions also set out):

1. Identify and recommend the optimal arrangements and responsibilities in the weather forecasting system that will best position New Zealand to meet future weather-related challenges and impacts in the context of climate change.

2. Consider the structural configuration of MetService and NIWA, based on the optimal system arrangements identified in point 1 above.

3. Identify if changes in access to weather data should be made and what these should be.

1.1 Project Hau Nuku builds on three reviews undertaken between 2001 and 2018

There have been three prior reviews of the weather forecasting system since the establishment of MetService and NIWA (in 2001, 2006, and 2018). The reviews were commissioned by the Minister of Finance, Minister for State Owned Enterprises, and Minister of Research, Science and Innovation as the shareholding Ministers of MetService and NIWA.[2]

The 2001 and 2006 reviews considered the possible risk to New Zealand's national weather and climate functions from maintaining the separation between NIWA and MetService.

The 2001 review identified long-term risks associated with existing arrangements and recommended an assessment group be established to consider options for the two organisations to work more closely together. The review led to shareholding Ministers setting expectations of greater collaboration between them.

The 2006 review found that MetService and NIWA were still not collaborating and recommended a merger of the two organisations, which ultimately led to a Memorandum of Understanding between them to improve collaboration.

The 2018 review focused on access arrangements for weather data and whether those arrangements were limiting third parties who want to develop innovative, value-added weather insight products and

[2] Shareholding Ministers of MetService are the Minister of Finance and Minister of State-Owned Enterprises. Shareholding Ministers of NIWA are the Minister of Finance and the Minister of Research, Science and Innovation.

services. The 2018 review suggested possible commercial gains from improved access to data but noted change would be needed to operating models if this were to be pursued and would come with additional costs to the Crown.

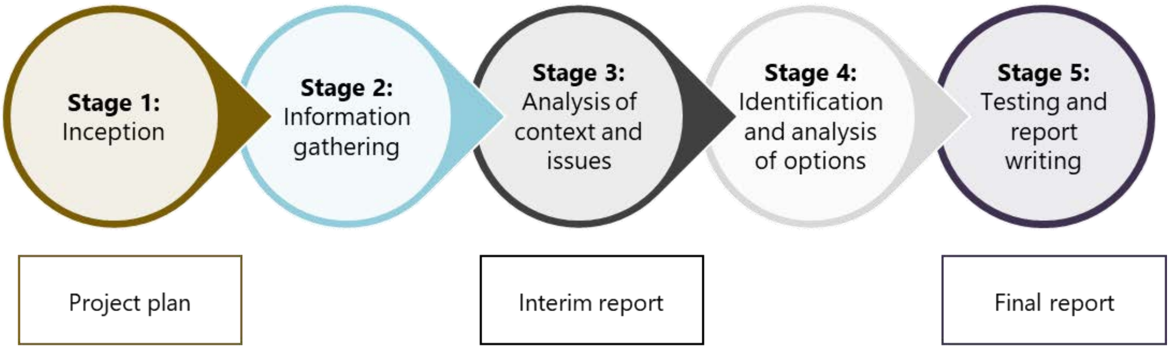
More detail on the prior reviews can be found in Appendix B to the appended interim report.

1.2 The review was broken into five stages aligning with the Regulatory Impact Analysis (RIA) framework

We broke the project up into five stages (as shown in Figure 6):

1. Inception leading to a project plan and stakeholder list
2. Information gathering through document review, research, and stakeholder meetings/interviews (as summarised in Appendix A to the appended interim report)
3. Analysis of context and issues (leading to the interim report)
4. Identifying relevant options and analysing these
5. Testing our findings and analysis and presenting and reporting by way of our final report. This is expected to be completed by the end of April 2024.

Figure 6: Stages of the Review



We sought feedback on drafts of both our interim and final reports from our project partners, MBIE, Treasury, MetService, and NIWA before these were finalised.

Our approach is consistent with the Treasury's guidelines for Regulatory Impact Analysis (RIA) (New Zealand Treasury, 2017). The process for impact analysis is as follows:

- *Description of the status quo*. This focuses on the features of the market or relevant social arrangements, existing legislation and regulation, and any relevant decisions that have already been taken. Essentially, we are explaining the state of the world and what has got us to this point.
- *Defining the problem(s) and assessing magnitude*. Defining a problem relies on being able to explain the gap between the current situation and the outcome being sought. In this context, we are looking at the current state of the weather forecasting system and what is believed to be the future weather forecasting system New Zealand needs. This essentially describes the case for change (why do we want to act?) and relies on us being able to articulate the size of

the problem(s), delineate the causes and symptoms of problem(s), and identify and diagnose the problem(s). These problems are typically market or regulatory failures that lead to suboptimal outcomes.

- *Defining the objectives.* Essentially, the objectives should describe what is being sought by taking action, and how any proposed intervention may have its effectiveness assessed.
- *Identifying and analysing the full range of options.* This involves coming up with potential interventions that address some or all of the objectives. Analysis of the options means assessing their relative effectiveness.
- *Considering consultation, implementation, monitoring, evaluation and review.* This involves, consulting on the above aspects, summarising options and recommendations, and considering how the recommended option would be implemented as well as plans for monitoring, evaluation and review.

Essentially, this process provides a tractable and readily usable framework for identification and analysis of issues and to be able to ask whether there is a role for government to intervene, and if so, what that intervention might look like.

1.3 The review used a range of sources to refine the findings

Our report draws on findings from engagements with a broad range of stakeholders across the weather forecasting system in the form of interviews, workshops, and an online survey. Stakeholders were asked to consider future trends applicable to the wider forecasting system, discuss the needs of the weather system in Aotearoa New Zealand, and identify barriers to those needs being met.

We interviewed over 50 stakeholders, received 145 responses to our survey and held a workshop at the Meteorological Society of New Zealand annual conference 2023. We reviewed over 150 documents in the form of journal articles, reports, international guidelines, ministerial briefings, and content from stakeholders. The key inputs to our review are detailed in Appendix A to the appended interim report.

Since the interim report we undertook several further engagements and workshops with data and climate scientists, NIWA (including its Te Kūwaha team), MetService, the Chief Science Advisors' Forum, the secretariat for the inquiry into the response to the North Island severe weather events, the External Reporting Board, and MBIE, Treasury and the Ministry of Transport.

1.4 The remainder of this report is set out in four further sections

The remainder of this interim report discusses the:

- case for change (section 2)
- options considered and recommended approach (section 3)
- recommendations and recommended implementation path (section 4).

An updated version of our interim report is appended as Appendix F, which provides more detailed context, while Appendices A to E provide answers to questions in the terms of reference, more detail on aspects of the options analysis, outline the assumptions used in the cost benefit analysis, and provide information on NIWA's data access systems (including usage, broad coverage and any conditions of use or charges) and further information to the interim report in relation to international data access.

2. A compelling case for change

This section discusses the:

- key relevant context relating to the weather forecasting system
- future needs of the system
- challenges/barriers to meeting these future needs
- objectives or principles for an optimised system (its ideal attributes).

We discuss each of these in turn next, with significant additional detail (particularly in relation to the current context) provided in the appended interim report. This case draws from the inputs discussed in section 1, which are detailed in Appendix A to the appended interim report.

2.1 Context: the system provides increasing value to New Zealand, with a role for government

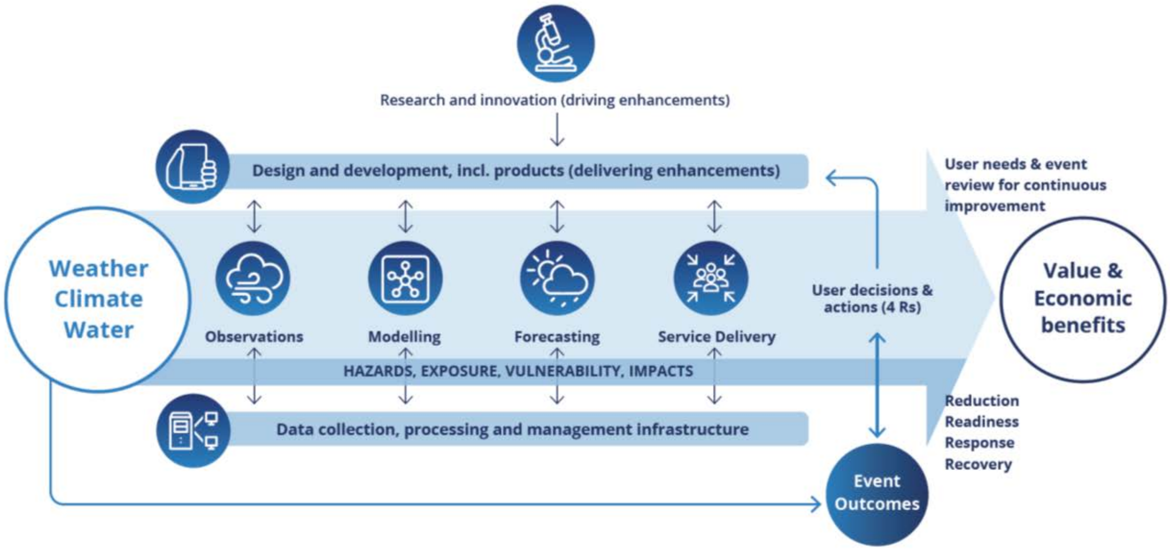
This sub-section summarises the:

- span of the weather forecasting system
- links between the weather forecasting and emergency management system
- relevant value, global context, and technology advancements
- role of government
- most recent institutional changes
- impacts of climate change.

The weather forecasting system spans research to operations (flowing to outcomes), with links across environmental sciences and with the emergency management system

A high-level overview of how New Zealand's current forecasting value chain should operate is shown in Figure 7. The weather and climate are observed using infrastructure and instruments, and the data from these observations is processed and stored. The data is input into models to predict what will happen in the short to medium term (weather) to medium-term (seasons) through to long term (climate). The forecasts are used to inform decisions for short term (emergency management), medium term (drought preparation) through to long term (climate adaptation).

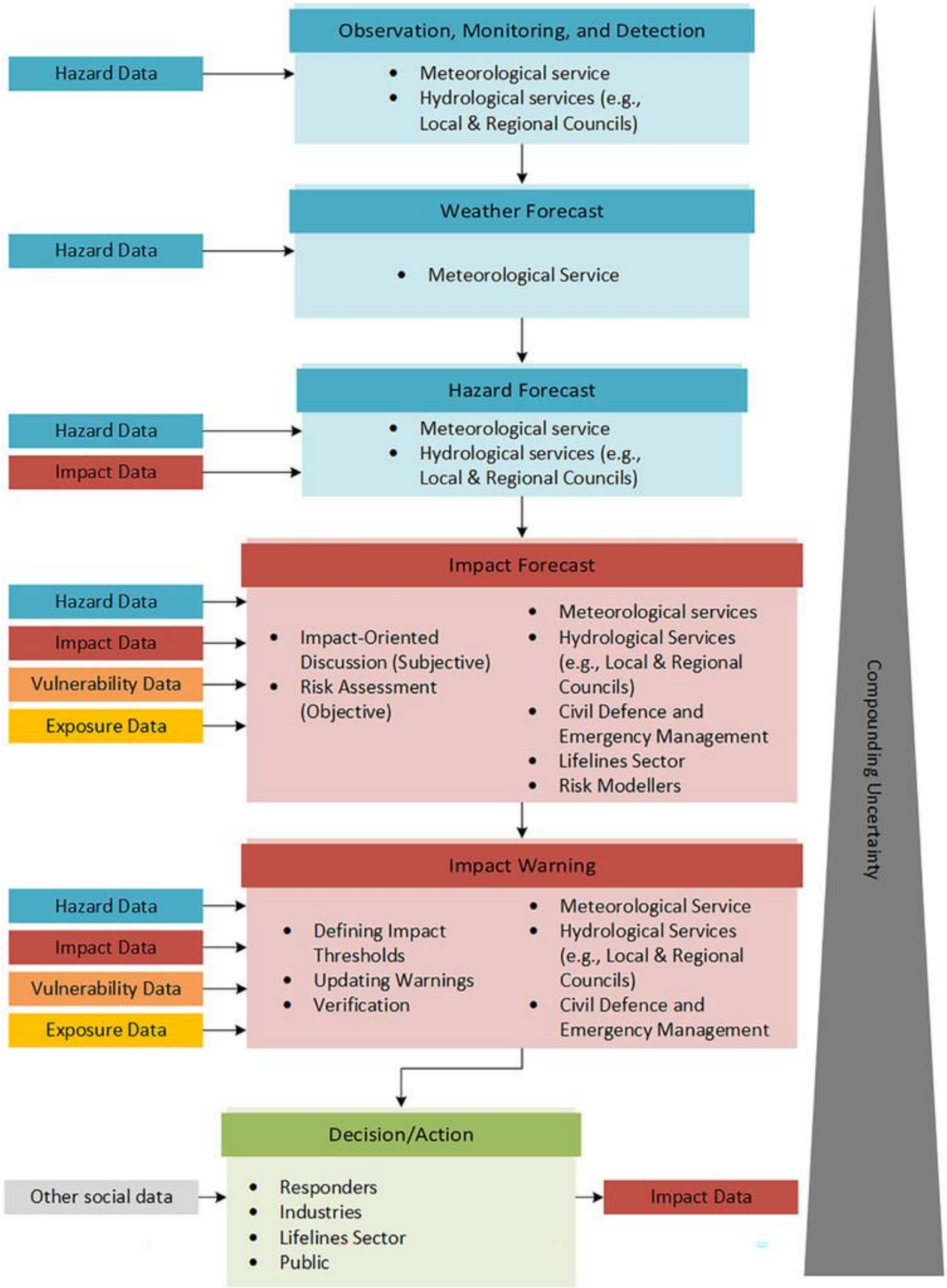
Figure 7: High-level overview of New Zealand's weather and climate forecasting value chain



Source: (MetService, 2023)

The National Civil Defence Emergency Management Plan specifies the roles of hydrological and meteorological agencies within the emergency management system, highlighting roles of MetService, NIWA and local authorities alongside those of other agencies. This is described in greater detail in sections 2.3, 3.8 and Appendix C of the appended interim report. Figure 8 sets out the impact forecast warning chain, with actors and sources of data in relation to severe weather set out in Figures 8 and 32 of the appended interim report.

Figure 8: Impact forecast warning chain



Source: (Harrison et al., 2022)

These aspects are considered in greater detail in sections 2.3, 3.5 and 3.8 in particular of our appended interim report.

The value from the weather forecasting system is far-reaching

Weather forecasting has social, cultural, and economic value. It is embedded in some industry processes (such as for airlines) and is present in many decisions from hanging out clothes to animal carry limits on farms. The value from the weather forecasting system is discussed in greater detail in section 2.1 of our appended interim report.

Weather forecasting operates in a global context with global models, obligations to contribute data, common data standards and international obligations across a range of hazards. New Zealand provides important inputs to these global models. Further, developments in artificial intelligence and machine learning offer opportunities across the weather forecasting system. These aspects are discussed in greater detail in section 3 of our appended interim report.

There is a role for government in ensuring the provision of a "public good" weather forecast

The nature of weather forecasting means there is typically a role for government to ensure the provision of a 'public good' weather forecast, which might not otherwise be provided. Governments classically underfund public goods and stretch to pay for the optimal level of supply of services such as weather forecasting. However, both in New Zealand and internationally, research suggests that public weather forecasting delivers considerable net benefits to society. Estimates vary but all agree it is a large multiple of cost. This is discussed in greater detail in section 3.1 of our appended interim report. The scope and method of analysis differs, but estimates of those specifically providing a ratio of benefits to costs of weather forecasting services in particular range from around 4:1 to 48:1 (some that consider more specific applications may be lower but still exceed 2:1).

Prior changes to institutional arrangements delivered efficiencies and the system performs as expected

Establishing MetService under a commercial model delivered efficiencies at the time and allowed it to draw on additional revenues. This is also true for NIWA under the CRI model. For instance, we understand the cost of the Ministry of Transport contract decreased in real terms for up to 10 years following the move and MetService draws significant advertising and other revenues (advertising revenues being driven by the popularity of its website and mobile application and other sources of revenue from the private sector through the provision of services). These revenues, in effect, support more investments in its infrastructure and systems than would otherwise be the case.

Survey respondents and those interviewed generally indicated a sense that the system was performing above average and as one might expect given the institutional arrangements, but as discussed below, these institutional arrangements are likely to limit the ability to meet future needs. Looking across the system, we see more concentration in the provision of observations, basic infrastructure, data and modelling and greater competition in downstream applications. This is likely to (at least) partly reflect natural monopoly characteristics in those areas upstream within the system.

Weather forecasting will be of increasing importance

Climate change is anticipated to result in more extreme weather in New Zealand, with increased risks and impacts of weather events. There are a number of drivers of need, including:

- increased weather events and needs for resilience given climate change, across New Zealand
- increased effects of those weather events and the increasing needs of emergency management (both this and the prior point are discussed in section 2.2 of our appended interim report)

- international stability risks and New Zealand's role in the Pacific (discussed in greater detail in sections 3.2, 3.6, 3.7 and 4.7 of our appended interim report)
- connections between hazards and reduced boundaries across sciences (floods, landslides, and weather-climate, etc – discussed in sections 2.3, 3.8 and 4 of appended interim report)
- expanding demands for accurate and localised weather forecasts for, for instance, management of energy demand and supply as renewable energy supply increases (discussed in sections 3.10 and 4 of appended interim report).

Further, there are considerable opportunities from technological developments and the role of data in improving models and understanding impacts including artificial intelligence and interfaces with other models. This is discussed in sections 3.4 and 4 of appended interim report.

International alliances are critical to our ability to participate. We cannot afford the development cost of our own global models, and we need considerable access to weather observations across the globe to understand our own weather. For instance, if New Zealand were participate in space weather, international arrangements would likely be of significant importance.

Each of these aspects are discussed in greater detail in our appended interim report.

2.2 Future needs provide a compelling case for change

New Zealand's future system needs go beyond what existing arrangements are expected to deliver. There is a compelling case for change to meet the needs of the future and make best use of capabilities and investment. These future needs are summarised in Table 2.

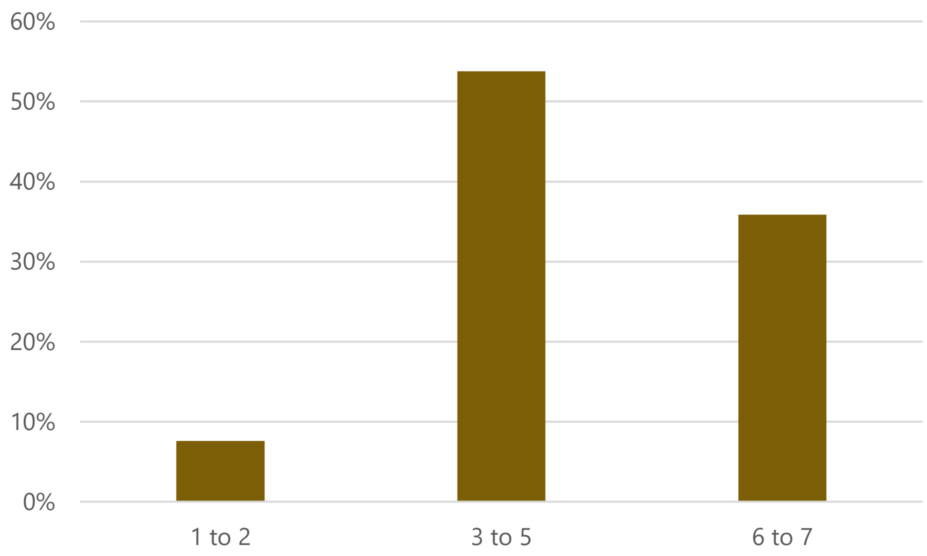
Table 2: Future needs for the weather forecasting system

	Access to global observations, modelling and capabilities with an increased coverage of the South Pacific.
	Prioritised investment targeted at **New Zealand's highest value/needs.**
	Ability to **leverage computing** capabilities, artificial intelligence and machine learning and increasing data to better understand/**link** with: • risks **across hazards** (including with interactions and increasing extremes) • **impacts**, including understanding highly localised conditions and different uses/applications (safety and commercial) • research, operations, applications and consumer demands.
	Clear **communications and engagements** that are: • understood, insightful and trusted • accessible to relevant communities • clear on actions needed from different parties.

	Customer **choice**, input and engagement, and innovation in research provider, products/application, and advice that is supported by open data access.
	**Changing roles** linking more with computer modelling and relevant environmental sciences.

Our survey of meteorologists and users of weather forecasts indicated (based on the 145 responses) considerable change to the weather system is needed to meet future needs despite above average ratings of the weather system. Respondents were asked what level of change is required within the weather forecasting system and/or institutions to meet future needs. Respondents were asked to rate from 1 (no change) to 7 (complete change). Around 8 per cent of respondents rated 1-2 (indicating no or low change), 54 per cent rated 3-5 (indicating considerable change), while 36 per cent rated 6-7 (indicating significant and complete change).

Figure 9: Need for change: survey response distribution



Source: Sapere analysis

Local government respondents provided the highest rating (7), while those in transport and agriculture provided the lowest rating (3). Importantly, no respondent group were of the view that no change was required.

Our survey results are discussed in greater detail in section 3.10 and relevant parts of section 4 of our interim report.

2.3 Challenges stem from current institutional arrangements

Our interviews, survey, workshops, and research highlighted several potential barriers to meeting future demands. These potential barriers largely stem from the current institutional arrangements, which (among other things) lead to potential issues around the efficiency and prioritisation of what is delivered from government spending, integration of information produced from that spending, and availability of information to support decision-making relating to the impacts of weather.

A summary of the root cause, themes that stem from this, and the implications and impacts is illustrated below. The figure illustrates that institutional arrangements are associated with (as discussed in greater detail in section 4 of our appended interim report):

A. **Limited resources and prioritisation as well as duplication** of effort, which leads to capability gaps, underinvestment, resources not collectively applied to most value for New Zealand, and issues around access to and consistency of public messaging. This is discussed in greater detail in sections 3.10 and 4 of our appended interim report.

B. **Data access limitations**, with a lack of integration between different data sources and barriers to accessing weather system data that reduce the potential size of the market and end applied use of data from the weather forecasting system. This is discussed in greater detail in sections 3.10 and 4 of our appended interim report, with Appendix D providing further information on NIWA's data access systems and 4.2Appendix E providing further examples of information on the international data access that is of particular relevance.

C. **Complex links and collaboration issues**, where there are opportunities to improve collaboration and better connect research, operational requirements and end applications/user demands. This includes opportunities for research to better understand how people perceive and respond to information about hazardous weather and impacts. This is discussed in detail in sections 3 and 4 of our appended interim report.

Collectively, this leads to impacts by way of the following:

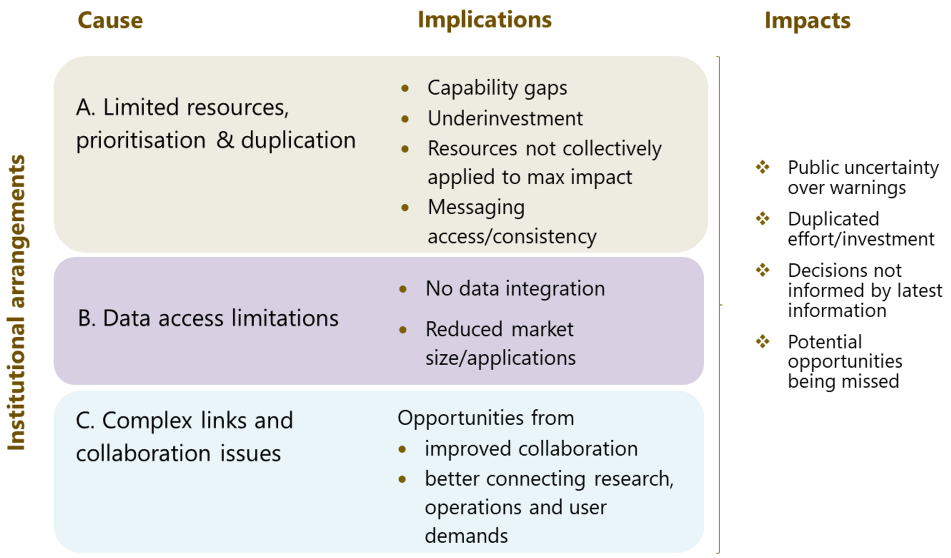
- **Public uncertainty over weather warnings** (or watches), which ultimately causes risk to lives and properties as well as economic activities. These risks increase with rising frequency of extreme weather and increasing duplication in weather forecasting (including exposure and number of parties publicly commenting). The costs associated with extreme weather events appears to have been growing, with a marked increase last year. This is discussed in detail in sections 2.2 and 4.2 of our appended interim report.

- **Duplicated efforts and investment**, which ultimately cost the Crown or customer and may lead to alternative activities not being undertaken. These risks increase with barriers/costs to accessing information and increasing duplication in weather forecasting (overlap in the scope of public providers). The former has been raised by stakeholders (and previously) and there is evidence of increasing overlap in scope of public providers. Overlaps appear present in both observation networks and associated costs as well as different services or areas of development/investment. This is discussed in greater detail in sections 3 and 4.6 of our appended interim report.

- **Decisions not being informed by the latest information**, which also causes risks to lives and properties as well as economic activities. These risks increase with barriers/costs to accessing information and issues of coordination/collaboration or role clarity, both of which have been raised as part of our analysis. Section 4.6 of our appended interim report discusses issues of collaboration in greater detail.

- **Potential opportunities that may be missed.** This risk also increases with barriers/costs to accessing information and issues of coordination/collaboration or role clarity, as well as any challenges in making the case for resourcing and making best use of resources available, each of which have been raised as part of our analysis (as discussed in section 4 of our appended interim report).

Figure 10: Potential barriers, implications and collective impacts



These issues are discussed in greater detail in section 4 of our appended interim report.

2.4 Objectives/principles for an optimised system

We developed the principles set out in Figure 11 to inform and help assess options.

Figure 11: Objectives/principles for an optimised system

Optimises use of **resources** to ensure **fit-for-purpose** core forecasting, informing & warning services, including associated infrastructure & capability (public weather and climate forecasting)

Improves **understanding/prediction of impacts, risks and necessary actions** and drives more **effective** planning and emergency management

Reinforces **trust** in the weather forecasting system and builds **social capital** across diverse needs

Builds strong **international links** and alliances supporting access to relevant global systems, data, infrastructure/models, and expertise

Enables **innovation** within system, including through ensuring ready **access** to public/publicly funded information

Is realistic, **practical** and minimises service disruption

Where:

- *Optimises use of resources* includes financial resources and different capabilities and encapsulates delivering net benefits to New Zealand and value from government investment by way of fit-for-purpose public forecasting services applying necessary inputs.
- *Improves understanding/prediction of impacts, risks and necessary actions* includes supporting collaboration across the weather forecasting systems, across hazards and with emergency management players to drive effective planning and emergency management (looking across the four Rs of emergency management – reduction, readiness, response and recovery – as well as similar thinking for other applications and sectors).
- *Reinforces trust in the weather forecasting system and builds social capital*[3] *across diverse needs* includes minimising the risk of confusion through unambiguous information from official sources and recognising the diverse needs of users and the importance of effective engagement. This is likely to involve clear roles and messaging around warnings and watches.
- *Builds strong international links and alliances supporting access to relevant global systems, data, infrastructure/models, and expertise* includes building on the existing relationships and forums for engagement and partnership.
- *Encourages innovation within the system* includes an openness to private competition and closeness to user demands. Importantly, it also involves working across the public and private parties and ensuring ready and easy access to public/publicly funded information (including channels to disseminate information) and ability to draw on and apply that information (such as appropriate formats and systems). However, this could be available for free or incorporate

[3] Social capital is defined in the likes of https://www.treasury.govt.nz/publications/speech/social-capital-and-living-standards-framework which states "Social capital refers to the social connections, attitudes and norms that contribute to societal wellbeing by promoting coordination and collaboration between people and groups in society".

a charge to recover the cost of making this available (including both the marginal cost of provision and a contribution to appropriate overheads).

- *Being realistic and practical* also includes the management of any transition.

3. Options considered and recommendation

This section covers the:

- identified long-list of potential options to address identified barriers
- prioritisation of this long-list, and role and levers available to government
- short-listed options
- assessment of short-listed options
- recommended solution.

We discuss next each of these in turn, breaking out the assessment of options into the various components.

3.1 A long-list of options was identified relating to potential barriers to meeting future needs

Given the potential barriers identified in the previous section, we developed the long-list of potential options shown in Table 3 and as discussed below, added the shaded options in working through the detail. The table shows which of the different causal issues from Figure 10 each option might address. Where there is a "?", this indicates that it is uncertain whether the option would address the causal issue or that whether it addressed it would depend on the design of the particular option (or the associated elements incorporated under the option). The options range from discrete interventions that may address only one causal issue, such as the ability to comment on weather warnings, through to structural options such as various mergers that could have the potential to address each causal issue depending on the approach taken.

To consider these options further, the next section looks at the various roles and levers available to government, again focusing on addressing the identified barriers and set up an optimal weather forecasting system.

Table 3: Long-list of options to address identified barriers to meeting future needs

Options	**A - Limited funding, prioritisation & duplication**	**B - Data access limitations**	**C - Complex links and collaboration issues**
The **status quo**			
Restricting the ability to **comment** on weather warnings until after the warning period	✓		
Removing weather forecasting from **NIWA's scope** of services	✓		
Requiring **open access** to data and research that is publicly funded		✓	
Spinning off NIWA's weather forecasting services (with access agreements to joint systems)	✓		
Merging the two organisations (with various approaches)	✓	?	?
Incorporating public weather forecasting under an existing **department**, such as NEMA, MBIE, MFE or MOT	✓	✓	?
Procuring public good weather services (or observations and data services) from **market** & MetService potentially partially/fully privatised or existing entities being focused on research or value-added services	✓	✓	?
Collaboration arrangements/agreements (e.g. MOUs, co-location)	✓?		✓
Joint ventures for non-public forecasting services	✓?	?	
Natural **monopoly regulatory** arrangements for weather forecasting infrastructure	✓	✓	?
Integrated hazard management* with shared data & communication platforms	?	✓	✓
International collaborations and/or mergers	✓	✓	
Integrated local and central government purchasing of services	✓	✓	✓
Complaints and/or **disputes resolution processes** for disputes **over pricing or access**		✓	
Licensing or **qualification requirements** in order to provide weather forecasting services	✓		

* indicates that this could include potentially extending beyond the weather forecasting system.

3.2 The role and levers available to government

With this long-list in mind, we then worked through the role and levers available to government given the context of the weather forecasting system, to identify additional options (reflected as shaded options at the end of Table 3) and to work through and develop a short-list of options, looking across these roles to address the identified barriers and achieve the principles.

We considered the aspects set out in Figure 12, covering funding, delivery and regulatory levers and worked through the questions set out within it detailing the range of potential choices, and working through which would address the barriers, support the objectives, and were practical given the context. We briefly summarise some of the thinking below with further detail in Appendix B, and answers or references for the full set of questions in the project Terms of Reference set out in Appendix A.

Figure 12: Roles and levers available to government and associated questions worked through

1. Funding
   - i. Where does the **government** have a **role** in the weather forecasting system?
   - ii. Which **agencies** have an **interest**?
   - iii. **How** should public good weather forecasting services be **funded**?

2. Delivery
   - i. What **needs to be delivered** by the Crown (scope)?
   - ii. What are the **skills/requirements** needed for delivery?
   - iii. Which **vehicle** should be used for delivery?

3. Other (regulatory) levers
   - i. What **additional (regulatory levers)** should be considered?
   - ii. Are such levers **needed**?

Funding of aspects that would be under-supplied

Funding should support the long-term provision of aspects that would be under-supplied by the market, and where the government is in a unique position. Our interim report found there is strong evidence of net benefits from a public weather forecasting service. Without government involvement, we expect there would be under-provision of public weather forecasting services (i.e. weather forecasting services designated for public awareness and safety purposes). In this context, the government's role is summarised in Figure 13 and discussed below.

Figure 13: The government's role in the weather forecasting system

Ensuring:

- **provision** of **public good** weather forecasting
- a **free market** and level-playing field for value-adding and consumer-responsive products and services.

By:

- Supporting **international links** and access
- Support for **openly accessible research**, linked to wider needs and applications
- **Funding public good** infrastructure/services
- Ensuring an **authoritative voice** around warnings,
- Ensuring **open access** to public good infrastructure/services.

Engaging delivery: **partnership** on core/public good:

- balances funding for long term infrastructure with ability to consider short-term/additional needs
- resilient, with continuity in capabilities, security, and information/services
- supporting international links

The government's role in the context of the market is ensuring the provision of public good weather forecasting where there would be under-provision (non-excludable and/or non-rival), where there is a public interest (positive externalities) and/or it would be more efficient for a non-market solution due to cost and/or international links required. On the other hand, a free market and level-playing field is needed for value-adding and consumer-responsive products and services.

More specifically, the role of government involves:

- supporting international links and access
- support for openly accessible research, linked to wider needs and applications
- funding public good infrastructure/services (basic systems: observations, infrastructure, and data, where there may be natural monopoly characteristics)
- ensuring an authoritative voice around warnings (through designation, funding, application, and potentially considering regulatory levers if appropriate)
- ensuring open access to public good infrastructure/services (whether free or cost-recovered, and with questions on where value-add is applied, but without barriers to access).

We expect this to be best achieved by a lead funding agency coordinating priority government services and partnering with a dedicated weather forecasting system delivery entity, in a way that:

- provides long-term funding confidence on which to base infrastructure investment decisions which support core services
- enables consideration and prioritisation of potential short-term or additional services to government on top of the core services
- supports the delivery agent to make a case for funding opportunities, and for these to be considered on their merits as a purchase/service separate to any ownership consideration
- maintains international links, both diplomatically and strategically, to support the quality of our weather forecasting system

- supports resilience of service provision with continuity across capabilities and security of information
- requires what is publicly funded to be publicly available (unless good reasons exist not to, such as for national security).

There are opportunities for better coordination and prioritisation across agency interests

Figure 14 provides an overview of stakeholders with a relevant interest in the weather forecasting system and potential cross-agency funding options. These are considered in the context where there are currently a multitude of different contractual arrangements with both MetService and NIWA without a lead agency responsible across the system nor effective prioritisation across government interests, data is not always easily available, and there is little external monitoring at a system level. In addition, as highlighted above, in the interim report the consumer demands of the weather forecasting system are expected to grow.

Figure 14: Stakeholders with an interest in the system and potential cross agency funding options

Stakeholders with interests:

- MOT
- DPMC/NEMA
- MFE
- DIA
- MBIE
- NZTA
- CAA
- Regional Councils/LGNZ
- Maritime NZ
- Treasury
- FENZ
- DOC
- Search & rescue (Police, coastguard, etc)
- Industries/private/other entities

Cross agency options:

- Interdepartmental executive boards
- Interdepartmental ventures
- Chief Science Advisors Forum
- Cross interests:
  - Transport
  - Emergency management
  - Local government
  - Science
  - Climate/environment forums

Long-term funding, led by a responsible central agency that monitors overall system performance, would support optimal outcomes. We considered the application of funding principles and tools considered recently in relation to geohazard science services, consistent with the Treasury's Cross-Agency Funding Framework (The Treasury, 2015b) , and tested this with the project steering group. This is summarised in Figure 15, with a fuller discussion in Appendix B.

Figure 15: Approaches and options for funding public weather forecasting services

Principles:
1. Align with benefit distribution
2. Purchasing decision: those best able to make relevant trade-offs, and
3. Coordination costs ≤ benefits from pooled funding

Tools:
- Charge
- Pool
- Centre

Options*:
1. Status Quo
2. **Coordinated** – lead agency coordinates and funds public services; may be separate additions but prioritised and monitored; data sharing, interoperable
3. **Extended** – 2 including local government for core services too
4. An interdepartmental board (or venture) for either 2 or 3

*All options would involve cost recovery for defined specific services; advertising

We suggest a coordinated or extended approach be considered, with the difference largely being whether local government funding is included in the overall coordination of public interests funding and prioritisation. A lead agency would:

1. Coordinate interests across government and prioritisation what comes from core funding.
2. Be responsible for long-term funding for the delivery of these core services.
3. Monitor system performance, and the public provision of data, information and where applicable outputs.
4. Facilitate consideration of additional marginal services.
5. Enable the delivery entity to undertake services for other specific needs.

Below we set out boxes showing customer arrangements in the UK and lessons suggested to us in relation to GeoNet that have also informed our recommendations in relation to funding, monitoring and data access.

Lessons from GeoNet on funding and access

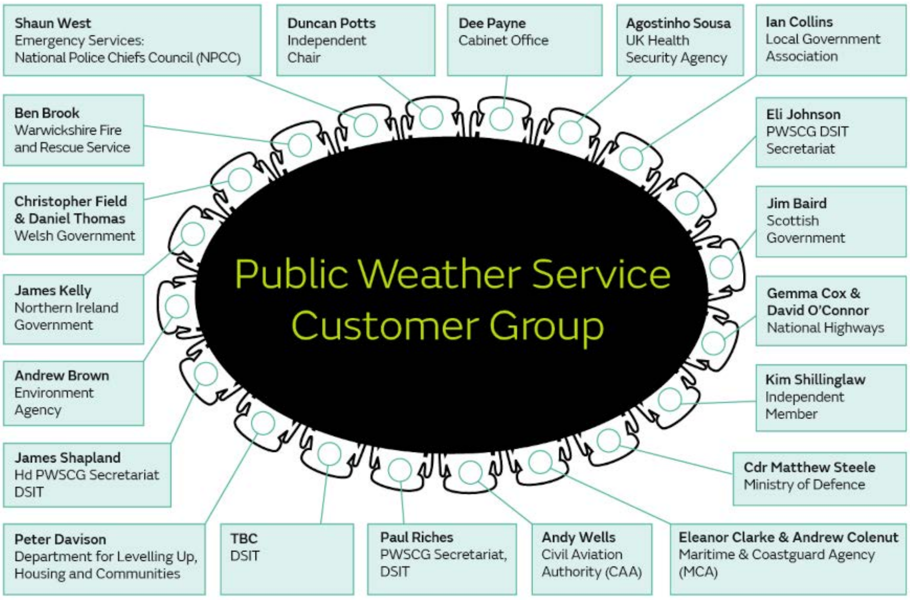
GeoNet came up in a number of our discussions from which there were two important relevant takeouts:

1) a lack of funding certainty and lead agency with a number of interested agencies created tensions, inefficiencies, and uncertainty that we were implored to avoid in the weather forecasting system, and

2) Geonet's open-access nature has been clear from the start and has supported good data; informed knowledge of risks; and stakeholder and public understanding, interest and confidence but there have also been tensions when private interests have sought coverage for specific applications where open data could have potentially limited further investment/coverage (though we are unsure if this has ever led to investment/coverage not being extended) as well as led to what may otherwise have not been public information to be able to be drawn on for wider understanding and research.

The UK's Public Weather Service Customer Group (PWSCG)

The PWSCG is an independent body which acts as the customer on behalf of the public and public sector users of the Public Weather Service (PWS). It is made up of members outlined in the graphic below and provides independent advice to Government ministers to enable the formal agreement of the PWS Customer-Supplier Agreement (CSA) between Government and the Met Office.



The PWSCG;s responsibilities include the following:

- Setting the current and future outputs required from the PWS and specifying its performance indicators and targets.
- Monitoring the performance and delivery of the PWS outputs against the agreed performance indicators and targets, and considering in-period modifications to the PWS as appropriate.
- Reviewing whether Met Office plans for the underpinning capability and international commitments are appropriately prioritised and have a demonstrable, value for money link to support the delivery of PWS outputs and other direct services to Government, the public sector and civil aviation.
- Reviewing the socio-economic benefits delivered by the PWS, commissioning additional research as necessary.
- Supporting cross-Government cooperation to increase the use of PWS outputs and raise issues relevant to wider Government, including through the Chair's representation on Met Office Governance groups.
- Providing independent advice to Government ministers on the PWS.
- Consulting widely with the public and the public sector users of the PWS, as appropriate, in order to effectively undertake its responsibilities above.

Source: https://www.metoffice.gov.uk/about-us/what/pws/pwscg/index and https://www.metoffice.gov.uk/about-us/what/pws/pwscg/tor

3.2.1 Government delivery of core services

Government delivery would be in the public interest for observations, infrastructure, data and modelling, and international engagement and responsibilities. Figure 16 summarises options for where the government has a core role in the delivery of public weather forecasting services. The focus on the core role is where there is a need for the government to ensure there is public provision of the service. Outside these areas, there is the potential for the private market to provide a sufficient service as well, meaning the distinction is more where the government should directly fund service provision rather than compete openly on an equal footing.

Figure 16: Scope of weather forecasting services where there is a core role for government delivery

Services:

a) Core/public services only

b) A + warnings

c) B + weather and climate research

Fields:

a) Weather

b) A + climate

c) B + hydrology

d) C + Oceanography

e) D + wider hazards

Considerations:

- Where is there potential for competition/ensuring level playing field?
- How is expertise developed and leveraged, what fields need to be applied?
- What forums might be possible to support links to what is funded?

The scope of core services for delivery includes maintaining an observation network, infrastructure provision, data and modelling, international engagements and weather-related reporting and warnings. “Weather” could usefully include climate and hydrology as well as oceanography. We highlighted in our interim report the potential value in linking across hazards.

Weather research does not need to be part of the core services and currently is not a large part of MetService’s activities. Nonetheless, there is a need for research priorities to be informed by the delivery entity and for its expertise to be leveraged as part of research where needed. Therefore, we expect there would be involvement in research commissioning as part of a panel or other forum inputting on research priorities, and likely involvement in research as well. However, this should be in a way that ensures a level playing field with other researchers and looks to partner, leverage and build New Zealand’s wider capabilities and insights in this space.

This would also enable the likes joint ventures and collaborations for value-added services or research. Nonetheless, there should be forums for the provider of public good weather forecasting to input into research demands and be involved in research, including in other to support capability development and information dissemination.

Delivery will require relevant skills, systems and relationships

There is a role for the government to deliver across the weather forecasting system. Here we consider what is required to ensure that delivery.

1. **Relevant scientific expertise** – this includes meteorology, environmental sciences (hydrology, climate, oceanography), and impact analysis (capability in targeted applications). It is possible that not all these skills need to be in the one entity, but there needs to be an ability to access and apply these skills.

2. **Data and computing expertise and capacity** – this includes computing, data storage and data analysis, data exchange (including external access) as well as artificial intelligence and machine learning and high performance/supercomputing.

3. **Communications expertise** – this includes relationship management, advisory, and being clear on impacts and necessary actions (working with relevant parties).

4. **Observation networks and data**, including design, investment, optimisation, and maintenance (again not all this need be in-house).

5. **Access to relevant international model(s) and data sets** as well as the international representation, engagement, and alliances to support and optimise these and improve coverage and capacity in the South Pacific.

6. **Models to apply and tailor various inputs to forecasts for local circumstances** – this includes the modelling capabilities, the models themselves, and the ability to predict and communicate impacts understanding the local context and diverse interests (which may include drawing on particularly localised data and/or industry-specific information held by others, covered under 8 below).

7. **Clear roles, areas of focus, responsibilities, and accountability lines** to ensure that the right people are doing the right things, and everyone knows what they should be doing. This would be supported by interoperability and ease of connection across systems (covered by 8 below).

8. **Systems to share data and information across different interested parties** and enable easy integration of different data and insights to support an understanding of impacts, understanding of local conditions, and novel applications. This would support efforts across the 4 Rs of emergency management and their broader applications.

9. **24/7 operations** to ensure that conditions are being monitored and forecasts are informed by the latest information, with the ability to respond in extreme events.

10. **Trust and credibility to advise decision-makers that builds confidence,** so that people are confident to act on advice and do so in sufficient time to optimise possible outcomes.

Options for organisation form

Figure 17 sets out options for the possible make-up of public delivery, as well as key design options and key considerations in determining the appropriate form(s) of delivery.

In terms of broader make-up, the status quo (A) appears unlikely to address identified problems in section 2.3 and is strongly associated with those problems, while status quo with attempts for improved collaboration (B) appears unlikely to be successful as it has been attempted in the past without successfully addressing underlying problems. This could include aspects such as co-location, joint directorships, or memorandums of understanding.

International agreements/mergers (E) may fall outside the scope for the review and risk undermining local representation (so would not appear to assess well against certain objectives/principles or delivery requirements above). In the face of issues with the interface and coordination with other actors within the New Zealand system, it is not clear that this option would focus on addressing the core problems identified. Instead, opportunities for greater international collaboration may be best supported through MOUs, capability sharing, joint investments in areas of common interest, regular dialogue and sharing of information (where a non-commercial model may provide further support noting existing efforts), and the likes of secondments.

Therefore, we suggest focusing on options involving enhancing the status quo or mergers of different forms. Consistent with MetService's submission, we have shortlisted a merger of relevant parts of NIWA and MetService into a new, less commercially-focused entity instead of an option of MetService acquiring relevant parts of NIWA, for the reason that despite the benefits a commercial model has brought in terms of costs, there are likely to remain tensions in relation to data access and potentially direction/priority in terms of use of capabilities. Further, if research is outside of scope, there may be a risk of effective reversion back towards the current arrangements.

In considering the form of any merger, we have considered the PSC guidance on advising on organisational form (Public Service Commission, 2022), with a key summary of form options provided and drawing what we consider to be key considerations in Figure 17.

When looking at possible institutional arrangements, Figure 18 sets out the broad option set, and we have considered the contemporary and prior guidance in relation to institutional form. We suggest the delivery function is one inside the executive branch of government. From this, we **rule out**:

- forms with a principal objective to operate as a successful business given the wider public interests and identified barriers
- forms with a high degree of Ministerial oversight, as there is a need for considerable operational independence given that the government's purchasing function will act as the main oversight arrangement
- an ICE as not being necessary/well suited.

This leaves a (as bolded in Figure 17):

- Statutorily Independent Function through a departmental agency or ACE
- Crown Entity Company (which could include a CRI), or
- Public Finance Act Schedule 4A (while the latest summary above suggests this is only where there is not 100 per cent Crown ownership, past guidance notes this is possible with 100 per cent ownership and more applicable for lighter accountability regimes).

Turning to the key considerations Figure 17, we find:

1. There are clear links between MetService's weather forecasting services and capabilities and NIWA's climate, hydrology and super computing capabilities in particular (the boxes below provide a rough estimate of the components of NIWA's business and their connection with the weather forecasting system). This bears considering relative to, for instance, certain GNS capabilities around hazard monitoring and impact analysis relating to natural hazards, as well as local government hydrology expertise and local government and NEMA's emergency management expertise.

2. Any public entity in this space should not be fully commercial, but there may be the ability to allow for commercial subsidiaries/joint ventures so long as this is on a level playing field.

3. Operational independence from Ministers is needed.

4. The contracting or specification of purchasing arrangement appears to be the key accountability mechanism (with the lead entity also responsible for monitoring the system as a whole), so governance and accountability could be lighter.

5. It is likely desirable for the model to allow for commercial subsidiaries/joint ventures with data equally available to any subsidiary as any other market participant.

6. The public interest perspective will need to be clear in both the mandate for the delivery entity as well as its funding arrangements. There is a risk that a company form/entity with its own board places incentives that could pull against a wider public interest, as Directors have duties to act in the interests of the entity. This possible tension may need to be considered relative to the need for a degree of operational independence from Ministers (or if necessary other government levers considered to address this possible tension).

Figure 17: Broad delivery form/structure option set and key considerations for appropriate form

Make-up:

a) Status quo: (SQ)
b) Collaborative SQ
c) Enhanced SQ: remove forecasting from NIWA scope
d) Merging capabilities
e) International agreement/merger

Design (if merger):

a) Existing: An SOE or CRI as one party acquiring the other/part of the other relevant to the weather forecasting system; or using a subsidiary
b) New commercial/mixed objective: New SOE, **Public Finance Act s4A company**
c) Closer to government: A **departmental agency**
d) Public but separate: **A Crown entity** or **Crown entity-company**
e) Collaborative: an interdepartmental venture
f) International/contract out: A local division offered as part of an international agreement

Considerations:

1. How important are links to wider NIWA functions?
2. How commerial vs public-focused should it be?
3. What balance is needed between Ministerial direction and independence?
4. How much governance and accountability?
5. Should the model allow commercial subsidiaries/JVs?
6. How to ensure ability to take wider public interest perspective?

Portion of NIWA's activities that form part of the Weather Forecasting System

Based on information provided by NIWA, we estimate that around half of its business and a slightly lower proportion of its research and scientific staff relate to the weather forecasting system. This is highlighted below in terms of average estimated portion of different business units, within which there are typically elements relating to the impacts of climate change that are higher (as indicated by the ranges). We further provide a graphic from NIWA that sets the broad staffing and aspects that fits more centrally within the system.

Tables 4: Portion of NIWA's business that is part of the Weather Forecasting System and Total FTE within system by business unit

Business Unit/Total	Research	Applied Science	Total
Aquaculture	20%	2%	16%
Coasts & Estuaries	18%	18%	18%
Climate, Atmosphere & Hazards	96%	98%	97%
Environmental Information	59%	60%	59%
Fisheries	12%	2%	3%
Freshwater	28%	22%	26%
Pacific Rim	100%	98%	98%
Oceans	63%	74%	69%
Science Awards	60%	N/A	60%
Te Kūwaha	16%	8%	15%
Total percentage	**54%**	**47%**	**51%**
Total Revenue within system ($m)	47.9	36.2	**84.1**
Total Costs within system ($m)	42.0	30.5	**72.6**
Total FTE within system (FTE)	**52**	**169.5**	**221**

NIWA Group Employees	Headcount February 2024	FTE February 2024
Scientists	292	278.10
Technicians	226	217.95
Vessels Crew & Workshop	39	39
Vessels Admin	12	12
Technology & Innovation: - IT - Systems Development Team - Supercomputing Team - Data Science Team	50	48.84
Science Library Services	4	3.50
People & Capability (HR)	10	9.20
Corporate and Science Communications & Marketing	17	16
Finance, Legal & Procurement	17	15.84
Other Science and Regional Support Services	51	48.11
Senior Management - Executive Team - Science Management Team - Operations Management Team	28	26.65
Unidata (Australia) - weather & water monitoring instruments & systems	15	14.84
Total	**761**	**730.03**

Note some numbers do not add due to rounding.

NIWA Forecasting Team

250+ staff

Science staff which benefit from or utilise envirormental forecasting information and data

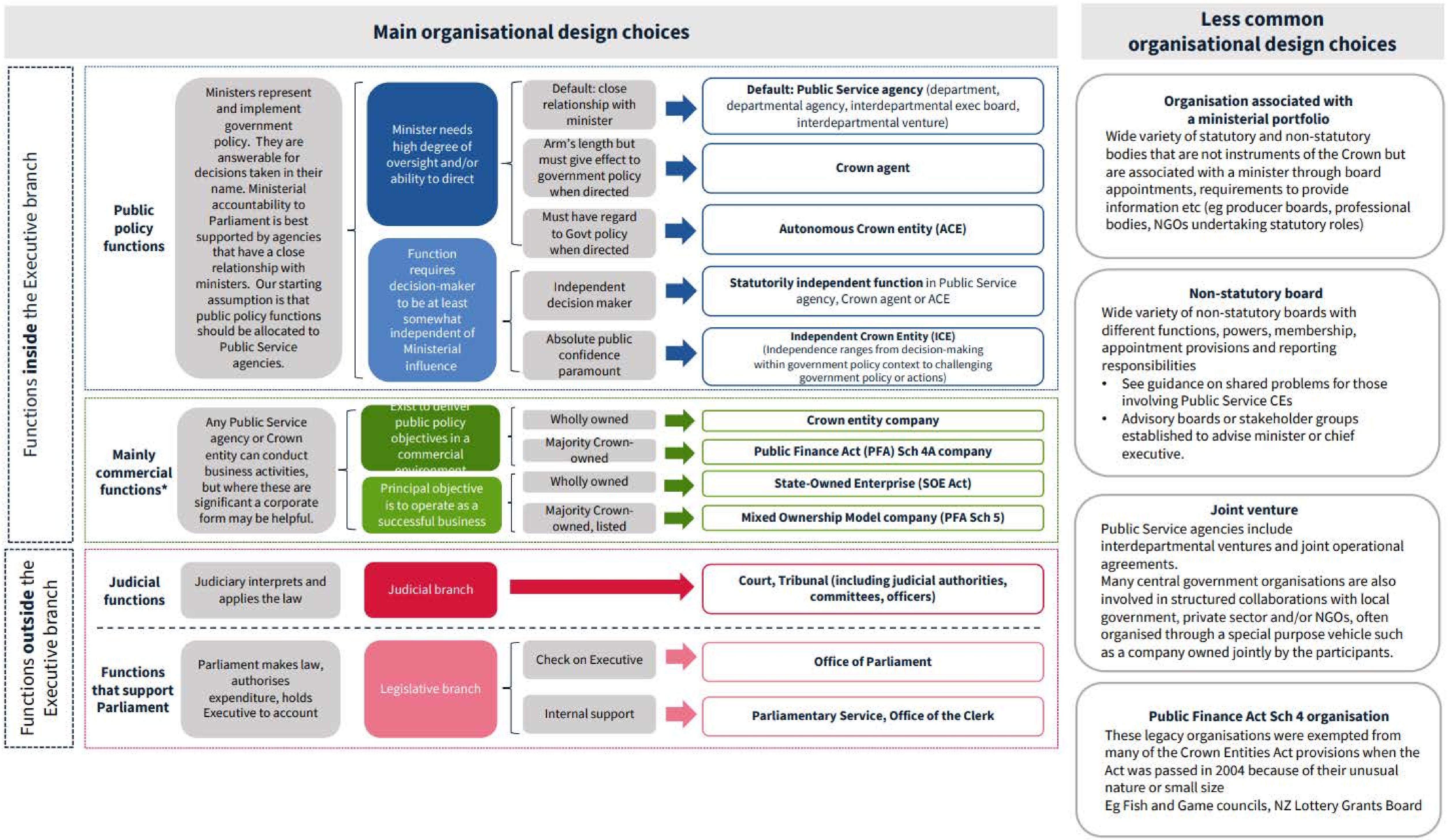
Research groups include: Aquaculture and Marine Natural Products, Aquatic Pollution, Chemistry and Ecotoxicology, Collections Curations, Deepsea Ecology and Fisheries, Environmental Isotopes and Molecular Biology, Fisheries and Marine Ecology, Fisheries Data Services, Fisheries Monitoring and Acoustics, Aquatic Plants, Freshwater Ecology, Freshwater Modelling, Inshore Fisheries, Marine Biodiversity, Marine Biogeochemistry, Marine Ecology and Aquaculture, Marine Ecosystems & Biosecurity, Marine Technology, Modelling & Recreational Fisheries, Natural Solutions, Marine Ecology, Ocean Geology, Ocean Sediments, Population Modelling, Urban Aquatic Environments, Water Quality lab.

Climate, Freshwater & Ocean Science

270+ staff

Roles include: meteorologists, forecasters, climate scientists, NWP modellers, climate modellers, atmospheric scientists, HPC research engineers, remote sensing researchers, data scientists, hydrologists, hydrological forecasting scientists, hydrodynamics scientists, hydrodynamics modellers, river modellers, sediment transport scientists, geomorphologists, coastal scientists, estuarine physical processes scientists, coastal modellers, coastal adaptation scientists, hazards analysts, natural hazards risk scientists, environmental social scientists, environmental economists, māori environmental researchers, environmental social scientists, freshwater researchers, marine scientists and māori graduate interns, 24/7 forecast operations team, environmental monitoring technicians, climate technicians, climate database managers, systems development team.

Figure 18: Public Sector Commission's Organisational Form Summary



Source: https://www.publicservice.govt.nz/assets/DirectoryFile/Organisational-form-summary.pdf

3.2.2 There are other levers available to protect the public interest

Having considered the government's funding and delivery roles, this section considers potential regulatory or other levers to address identified potential barriers, drawing on practices in other jurisdictions or sectors.[4] In addition to potential structural options in relation to the delivery of public weather forecasting services, Table 5 notes that there are alternative options/levers in particular in relation to dealing with issues relating to data access and inconsistent public messaging. These could either be part of a package of recommended changes that could be considered now or also serve as important options for escalation if the recommendations or ultimate decision taken prove insufficient in addressing these barriers.

Table 5: Potential regulatory and other levers available to address potential barriers

Potential barriers to address	Possible regulatory lever	Other alternatives
Data access restrictions	Natural monopoly-type regulation of pricing and access	Self-regulatory models Agreeing to periodic open-book reviews by independent experts
	Complaints and/or disputes resolution processes for disputes over pricing or access	
Inconsistent messaging and public uncertainty over warnings	Restrictions on communications that cut across weather warnings (or potentially watches too)	
	Licensing or qualification requirements in order to provides weather forecasting services	

Data access

There are several natural monopoly regulatory regimes that focus on pricing and access that could be drawn from. For instance, in New Zealand there are regimes relating to electricity transmission/distribution, airports telecommunications, and the dairy industry. There are numerous other arrangements internationally. In addition, there are several complaints and disputes resolution regimes that could be drawn from to design an avenue to deal with any complaints in relation to pricing or access. These exist in relation to ACC claims, legal services, and many utilities/professional industries, for example. Applying something to weather forecasting services would provide an avenue beyond the direct organisation, Minister, or where appropriate the Commerce Commission. The challenge with such regimes in this context would likely be ensuring that the benefits justify the costs and therefore smaller interventions may also wish to be considered, or less interventionist approaches

[4] We note there is a much wider set of regulatory tools and approaches. For instance, see: https://www.regulatorytoolkit.ac.nz/resources/papers/book-1/regulatory-management-in-new-zealand-what,-how-and-why

(for instance NZ Post discloses its access agreements publicly, and there are other information disclosure arrangements in relation to costs and services that apply across several regulated sectors).

The are different self-regulatory options that could be considered, including firm-based service charter, aspirational codes, accreditation/quality assurance schemes, model contracts, external dispute resolution, standards, or legal codes/co-regulation.[5] A further alternative could be for the public delivery entity/entities to agree for a periodic review of their pricing and access arrangements, and the openness of these, by an independent expert that is agreed with or appointed by the monitoring agency each time.

Inconsistent public messaging

Options beyond structural changes in addressing issues around consistency of public messaging and uncertainty over warnings include restrictions on communications that might cut across warnings (or watches). For instance, communications in relation to the area and the time period could be limited to referencing the official communication or potentially to simply providing tailored application consistent with the official forecast. Our analysis has suggested that at present, the main cause for confusion is that there are two publicly owned organisations providing at times inconsistent messages and that most people are less concerned and able to compare across private commentary and official public communications. However, it is possible that this could change if there were to be significant growth in the private market for weather forecasting services.

The other option highlighted is requiring the licensing or certain qualifications in order to provide weather forecasting services. This approach is applied in Japan as noted in (Hatori et al., 2016). This was not an option that came up in any of our stakeholder discussions and given the evolution of services could act to inhibit or slow innovation. If it were to be considered, lower cost options such as registers could also be considered such as exist in relation to postal operations (MBIE, 2024).

[5] For instance, see: https://businessnz.org.nz/wp-content/uploads/2022/07/Regulation-Perspectives.pdf

3.3 Five options were shortlisted based on this approach

Figure 19: Short-list of options provides an overview of the options that we shortlisted. These include:

- The status quo: with the two entities operating as they do at present or as they are expected to evolve individually facing their existing incentives.
- Option 1: enhancements to the status quo. This involves requesting that NIWA's scope of services exclude services/functions that MetService is responsible for (to address duplication).
- Option 2: integrating NIWA and MetService alongside NIWA's other functions. This is likely to involve NIWA acquiring MetService and operating as a subsidiary, at least initially. Then there would be the ability to draw on different capabilities and systems across the two organisations, and to coordinate communications and messaging.
- Option 3: a new public weather service entity that includes the components of MetService and NIWA that fall under the weather forecasting system and is less commercial than an SOE with the ability to design anew. This would involve combining weather and climate capabilities, with either close connection or incorporation of hydrology and oceanography as well. This would be set up as a Public Finance Act 1989 Schedule 4A (PFAs4A) company.
- Option 4: integrating both capabilities in relation to the weather forecasting system as well as capabilities relating to other natural hazards (picking up on the approach taken in Japan as highlighted in the final appendix of our appended interim report). This would either be option 2 with relevant components of GNS, or with the relevant weather forecasting system elements incorporated within GNS. This could include the GeoNet capabilities and RiskScape as well as GNS's research and understanding in relation to impacts.
- Option 5: integrating the weather forecasting capabilities with those held within NEMA in relation to emergency management. This would involve the relevant components much like option 3, but sitting within NEMA, and tasked with existing contracts and responsibilities of MetService and NIWA that fit within the weather forecasting system.

Across options 1-5, there would be coordination and prioritisation of funding for delivery of core weather forecasting services and warnings and shifting to elements of long-term funding with the lead funder monitoring performance of the system, as well as the performing of public delivery entity/entities in delivering against funding agreements. Any public delivery entity/entities would need to make publicly funded data and research publicly available, and potentially publicly funded outputs as well where agreed/funded (and unless there were good reasons not to). There would also be a check on pricing and access to information, likely through the monitoring entity engaging periodic reviews of this.

We consider how each of these assess against the objectives for the future system in the next section. Options 4 and 5 are technically outside the scope of the review, however we thought identifying them and undertaking this exercise may be useful.

For options 2-4, there are different potential organisational forms including a departmental agency, Crown Research Institute (CRI) or other Crown Entity Company, Public Finance Act 1989 Schedule 4A company (PFAs4A), and an Autonomous Crown Entity. We suggest a CRI for either options 2 or 4 for ease of change, and a PFAs4A for option 3 to start anew and be clear in tailoring the purpose, noting this preserves the potential for commercial elements (e.g., subsidiaries or joint ventures) and allows operational independence without needing specific legislation or overwhelming an existing institution and potentially diverting its purpose.

We discounted setting up a new departmental agency under the likes of the Ministry of Transport or MBIE, in order to preserve the option for commercial operations and given the likely additional cost involved with this over other alternatives noted here.

Figure 19: Short-list of options

	SQ	1. ESQ	2. Integrate	3. New	4. Broader	5. Linked to EM
Funding, monitoring	Existing	**Coordinated, prioritised,** w/ **long-term funding** agreement for delivery (core), **monitoring** system performance				
Data access		**Publicly funded** data and research is made **easily available** (and where funded/agreed, outputs too)				
Additional integration considerations		*Investment case* for **data integration** and **access** platform				
		Investment case for **interoperability** in IT **systems** across EM agencies				
Scope		**Enhanced SQ**	**Full integration**	**New** integrated prediction-focused entity	Expanded integration **across hazards**	**Integrated with NEMA**
Institutional form		SOE, CRI	CRI	PFAs4A	CRI	Departmental Agency
Checks		Check on pricing/access		N/A	Possible check	N/A

3.4 Options 2 and 3 are the best options against principles for an optimised system

Having shortlisted five options, we assessed these options against the objectives/principles for an optimal system set out in section 2.4. This assessment is summarised in Table 6.

From this, options 2 and 3 were then considered further in terms of cost benefit analysis as they assessed better on all criteria other than practicality, and do not stray outside our terms of reference. The difference in relation to practicality is because they involve greater change, which a CBA will help assess if this would overall be worth the associated cost.

Further information in relation to GNS would be needed to assess option 4 further, and similarly in relation to NEMA for option 5. We note that GNS has a headcount of around 507 (GNS Science, 2023) and NEMA has around 153 FTE (NEMA, 2023). This suggests that it would be a significant shift for NEMA to absorb public delivery functions and expertise in relation to the weather forecasting system that currently employs a larger number than this. We note both have 24/7 operations centres which could provide an opportunity to consider efficiencies, but that NEMA has a focus on emergency management rather than the underlying science that may inform its functions or on other applications within the weather forecasting system.

Table 6: Assessment of shortlisted options against objectives/principles

	Status Quo	Option 1: ESQ	Option 2: Integrate	Option 3: New	Option 4: Cross hazard focus	Option 5: Integrated with EM
Optimises resource use, fit for purpose	0	+ Through reducing direct overlaps, we expect an improvement in resource use through reduced duplication plus more coordinated purchasing. However, still likely to be less than optimal if coordination challenges remain. Expect any reduction in market opportunities for NIWA (and any impact on its investments) to be offset by reduced friction in the market and more coordinated and longer term purchasing.	++ Expect to coordinate capability better in delivery and purchasing, risk may be in relation to efficiency without the same commercial incentive Should improve efficiency, resilience, and potential long term to improve capability through integration.	++ Expect to coordinate capability better in delivery and purchasing, risk may be in relation to efficiency without commercial incentive. Whether it is able to take into account the needs of New Zealand more easily will depend on it not being an SOE. Should improve efficiency, resilience, and potential long term to improve capability through integration.	++ Expect to coordinate capability better and allow broader skills to be applied, risk may be in relation to efficiency and internal coordination. Should improve efficiency, resilience, and capability.	+ Through reducing direct overlaps, we expect an improvement in resource use through reduced duplication plus more coordinated purchasing. Doesn't achieve as well as others as there may be too great a focus on emergency management rather than science and applications.
Understanding of impacts, risks and actions and improved effectiveness	0	+ Increased access and reduced direct competition as well as investments should support improvement.	++ Increased access and removed direct internal competition as well as investments should support improvement as well as bringing together broader key capabilities. Communications will need to clarify relevant roles/functions.			++ As with options 2-4, but with a risk in terms of focus beyond EM.
Trust and social capital	0	+ Improved clarity of voice would increase trust.	++ Increased ability to leverage different relationships and expertise; to channel and coordinate communications is expected to improve trust, social capital, and engagement.			++ As with options 2-4, but with a risk to independence of scientific expertise.
International links	0	0	+ Dealing with one organisation may simplify international relationships and enable these to be leveraged over different applications.			
Innovation & access	0	+ There is a risk that with reduced publicly owned competition in weather forecasting that there is less innovation. We suggest this is likely to be more than offset by clarity of roles and flow-through to leveraging human capabilities and improved integration from research to operations.	++ There is a risk that with reduced publicly owned competition in weather forecasting and less commercial focus that there is less innovation. We suggest this is likely to be managed through focus on consumers, and data being available to private providers and offset by clarity of roles and greater agglomeration benefits and building of human capabilities. The removal of significant competition within government and revised focus on public good, together with monitoring and investment cases should support this.			+ As with option 1 with some agglomeration, but potential for reduced focus on the science means not the extent of options 2-4.
Practical	0	0 It is assumed that committed services would not be impacted as these would be run through and re-tendered.	- There will be a level of organisational change and uncertainty during this period. While the change is realistic and possible, and service disruption should be manageable, there is some risk relative to the SQ short term.	- There will be a level of organisational change and uncertainty during this period. While the change is realistic and possible and service disruption should be manageable, there is some risk relative to the SQ short term.	- There will be a level of organisational change and uncertainty during this period. While the change is realistic and possible and service disruption should be manageable, there is greatest risk relative to the SQ in the short term.	- There will be a level of organisational change and uncertainty during this period. While the change is realistic and possible and service disruption should be manageable, there is greatest risk relative to the SQ in the short term.
Overall assessment	**0**	**4+**	**8+** (Potentially less disruption and greater integration across skills but risk of reduced access relative to option 3)	**8+** (Potentially more disruption but could be better access relative to option 2)	**8+** (Potentially most disruption but better access relative to option 2 and greatest access to skills and visibility across hazards)	**5+** Expect a number of improvements but a risk that applications beyond emergency management receive less attention

Scale: ++ much better than the status quo, + better than the status quo, 0 about the same as the status quo, - worse than the status quo, - - much worse than the status quo.

3.5 Full integration of NIWA and MetService provides the greatest net benefits

We undertook a high-level cost benefit analysis of options 2 and 3 relative to the status quo, based on these being the options within the terms of reference that assessed best against the objectives for the future system, and in the knowledge that a more detailed cost benefit analysis would need to be informed by a detailed design working with the agencies to design each option in detail. Figure 20 provides an overview of the relevant benefits and costs, and Table 7 outlines the categories of benefits under options 2 or 3, while Table 8 outlines the categories of costs and risks. For both, we identify who these accrue to and whether they are direct or indirect. Following this we either quantify each or provide a sense of the potential significance.

Figure 20: Benefit and cost categories for options 2 and 3

- **Prioritisation**/org alignment with NZ interests (public)
- **Increased application** of weather data, innovation in services (public, competitors, customers)
- **Improved services**: detection of severe weather and impacts (public, customers): FAR, POD
- **Interoperability** with EM, CRIs, etc (public, relevant agencies)
- Operating **cost saving** (MS/NIWA)
- Cost savings to others (CEM, councils, researchers) – search, transaction, coordination
- Capital cost savings (MS/NIWA)

Transition costs

1) Option detailed design
2) Change in legislation
3) Moving, rebranding, establish institutional policies, etc
4) ST: increased staff turnover, redundancies? + recruitment costs

Open data costs

Risks:

1) Reduced financial sustainability/funding certainty
2) Lack of efficiencies/cost management
3) Loss of staff
4) Loss of innovation
5) Service disruption/lost efficiencies in transition

Table 7: Benefits of options 2 or 3

Benefit	Description	Relevant party
Indirect benefits		
Improved prioritisation of effort and investment	This is the benefits from efforts and investment being more aligned with where there is the greater benefit to New Zealanders (with a reduced consideration of the need to monetise applications)	Public
Increased application of weather data	The benefits from additional applications of weather data, supported by improved access to data and the merging of capabilities and systems, as well as the innovation in services and products as a result of these things	Public, competitors, customers
Improved services	Potential benefits in terms of greater and earlier detection of weather, reduced false positives and greater probability of detection to the extent that this results from the changes proposed or from these benefits being realised earlier, or to a greater extent, as a result	Public, customers
Greater trust	Benefits in terms of increased confidence, understanding and greater likelihood of taking action which may save lives and assets	Public, customers
Improved interoperability	Benefits from improved interoperability across systems, with emergency management and across CRIs, leading to improved applications, greater confidence, increased speed of knowledge transfer and warnings and therefore actions and improved understanding of impacts	Public, customers
Direct costs-savings		
Operating cost savings for MetService and NIWA	Operating cost savings because of merging entities in terms of reduced combined costs for IT systems and data, and executive and back-office functions	MetService, NIWA and as a result the Crown
Cost savings to other parties	Reduced search, transaction, and coordination costs for those using weather information	Customers and stakeholders
Capital cost savings	Reduced collective capital investment needs and increased resilience as a result of joint network and systems.	MetService, NIWA and ultimately the Crown

Table 8: Costs for options 2 or 3

Cost	Description	Relevant party
Transition costs		
Decision-making	The costs of officials, Ministerial and Cabinet decisions	Government
Detailed option design and change management	Consultation, co-design, needs, role and functions/services analysis and detailed analysis of systems personnel and value, and change management to transact and shift to amalgamated state	NIWA and MetService
Merger clearance/authorisation	If needed, renewing Crown Law advice and if appropriate seeking Commerce Commission merger clearance or authorisation	Government
Changes in legislation	To establish or remove an entity/entities from relevant Acts and if needed to allow a merger	Government
Redundancies	Costs of redundancies if the changes trigger redundancies clauses in employment contracts	NIWA and MetService
Costs of opening up data access		
Investments in systems	Investments needed to support easy and open access to weather data	Government
*Forgone revenue**	*Forgone revenue to MetService and NIWA as a result of opening up access*	*NIWA and MetService*
Advisory costs		
Investment cases	Costs to develop and consider the proposed investment cases for improvements in data access and interoperability across systems	Government
Risks		
Reduced financial sustainability/funding certainty	We think this is unlikely, but there is a risk that the changes reduce rather than increase financial sustainability or funding certainty. This would particularly be the case if there was increased reliance on the Crown rather than private sources of funding without any changes in the ability to make the case for funding to the Crown	NIWA and MetService
Lack of efficiencies/cost management	While we have given ranges and tried to be conservative, there is a that the expected savings are overstated or do not get realised, or that with less of a commercial focus there is a loss of cost management	NIWA and MetService
Loss of staff	With any change process there is a risk that there is increased staff turnover during or as a result of the changes. However, we also heard that there has been some turnover linked to the current challenges and our proposed approach seeks to manage this. Nonetheless, some level of redundancies is considered where it is thought this may be triggered too	NIWA and MetService

Cost	Description	Relevant party
Loss of innovation	If there were a reduction in competitive tension as a result of the changes, there may be a risk of a reduced incentive to innovate. However, our proposal seeks to maximise both the opportunity and incentives to innovate	Public
Service disruption/ inefficiencies during transition	With any change, there is a risk of service disruption and/or inefficiencies during the transition. We have been mindful of this in our suggested approach and recommend this be a key consideration through any implementation	Public and customers

**NOTE this is transfer we highlight rather than a net economic cost and only additional costs of opening up access rather than forgone revenue are included in the CBA*

3.5.1 Net benefits from full integration

The magnitude and confidence of the identified costs and benefits of option 2 and who each accrues to are set out in Table 9 along with the estimated net monetised and non-monetised benefits. Benefits and costs have been stress-tested for conservatism. Scenarios have been run where:

- costs are larger than in our central estimate
- benefits are lower than in our central estimate
- costs associated with the transition period accrue over a longer period than in the central case (two-year transition period)
- benefits accrue more slowly in the central case (benefits start to accrue from year three).

We estimate that the net monetised benefits are in the order of $104.1 – $139.0m over the next 50 years with a further medium level of non-monetised net benefits. Given the data gaps, high-level nature of this and the time available there is a somewhat wide range and low level of evidential certainty, that we expect would improve with more detailed design work. Nonetheless, we suggest this is sufficient to recommend pursuing this course of action.

Table 9: Monetised and non-monetised costs and benefits for Option 2, (present value $m)

Affected groups	Comment	Impact (PV $m)	Evidence Certainty
Additional benefits of the preferred option compared to taking no action			
Indirect benefits			
Public	Improved prioritisation of effort and investment	Medium	Low
Public, competitors, customers	Increased application of weather data	Medium	Low
Public, customers	Improved services	Medium-High	Medium

	Greater trust	Medium	Low
	Improved interoperability	Medium-High	Low-Medium
Direct Benefits			
MetService, NIWA and ultimately the Crown	Operating cost savings for MetService and NIWA	173.7 - 194.0	Medium
	Reduced collective capital investment needs and increased resilience as a result of joint network and systems.	0.6	Low
Customers and stakeholders	Reduced search, transaction and coordination costs for those using weather information	Medium	Low
Total monetised benefits		174.3 - 194.6	Medium
Non-monetised benefits		Medium	Low
Additional costs of the preferred option compared to taking no action			
Transition costs			
Government/ NIWA and MetService	Detailed option design and change management	2.1 - 5.9	Low
	Moving, and other establishment costs	0.2 - 0.4	Low
	Changes in Legislation	0.1 - 0.3	Low
	Redundancies	1.2 - 1.8	Low
Costs of opening up data, advisory costs, and deadweight loss			
Government/ NIWA and MetService	Investments in systems	1.5 - 2.8	Medium
	Investment cases	0.7 - 1.4	Low
	Costs of open data access	40.4 - 44.4	Medium
Deadweight loss	Deadweight loss accounts for the distortionary impact of activities funded by taxation	9.3 - 12.5	Medium
Total monetised costs		55.6 - $75.0	Low

Non-monetised costs		Low	Low
Net benefits/costs of the preferred option compared to taking no action			
Net monetised benefits		NPV: 99.2 - 139.0 BCR: 2.3 – 3.5	Low - Medium
Net non-monetised benefits		Low	Low

3.5.2 Fewer net benefits from a new entity

The magnitude and confidence of the identified costs and benefits of option 3 and who each accrues to are set out in Table 10 along with the estimated net monetised and non-monetised benefits. Benefits and costs have been stress-tested for conservatism. Scenarios have been run where:

- costs are larger than in our central estimate
- benefits are lower than in our central estimate
- costs associated with the transition period accrue over a longer period than in the central case (two-year transition period)
- benefits accrue more slowly in the central case (benefits start to accrue from year three).

We estimate that the net monetised benefits are in the order of $26.8 – $50.3m with a further medium level of non-monetised net benefits. Given the data gaps, high-level nature of this and the time available there is a somewhat wide range and low level of evidential certainty. Nevertheless, we are confident that there is a relative difference to option 2 sufficient to progress with only considering option 2 (or broader applications) rather than option 3.

Table 10: Monetised and non-monetised costs and benefits for Option 3, (present value $m)

Affected groups	Comment	Impact (PV $m)	Evidence Certainty
Additional benefits of the preferred option compared to taking no action			
Indirect benefits			
Public	Improved prioritisation of effort and investment	Medium	Low
Public, competitors, customers	Increased application of weather data	Medium	Low
Public, customers	Improved services	Medium-High	Medium
	Greater trust	Medium	Low
	Improved interoperability	Medium-High	Low-Medium

Direct Benefits			
MetService, NIWA and ultimately the Crown	Operating cost savings for MetService and NIWA	94.0 - 105.0	Medium
	Reduced collective capital investment needs and increased resilience as a result of joint network and systems.	Medium	Low
	Capital costs	0.5 - 0.6	Low
Customers and stakeholders	Reduced search, transaction and coordination costs for those using weather information	Medium	Low
Total monetised benefits		94.5 - 105.6	Medium
Non-monetised benefits		Medium	Low
Additional costs of the preferred option compared to taking no action			
Transition costs			
Government/ NIWA and MetService	Detailed option design and change management	2.1 - 5.9m	Low
	Moving, and other establishment costs	0.2 - 0.4	Low
	Changes in Legislation	0.3 - 0.5	Low
	Redundancies	0.7 - 1.1	Low
Costs of opening up data, advisory costs, and deadweight loss			
Government/ NIWA and MetService	Investments in systems	1.4 - 2.8	Medium
	Investment cases	0.7 - 1.4	Low
	Cost of open data	40.4 - 44.4	Medium
Deadweight loss	Deadweight loss accounts for the distortionary impact of activities funded by taxation	9.2 - 12.1	Medium
Total monetised costs		55.2 - 72.5	Low

Non-monetised costs		Low	Low
Net benefits/costs of the preferred option compared to taking no action			
Net monetised benefits		NPV: 22.0 – 50.3 BCR: 1.3 – 1.9	Medium
Net non-monetised benefits		Low	Low

3.6 Possible benefits from bringing together capabilities

There are considerable benefits from bringing science and technology functions together organisationally and, where appropriate, through co-location or some other form of adjacency. Historically, there have been many initiatives to try to support CRIs to collaborate rather than operate independently in order to respond fully to the challenges presenting New Zealand and its industries, given the barriers that can exist to working beyond organisational boundaries. Bringing NIWA together with MetService or other science-based organisations could reveal benefits in:

- the quality of research outputs and/or commercialisation of ideas
- reduced costs (both search and execution costs) of collaborating, and thus increase the returns to the collaboration.

The greatest positive effects occur for researchers and firms undertaking similar activities but there is also evidence of positive interdisciplinary spill overs between researchers in different academic fields or commercial sectors.

Physical proximity plays a critical role in predicting the impact (both intensity and quality) of scientific research from research laboratories.

- Intensity of co-publication is significantly higher when researchers are in immediate proximity (40 times higher within laboratories than between laboratories in the same town).
- Co-located laboratories were around 1.4 times more likely to produce a research paper in the highest quartile of citation distribution.
- After co-location, laboratories are more likely to pursue both lower-quality projects (more marginal ideas being developed) and high-quality projects (research teams apply more effort and improve the quality of their projects).
- University science park co-location impacts positively on research productivity and firm-level patenting research (estimated at around 0.6 compared to around 0.3 for those not co-located on a park).
- Geographic distance significantly decreases the probability of generating and obtaining joint patents.

There are possible disbenefits from co-location at times, such as, the separation of science research from science delivery. There is no easy answer and there are several ways that capabilities can be organised with the prospect of increased appropriate adjacency of functions and activities.

Implementation of such adjacency either physically or virtually through co-location or team-based work would likely yield considerable productivity and other benefits. In contrast, current institutional arrangements have tended to hinder such adjacency.

3.7 We recommend full integration of NIWA and MetService

Figure 21 provides an overview of our recommended approach and highlights where specific aspects are aimed at addressing specific identified barriers (others seek to address multiple barriers). The recommended option would include:

a) **enhanced funding and monitoring** of the system performance as a whole, prioritising across government purchasing interests for core services and taking a long-term view. This would involve a lead agency responsible for funding and contracting for core services, coordinating and prioritising across different demands, and monitoring performance of the system as a whole as well as against funding conditions.

b) **merging relevant capabilities** and system to ensure that relevant insights are able to be drawn on and inform a greater understanding of impacts, coordinate communication in a way that reduces ambiguity and draws on different communication channels, and support efficiencies in the management of observations, data and modelling and remove duplication. This would involve integrating meteorology, climate science, hydrology, oceanography and data science expertise to draw on these complementary skills and provide better understanding across hazards and impacts. This would be achieved by NIWA acquiring the shares in MetService and initially operating it as a subsidiary and following detailed co-design, amalgamating where this makes sense in order to best meet New Zealand's needs (including ensuring a level playing field with other providers/applications). Under this approach NIWA's functions outside the weather forecasting system would likely be unaffected though would be able to draw on the broader combined capabilities.

c) **improve data access** to support the application of weather data and modelling by external parties. This would include reviewing data access policies and systems and moving as quickly as possible to ensure full transparency of what data exists and that all publicly funded data is easily available and that any costs and access arrangements are justifiable. We suggest that the monitoring agency would also, every five years or so, commission assurance of the access and pricing of data, research, and where applicable, outputs to determine whether these are consistent with a level playing field for downstream applications, and make recommendations if necessary for changes in order to support this (which would then be priorities for funding and monitoring discussions).

d) **explore investments in data access and interoperability** of systems to support the ease of sharing information and drawing together different insights by developing investment cases for each. This would include the systems to support data access and application, which for instance may also include the way the data is captured and fields considered (such as whether data could capture and presented breakdowns relevant to different Māori decision-makers and communities) as well as how this can be accessed and absorbed to support different applications. The second investment case would consider how different systems are able to share and incorporate information from others so that each is able to be informed by the relevant insights it captures and apply and combine these insights to greatest effect.

Figure 21: Overview of proposed arrangements and mechanisms

Funding, monitoring	Coordinated, prioritised, with long-term funding agreement for delivery (core), monitoring system performance
Data access	Publicly funded data, research and outputs made easily available Transparency over data available; clear policies for data provision that support a level playing field and clear principles and user-friendly systems for pricing and access with limited restrictions
Additional integration considerations	*Investment case* for data integration and access platform
	Investment case for interoperability in IT systems across EM agencies
Scope	Integrated meteorology, climate science, hydrology, oceanography and data science and modelling; integrated systems and observation network
Institutional form	CRI – NIWA evolved incorporating MetService's expertise, roles and systems; achieved through NIWA acquisition of NIWA and integration into a co-designed element of NIWA
Checks	Monitoring agency to engage periodic assurance of data access and pricing arrangements

The 2006 review of New Zealand's weather system arrangements reached the same general recommendation and drawing on a Crown Law opinion found that:

s 9(2)(h) [redacted]

[redacted]

[redacted]

[redacted]

We suggest that an update of this opinion(s) be sought. We have assumed a merger clearance would be sought and that other considerations are worked through as part of detailed design for any change.

This option is considered to best leverage the capabilities available (within our scope of review), and existing structures and systems in place. It limits the risk to the elements of NIWA outside the weather forecasting system but where there are nevertheless links that are of value for those functions.

However, it will require detailed design (drawing on the knowledge and expertise of both MetService and NIWA) to make the most of the opportunity to think afresh about what is needed and how this is focused and organised. It will be extremely important to ensure continuity of services and bring together the relevant skills around a common purpose, considering the most appropriate timing for aspects to be changed, and ensuring operational weather forecasting receives sufficient focus and priority. The role of the combined entity will also need to be clear relative to, and support, the responsibilities of local government and other actors in the system. Further, in drawing together these components, it will be vital to ensure that there is transparency about what data exists, and that data is made easily available to others based on clear principles around the nature of any charges and in a manner that supports a level playing field for value-added services.[6]

3.7.1 Supporting the transition and role of weather forecasting

We recommend that the co-design of the future arrangements could be informed by a supporting vision, priorities, key requirements and appropriate expertise and governance.

Vision

As part of the co-design exercise, as well as drawing on what already exists, the current entities may wish to develop a shared vision both for the overall organisation and for its role in the weather forecasting system. The latter could usefully be informed by the WMO's vision and strategic priorities in its Strategic Plan 2020-2023:

> "By 2030, we see a world where all nations, especially the most vulnerable, are more resilient to the socioeconomic consequences of extreme weather, climate, water and other environmental events; and underpin their sustainable development through the best possible services, whether over land, at sea or in the air."(WMO, 2019)

[6] This is consistent with the recommendations of the Commerce Commission to establish clear and transparent principles of negotiation (of price and non-price terms of weather data access) and include these on their websites. See: https://comcom.govt.nz/__data/assets/pdf_file/0031/294088/Meteorological-Service-of-New-Zealand-and-National-Institute-of-Water-and-Atmospheric-Research-Investigation-closure-report-31-March-2021.pdf We recommend the same in terms of publishing what data is available and data access policies, and that the policies and principles aim to support a level playing field and meet both international obligations (under the WMO – with recent developments in the WMO's data policies set out in Appendix E) and the broader public expectations of a government-owned entity and principles of operation as a CRI under section 5 of the CRI Act.

WMO's priorities

> "(1) Enhancing preparedness and reducing loss of life, critical infrastructure and livelihood from hydrometeorological extremes;
>
> (2) Supporting climate-smart decision making to build or enhance adaptive capacity or resilience to climate risk;
>
> (3) Enhancing socioeconomic value of weather, climate, hydrological and related environmental services."

While (2) has a climate focus, this could be broadened to include all three focus areas of the WMO: weather, climate and water.

Key requirements

Key requirements for the co-designed solution would include that they:

- efficiently drive a science research agenda that maps to direct societal benefits and enables rapid uptake of associated research outcomes to improve operational services
- make efficient use of scarce resources in New Zealand, leveraging local expertise (including those external to the amalgamated entity, such as academia and the private sector), and international partner agencies in the meteorological and hydrological community
- deliver effective warning services for weather and related hazards and impacts, supported by a single authoritative voice, and drawing on wider expertise as needed across the New Zealand science sector
- seamlessly integrate with other official providers of natural hazards advice, enabling impact-based multi-hazard early warnings for all (delivering on the WMO EW4All initiative)
- build on strong brand and trust to enhance engagement across the weather system, including a diverse range of users and other stakeholders, to support more effective outcomes across the 4 R's of activity in emergency management (reduction, readiness, response and recovery)
- are able to identify and adjust in response to new and emerging requirements or technologies (such as machine learning/AI)
- enable research and innovation across the wider science and innovation community through an appropriate level of open access to data, products, and Crown-funded research outputs
- are funded to deliver State obligations (i.e., internationally-agreed services) and safety-related services for New Zealanders (i.e., those that keep the country moving and safe), and to provide highly resilient supporting infrastructure.

Expertise and governance

We recommend that the co-design of the future arrangements are supported by those with expertise in organisational design and change management that are jointly agreed by both MetService and NIWA's boards to facilitate buy-in to the process. The process is likely to also require sub-groups with particular expertise from across both organisations to work through elements of detailed design (e.g. IT systems, modelling capabilities, observation networks, data storage and processing, licences and contracts, finance, human resources, sectors). The existing boards of MetService and NIWA would be responsible for supporting professional and open input to this process from the context of best meeting New Zealand's future needs and supporting the direction set out in this report.

Once agreed, NIWA's board would be responsible for overseeing the acquisition of MetService's shares and the actual transition to an amalgamated entity to support future needs, including any changes to roles, organisational structures, and personnel. In order to ensure a level of focus on operational weather forecasting, a separate board or steering/advisory group may be appropriate to support the amalgamated entity's operational weather forecasting, and the skills currently available across MetService and NIWA could be drawn on to support this.

4. Recommendations and roadmap

This section outlines our recommendations and subject to relevant approvals at each stage an outline of the timing and approach to shift to the proposed arrangements for the weather forecasting system.

4.1 Recommendations

We recommend that officials seek Ministerial and then Cabinet agreement in principle to:

1. Incorporate the following **core elements** of the government's role in the future weather forecasting system:

    a) Enhanced funding and monitoring of the system performance as a whole, prioritising across government purchasing interests for core services and taking a long-term view.
    b) Merging relevant capabilities and system to ensure that relevant insights are able to be drawn on and inform a greater understanding of impacts, coordinate communication in a way that reduces ambiguity and draws on different communication channels, and support efficiencies in the management of observations, data and modelling and remove duplication.
    c) Improve data access to support the application of weather data and modelling by external parties. This includes being transparent about what data exists (such as that illustrated in Appendix D) but with component information being set out publicly, that data is made easily available to others (user-friendly systems, with data easily downloadable, and in formats that support different uses) based on clear data policies and clear principles around the nature of any charges, and in a manner that supports a level playing field for value-added services (including limiting any restrictions on the use and re-use of information).
    d) Explore investments in data access and interoperability of systems to support the ease of sharing information and drawing together different insights.

2. **Empower the funding and monitoring agency lead** to undertake long-term planning, funding and coordination. This will include:

    a) determining where that lead best sits (e.g., MOT, MBIE, MfE or potentially DPMC or DIA)
    b) making any necessary changes to funding across votes and to roles and responsibilities
    c) shifting funding agreements over time
    d) supporting periodic public independent assurance of data access and pricing.

3. **Improve coordination, implement detailed design and shift to the proposed delivery arrangements**, including the following:

    a) Requesting that NIWA coordinate with MetService on its communications and public messaging around severe weather in order to support a single authoritative voice informed by the best available information where the respective roles support clarity of understanding an insight and delivers on contractual commitments but avoids potential confusion while the detail of the future arrangements envisaged in this report are worked though and transitioned to.

b) Consulting with NIWA and MetService regarding its purpose and functions in the future weather forecasting system, review capabilities, systems, functions and needs, and co-design a new amalgamated whole and appropriate operating model that supports future needs, delivering core services and supporting downstream applications on a level-playing field to other providers.
c) Removing MetService from State Owned Enterprises Act.
d) NIWA acquiring the shares in MetService and incorporating initially as a subsidiary and in the medium term requiring MetService be retained as a brand, as New Zealand's authorised meteorologist.
e) Shifting to that model and cancel/novate/renew contracts under it as appropriate, including realising clear savings opportunities as early as possible.

4. **Review:**

a) data access arrangements from the new entity periodically as part of wider system monitoring
b) the effectiveness of the new arrangements once operationalised, considering the new entity's role in downstream markets (and gaps if it did not operate in them), and whether there is a need for any of the other regulatory measures flagged as possible further escalations to be considered in order to meet future needs and objectives for the system.

4.2 Roadmap to transition to proposed arrangements

Table 11 sets out a suggested roadmap to implement our proposed recommendations. We note where aspects may be considered optional. Important to this is the detailed design of the amalgamated entity, which we suggest needs to involve consultation with NIWA and MetService on its purpose and functions in the future weather forecasting system, review capabilities, systems, functions and needs, and to co-design a new amalgamated whole and appropriate operating model that supports future needs, delivering core services and supporting downstream applications on a level-playing field to other providers. This is likely to involve a series of workshops engaging staff across both organisations together, with regular information updates and joint teams exploring particular areas for fuller understanding and detailed design (e.g. IT system, modelling capabilities, observation networks, data storage and processing, licences and contracts, finance, human resources, sectors). This would best be facilitated by those with expertise in organisational design and change management.

Table 11: Recommendation implementation roadmap

Step	Possible timing
Officials consider report, agree recommendations and advise Ministers	May 2024
Legal advice sought on whether a merger clearance or authorisation is required	May-June 2024
Ministers meet, consider recommendations, and agree to seek Cabinet decision for changes in principle	June-July 2024
Optional: Officials develop consultation document and plan public consultation on proposed approach	June-July 2024
Optional: Government consultation on proposed approach	August-September 2024
Consultation on co-design of intended amalgamation	August-October 2024
Officials consider consultation and seek Ministerial and Cabinet final decisions	November-December 2024
Optional: Merger clearance sought	December 2024
Investment cases commissioned	December 2024
Ministers request: 1) open access to weather data from MetService and NIWA, 2) NIWA not to expand in weather forecasting until MetService is acquired, 3) subject to merger clearance (if needed) NIWA acquire the shares in MetService	January 2025
Changes in funding and monitoring arrangements established (MBU funding changes, roles recruited to, and new responsibilities operationalised)	March 2025
Detailed design arrangements for new entity agreed	March 2025
Merger clearance obtained (if not Legislation will be required and we expect dates would be pushed back a year, including benefits realisation and additional costs of legislation)	March-June 2025[7]

[7] Based on conservative interpretation of https://comcom.govt.nz/__data/assets/pdf_file/0020/91019/Mergers-and-acquisitions-Guidelines-May-2022.pdf

MetService removed from SOE Act	April-June 2025
NIWA acquire the shares in MetService	April-June 2025
Cabinet considers investment cases	June 2025
Savings start to be realised from IT systems and network integration, reduced licencing costs, and efficiencies in back-office functions	June 2025 onwards
Shifts in systems and structures	June 2025 onwards (timing shifts as appropriate based on earlier detailed design work)
Assurance of open access arrangements	Quarter 1 2026
Review of new arrangements	Quarter 4 2026

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Appendix A Answers to questions in Terms of Reference

The body of this report provides the key recommendations, addressing the goals of the project. For completeness, below we answer the specific questions from the original project terms of reference. Firstly, addressing considerations noted in respect of the project objectives and secondly, answering questions posed to guide reviewers.

Table 12: Answers to Terms of Reference considerations for project objectives

Question	Answer / Reference
Initial considerations	
Identify global standards, expectations, benchmarks and functions for a national weather research and forecasting system that is fit for the climate change future.	There are demands from sectors across the country, including for instance emergency management, aviation, maritime, energy, agriculture, banking and insurance, building and construction. The demand is growing, given the increasing opportunities, speed, quality and expected impacts of weather events. Sections 2 and 3 of our interim report provide greater context on this and, for instance, World Meteorological Organization (2021), (2022) provide thoughts on the functions of a national provider – for instance the latter provide "elements of the vision of an idealised NMS in 2030+" in Box 11, which include: 1) playing a central role in the provision of weather, climate and water services with the important mission of supporting national needs; 2) seen as a competent and authoritative provider actively contributing to the prioritized societal missions; 3) having a consolidated observing network with a sustainable funding and operating model; 4) cloud technologies will be used by NMSs to access the wealth of Earth-system data and ensemble predictions provided with an open data policy by global centres, and organizations at kilometre-scale resolution for weather, oceans, sea ice, atmospheric composition, floods and fire danger data; 5) ML will be fully integrated into NMS weather and climate services; 6) The NMS takes part in national and international collaboration and cooperation that will improve its services to end users and other governmental agencies.

Understand the current and future demand for weather forecasting services in New Zealand. Identify inefficiencies, deficiencies, gaps and overlaps in New Zealand's current system.	This is discussed in sections 2.2- 2.4 with further background in the interim report. Inefficiencies include duplication of effort and collective capacities not being optimised, through lack of clear system priorities or process to prioritise across public needs. Deficiencies and gaps include a lack of integration of relevant information to inform the impacts of severe weather (e.g. floods, storms, landslides), certain gaps in the observation network and local coverage, a lack of space forecasting, nowcasting of severe weather, and potential improvements in relation to long-range forecasting. This is discussed further in section 3.10 of the interim report. Overlaps are most present in the observation networks and international data and modelling acquisition and in the provision of shorter term weather forecasting services. This is discussed further in aspects of section 3 of the interim report.
Define the attributes of an optimal weather forecasting system encompassing weather research, observation, modelling, forecasting, hydrology, warning, severe weather impacts, data access, and communication services in New Zealand	This is discussed in sections 2.2 and 2.4 with our recommended approach in light of this in sections 3.6 and 4.
Outline the current responsibilities of MetService and NIWA within the existing forecasting system and identify any future capability requirements.	See section 3 (particularly, 3.1, 3.5, 3.6 and 3.7) of interim report in relation to the existing system and section 2.2 in relation to future requirements.
Identify the most efficient and beneficial use of national weather observing infrastructure, technology platforms and assets, and to what degree the outputs should be independent, integrated and/or shared. National resilience should be considered.	This is considered in section 3 as well as in interim report. We note that the national weather observing infrastructure, technology platforms and assets have natural monopoly-like characteristics and that there would be efficiencies from the integrated or shared management and use of these rather than their largely independent management at present. Integrated management is expected to result in cost savings [of around X]. Savings are possible without impacting national resilience. However, national resilience should be a consideration when determining the extent to which duplication is addressed and the need for sufficient redundancy (in terms of systems and observations and/or maintenance). Further, to ensure benefits are maximised the research and data that are publicly funded should be publicly available and the funding lead should consider cases for open access to modelling/outputs. This could be on a cost-recovery basis.

The review will outline a number of options, including a preferred option, for the most appropriate and financially sustainable institutional and structural arrangements for MetService and NIWA. This would include how best to develop a pathway for research-to-operation-to-decision which incentivises investment in the system and adoption of new technology. This involves consideration of institutional and funding arrangements, their costs, benefits, risks and opportunities.	See section 3.
Analyse the degree to which competition is desirable in the delivery of weather forecasting functions and services and, if so, what that should look like with regard to the implications of competition law under the Commerce Act 1986.	We suggest that competition should be supported in research and downstream forecast, products, advisory and communication services where there are fewer natural monopoly characteristics. This is already where there is greater competition (see section 4 and Appendix E of the interim report). In light of this, we recommend that publicly funded data and research be made openly and easily available (in a format that can easily be applied, including for commercial use) and that the funding lead consider cases for open access to modelling/outputs if funded/cost-recovered.
Provide high-level options for more rationalised funding arrangements for weather-forecasting-related science that supports the new arrangements that are recommended (having regard to existing aggregate funding and staffing levels).	We suggest that a more coordination approach to the purchase of services on behalf of the Crown. We also estimate that there should be cost savings possible from our recommended approach. These could be used to address some of the gaps and support greater integration with emergency management. While opening access to data may initially cost the Crown more and there would be transition costs, we suggest that the recommended option should have greater benefits than costs.
Analyse the current issues associated with the constraints around data access, the public and private good nature of data, costs of providing it, funding, and options on how problems with data access could be resolved.	Constraints largely stem from institutional arrangements that provide a disincentive to openly sharing data because it could be the source of competition advantage. We also heard of examples where the government had paid for data to be made publicly available but did not enforce this or even waived that requirement where the public delivery agency wished to use the data for further commercial applications.

	Technical constraints can relate to the format in which data is made available, the uses for which the data is sought (e.g. pricing and access may be limited to a single use and differ between commercial or other uses), size or access limits (for instance Cliflo allows a maximum of 40,000 observations to be obtained per query which creates a significant barrier if a large amount of data is needed and we understand certain observation stations cannot be accessed when downloading data),[8] and the design of the interface for accessing information (that limits the ability to easily absorb and integrate information, separate to the ability to download past data flagged above). These constraints effectively limit the market/applications given that MetService and NIWA, while incentivised to meet commercial opportunities, have limited resources (and others who may be able to bring different experience, skills and insights are constrained) Costs of opening data access are expected to be in the order of $40.4 million to $44.4 million in present value terms, with forgone revenue an addition to this that is not factored into our cost benefit analysis as it is a transfer, though it would be relevant to the Crown. We suggest this be considered from existing public funding sources given the overall savings expected to the Crown and wider benefits. We suggest increased monitoring of the system and of the cost and access arrangements in future. This should be led by a monitoring agency responsible for overseeing the system as a whole. It would include a regular assurance-type function with open books could be undertaken and as a point of escalation if needed a low cost form of economic regulation arrangements could be considered.

[8] For example, if a user wanted to obtain 10 years of rainfall data from one station at 30-minute intervals, the user would have to run the query five times, manually checking the date and time of the last observation in the query output before running the query to extract the next batch of observations. If a user wanted the same data at 2-minute intervals, they would need to run the query at least 65 times. This is only for one variable (rainfall). The number of queries multiplies for every additional variable and it would not be uncommon for users to want multiple variables.

Other relevant matters	
Financial viability and sustainability into the future of both entities (including major capital requirements).	Both MetService and NIWA are financially viable. Were NIWA to win either the Ministry of Transport (39% of revenue) or aviation contracts (14% of revenue) or be deemed the official provider of forecasts for emergency management, this would have implications for MetService's financial sustainability and, risk undermining its core purpose. Both entities have capital investments that they will need to make that if considered in terms of the wider needs of the system, would be rationalised relative to each investing to meet their individual needs.
The weather forecasting markets in which these entities operate, any overlap between their services, functions, research and services, and investments, and whether any overlaps are desirable.	See section 3 (particularly, 3.1, 3.5, 3.6 and 3.7) of interim report in relation to the existing system and sections 2.2 - 2.4 in relation to future needs and potential barriers to meeting these under existing arrangements.
Māori needs in relation to weather forecasting and data should be considered as part of the assessment.	This is the focus of section 3.9 of our interim report and has feed into the needs discussed in sections 2.2 - 2.4.

Table 13: Answer to Terms of Reference guiding questions (from its Appendix)

Question	Answer / Reference
Optimal arrangements in weather forecasting system	
What is the demand for weather forecasting services in New Zealand?	There are demands from sectors across the country, including for instance emergency management, aviation, maritime, energy, agriculture, banking and insurance, building and construction. The demand is growing, given the increasing opportunities, speed, quality and expected impacts of weather events. Sections 2 - 4 of our interim report provide greater context on this.
Are there any gaps in the weather forecasting system in New Zealand in light of climate change?	See the answer to the second question in Table 12
What is the international landscape (including best practice) for the provision of weather forecasting services in light of climate change? What are the future trends, capabilities and investments required?	See the answer to the first question in Table 12 as well as Appendix E. We note trends include the increasing application of AI/ML, the increasing accuracy of NWP, and the increasing links across hazards and environmental sciences. Capabilities are broadening and there is increasing collaboration across hazards and scientific fields. There are also truly global models being constantly refined and improved by growing observation networks (including programmes to extend coverage of the South Pacific) and applying the computing capabilities to draw on the wealth of data on past experiences. In this context there is significant international investment. For instance, recently a 15-year, £30 million research partnership was announced between Reading University, the UK Met Office and the European Centre for Medium-Range Weather Forecasts was announced to provide more accurate forecasts up to six weeks ahead drawing on insights looking at Oceans, cityscapes and newly digitised older data (Fox-Leonard, 2024). In addition, the New Zealand is assisting with the USD 167 million Weather Ready Pacific programme (ReliefWeb, 2024).
Considering climate change and increasing frequency of severe weather events, what is the likely future demand from existing and future weather forecasting services in New Zealand?	Demand will continue to grow, with increasingly diverse needs and applications of weather data and increasingly tailored applications for different context and given different value drivers/propositions.

	See section 2 and answers to the first question in this table.
How should New Zealand be positioning its weather forecasting capabilities into the future?	See sections 2.2 and 2.4
Configuration of MetService and NIWA	
What are the areas of overlap of services between MetService and NIWA?	In particular, short-term weather forecasting and oceanography. See the answer to the second question in Table 12
Are NIWA and MetService's current institutional arrangements fit for purpose?	No. Improvements are possible to meet future needs as suggested in this report.
What are the risks and opportunities of continuing with NIWA and MetService's existing institutional arrangements?	See section 2.3
What are the opportunities for closer collaboration between MetService and NIWA?	See section 3 and the interim report. Opportunities include in relation to connecting research to operations and applications, access and application of data and leveraging modelling capabilities and systems, communications, predicting impacts, incorporation of hydrology and linking between weather and climate as well as Oceanography and computing/modelling, seasonal and longer-term forecasting, and back casting.
What are the options for a research-to-operations pathway between NIWA and MetService considering competition law?	See section 3. Broadly, merging functions and capabilities with sufficiently open access to data and information to other parties, supporting MetService to input into research needs that inform research funding, and separating public and commercial functions.
What degree of competition is desirable in the delivery of research and weather forecasting services? Consider the pros and cons of competition in the system.	Competition is desirable in portions of the market where there are not natural monopoly characteristics, chiefly research and downstream application of weather data and modelling.
Is there a more appropriate and financially sustainable set of institutional and structural arrangement between NIWA and MetService that could lead to a better outcome for New Zealand? This question should canvas incentives for the sector to invest and adopt new technology.	Yes, we suggest merging capabilities and removing within government competition would be more financially efficient (and effective) and improve incentives and connections when combined with suggested changes to funding and monitoring as well as data access.

Considering the current levels of science funding for weather forecasting, are there options for a more rationalised funding arrangement that supports the new arrangements that are recommended? (assuming the same aggregate level of funding)	Yes. We suggest greater prioritisation and increased role in relation to funding and monitoring a more long-term outlook would support what is being recommended.
Is the connection between NIWA, MetService and the emergency management agencies effective during severe weather events?	A recent review into recent severe weather events highlighted the potential for enhancements in common operating platforms, multi-agency operational exercises, and applying precautionary principles understanding the likely impacts of weather forecasts (Bush International Consulting, 2024). Further, the North Island Weather Events provided a range of recommendations and identified potential improvements that align with this report including needs for common operating platforms, the real-time provision of data and information across agencies, improving connections with communities and in particular iwi and Māori, clarifying roles, developing warning systems across natural hazards, and includes the following recommendations: "B. Note the Inquiry endorses the Weather Forecasting System Review to (among other matters) identify changes in access to weather data. C. Require that timely and enhanced weather and hydrological forecasting is provided to and used by all councils and government agencies (DIA, 2024)."
What are the implications for competition in the wider weather forecasting services market in New Zealand for the options proposed regarding institutional arrangements?	We suggest value from merging government capabilities in providing core public weather services and opening this up so that information is readily and easily available and can be connected to various applications. That is that competition may reduce in core infrastructure-related elements where there are natural monopoly characteristics but opened up in downstream applications and supporting research.
Access to weather data	
What are the appropriate arrangements for access to weather data	See sections 3 and 4. We recommend open access to all publicly funded weather data, and that the funding lead consider cases for open access to modelling/outputs. This could be on a cost-recovery basis.

What are the costs and benefits and risks of opening the access to weather forecasting data (e.g. would this have any impact on public safety)?	See section 3 and the answer to question 9 in Table 12. We suggest that so long as there is an official authoritative voice, opening up to competition should not undermine public safety. However, if concerns emerge as the market develops, we have also identified potential escalation options by way of possible regulatory measures.
Would regulation regarding data quality and accuracy of weather forecasting be required if there is open access to data?	We do not suggest this is needed at present but have highlighted options that could subsequently be considered if judged necessary with public disclosure one of the least costly approaches.

Appendix B More detailed aspects of the options analysis

This Appendix provides further information on aspects of the options analysis summarised in the body of the report. It does this my way of additional information on key aspects referenced in the report rather than by repeating through a more fulsome discussion.

Principles and options for how the government undertakes its funding role

In-keeping with the approach for Geohazards science services, the following policy principles (consistent with the Treasury's Cross-Agency Funding Framework) were used in thinking about funding and the broad funding option set. Core issues in relation to funding approach we considered included:

- The need for long-term funding confidence.
- An ability to prioritise needs across different government interests.
- The need for the delivery agent to make a case for funding opportunities and for these to be considered on their merits as a purchase/service separate to any ownership consideration.
- The requirement to share what is publicly funded.

Funding principles

Consistent with the recent approach for geohazards science services we considered the following principles to be applicable:

1. Align with benefit distribution
2. Purchasing decision should rest with those best able to make relevant trade-offs
3. Coordination costs should not exceed benefits from pooled funding.

In addition to this, we considered whether a funding approach would address existing problems and create the right incentives.

Funding tools

As noted below, the current settings involve a mix of central funding (through the MOT contract with MetService and MBIE's science funding to NIWA) and charging for services (both public and private, and including charging the aviation sector for aviation forecasts). In addition, advertising on its websites and applications also provide some level of commercial revenue to MetService at present.

Option	Characteristic	When to use	Applicability?
Charge	• An agency provides a good or service to another entity and charges a fee to recover costs • Agencies have a "customer-provider" relationship and the provider may have relationships with several customer agencies (or third parties) • The provider may have a specialist skill or role • Source of funding: agency or third-party charges	• Recommended when one agency is providing specific benefits through services to one or more agencies • Suitable for customer-provider transactions between agencies that involve direct benefits to the purchaser • Requires the agency providing the services to have a clear understanding of their own costs to ensure they charge on a cost recovery or marginal basis	• Used currently. • Makes sense for specific applications such as aviation forecasts or industry applications (e.g. Waka Kotahi, energy-sector) so long as marginal costing is sufficient to ensure these services aren't cross-subsidised by public funding at the expense of competition. These services are also dependent on core infrastructure and users of core data are quite dispersed. • Challenge in using this approach for funding core/public services as one party is required to contract these and there are challenges in scope and looking across demands (currently addressed in part through MOT's reference group)
Pool	• A small group of agencies pool funds and work together to achieve a common goal • One common output/service sought by a number of agencies • Often supported by cross-agency governance to facilitate joint decision-making • One lead agency may manage the Club Fund on behalf of all • Agreed cost sharing arrangements • Amount of funding contributed from participating agencies varies according to formula e.g. equal shares, agency size, budget size, benefit size	• Small number of committed agencies (usually 5 or fewer) with a common goal and where associated transaction costs are low • Benefits of working together need to outweigh transaction costs • Agencies can agree on the attribution of costs and benefits to each participant • The timing of costs and benefits is similar for all participating agencies • There are clear and strong incentives on agencies to fund and support the initiative	• Key parties with a relevant interest are set out above. These are quite disparate with some common but different goals and needs. It would be difficult to apportion benefits back to each in relation to core/public services. • Could be opportunities to consider pooling for various common needs and then using as an input to prioritisation of efforts/investment. E.g. NEMA and councils consider coverage of observation network, and quality needed for warnings and offer to pay for its interest in this, which may then be combined with transport agencies in terms of their needs and MfE/councils in terms of land-use planning, etc.
Centre	• Funding allocated to agency baselines to perform a cross-agency activity, often on behalf of the State sector • Suitable for system-wide initiatives where the benefits to agencies are not commensurate with the costs incurred • Sources of funding: mandatory contributions from agency baselines and/or new Crown funding • Can be low incentives to improve efficiency	• System-wide and dispersed benefits • Coordination and transaction costs from a non-centralised system are very high	• All public-sector agencies benefit from a more resilient New Zealand and a more efficient and effective emergency management sector. However, the benefits to most public sector agencies are indirect, not direct. Mandatory contributions from across agency baselines may therefore not be appropriate. • Currently, public weather forecasting services are funded out of Vote Transport and weather forecasting research/services through funding from MBIE, and other agencies pay for particular services and products they require to operate, including those from NIWA (such as DOC and FENZ) and MetService (e.g. NZTA, Transpower). • This model recognises the significant public benefits from the provision of weather forecasting services but risks missing opportunities across different interests.

Short-list of funding options

All options would likely involve cost recovery for defined specific services such as specific roading network observations and we suggest the use of advertising can also play a role in reducing the cost to the public/state (noting this must not undermine the ability to access necessary information, including if another party were to make the same information available without advertising). Together with this, options involve:

4. Status quo – MOT contract for public good aspects, the rest is separate.
5. **Coordinated** – a lead agency (DPMC, MBIE, MOT, or Treasury) coordinates and ensures funding of core public services. These core public services are funded by the central government lead. As the Ministry of Transport does at present, input will be sought on service priorities from across interested stakeholders. Separate to this, interest-specific needs may be funded by pooled groups where appropriate (e.g. transport, emergency management) or by individual interests but there is prioritisation across government services through visibility and monitoring by the lead agency and with requirements for data and where appropriate output sharing and ease of interoperability.
6. **Extended** – as with 2, but local government needs are also part of the prioritisation and coordination. This would be at the basic observations, data and services level and would not undermine the ability for individual actors to seek specific tailored information (though where publicly funded, this would also be openly available and easily accessible).
7. An interdepartmental board (or venture) for either 2 or 3.

We recommend either options 2 or 3 as:

- option 1 is associated with current problems, and
- option 4 appears to have some potential merit on first principles as a way of supporting coordination, being strategic, and prioritisation; however, we consider there may be a very high risk that 4 would not be successful given the challenge of determining which agencies would be included and the level of priority they may place on it. There could be greater priority if an option 4 applied to hazard management functions more generally (though this is outside our scope and could potentially bring risks of insufficient focus on weather).

We expect that differences in local and central government funding approaches mean that option 2 is likely to be more practical but suggest that both NEMA and DIA be among those consulted with a view to improving visibility and supporting the local government interests being considered at the prioritisation level.

Appendix C CBA detailed assumptions

Common modelling parameters

Table 14: Common modelling parameters

Parameter	Value/ assumption	Rationale
Discount rate (real)	5%	New Zealand Treasury's recommended discount rate for regulatory proposals
Modelling time frame	2025 - 2075	We assume that decisions are made consistent with our recommendation implementation roadmap, with implementation and transition costs spread over 2024 and 2025, review costs in 2026 and then every 5 years, and benefits accruing from 2025. We model impacts over 50 years to 2075
Inflation rate	2%	Representative of New Zealand's long-run inflation rate. Additionally, assuming any long-run value other than 2% is implicitly challenging the RBNZ's ability to perform its role, which is significantly outside of the scope of this report.
Deadweight loss	20%	Everything funded by taxation has a distortionary impact on the behaviour of other participants in the economy. Value is taken from the Treasury CBAx impacts database.

Quantified benefit assumptions

Table 15: Quantified benefits and associated assumptions

Benefit category	Description	Source
Operating cost savings	Operating cost savings as a result of merging entities, in terms of reduced combined costs for IT systems and data, and executive and back-office functions	Based on discussions with NIWA and MetService and information on their systems and staffing, stress-tested through each option, both in quantum, and how quickly benefits can be realised.
Capital cost savings	Reduced collective capital investment needs and increased resilience as a result of joint network and systems. public/industrial/ large-residential)	Based on discussions with NIWA and MetService on how integration would influence their capital expenditure plans.

Quantified cost assumptions

Table 16: Quantified costs associated with mandatory energy performance ratings

Cost category	Cost description	Cost assumption / estimation
Detailed options design and change management	Consultation, co-design, needs, role and functions/services analysis and detailed analysis of systems personnel and value, and change management to transact and shift to amalgamated state	Based on discussions with NIWA and MetService, and sense-checked against previous private & public merger & acquisition costs.
Changes in Legislation	To establish or remove an entity/entities from relevant Acts and if needed to allow a merger	Estimating the cost of new public health legislation (Wilson et al., 2012). This paper estimates the cost per page of legislation. Costs have been updated to account for inflation.
Redundancies	Costs of redundancies if the changes trigger redundancies clauses in employment contracts.	Cost savings in terms of staff have been estimated in discussion with NIWA and MetService. 1 month redundancy is assumed.
Investment case advisory costs	Costs to develop and consider the proposed investment cases for improvements in data access and interoperability across systems	Based on discussions with NIWA and MetService, and sense-checked against previous private & public merger & acquisition costs.

Appendix D NIWA's Data Access Systems

The below information is a summary provided by NIWA of the high level (per Delivery System) external use of data and information that NIWA makes available. The numbers are best estimates and based on information as available to NIWA. Since 2020 NIWA also leads the pan-CRI National Environmental Data Centre Initiative.

Data type	Access (URL)	Description	Data provided	Data users pa	Data downloads per annum
Data Public Services – National Significant Databases and Collections					
Climate Data	Cliflo.niwa.co.nz	Quality controlled observation and statistics from land weather stations older than 24 hours available for download Note: Some datasets provided to WMO international databases	About 100,000 timeseries of over 50-year length	About 5000 active users	2,500,000 (1,000,000,000 data rows)
River flow data	Hydrowebportal.niwa.co.nz	Data from: 40 NIWA reference sites Historical archive data 350 commercial sites available at request Note: This data is also consumed for the Council LAWA portal	About 800 timeseries of over 40-year length	Public Webpage, no registration required	2,000
Discrete River water Quality data	Hydrowebportal.niwa.co.nz	77 NIWA reference sites and historical archive available for download Note: This data is also consumed for the Council LAWA portal	About 1500 timeseries of over 30-year length	Public Webpage, no registration required	2,000
Freshwater Fish Data	nzffdms.niwa.co.nz	Freshwater fish and associated habitat observations collected and entered by 368 registered users from various organisations across New Zealand. Data is available for download without registration	About 130,000 observations of freshwater fishes	Public Webpage, no registration required to	4,500 + 1,500 (GBIF)

		Note: this data is served to international GBIF portal as part of NIWA Freshwater Biodata Service (see below)	and habitat over the last 120 years	download. 368 users currently registered to add data, of which 47 have logged on in the last 30 days	
Invertebrate Collection	https://niwa.co.nz/our-services/online-services/nic	Specimens from invertebrate phyla as a result of about half a century of marine taxonomic and biodiversity research in the New Zealand region, the South West Pacific and the Ross Sea, Antarctica Note: This is provided to international OBIS/GBIF as part of the NIWA Marine Biodata Service (below)	Estimated 350,000 preserved physical specimen jars/pails available to researchers on request (currently 171,694 records registered in niwainvert database, 142,953 of these records made publicly available via OBIS/GBIF)	Provided publicly through GBIF/OBIS, no registration required	~7,000 3,929 (OBIS in 2024 so far) 2604 (GBIF in 2024 so far) 7863 (GBIF in 2023) 24,981 (GBIF since 2019)
Other Public Data Services					
NIWA Weather	Weather.niwa.co.nz	Weather Forecasts for key locations across New Zealand as graphs / video through Web and App API is **NOT** free		Public Webpage, no registration required	450,000 hits API - 100k / day

Tides Forecaster	Tides.niwa.co.nz	Tide Forecasts for any point, available for download. Free API		Public Webpage, no registration required, API used by 3rd parties NIWA website and app	52,000 hits API - 20k / day
UV API	api.niwa.co.nz	Free API , funded by Cancer Society		3rd parties and NIWA website and app	API - 10k / day
High Intensity Rainfall Data	Hirds.niwa.co.nz	Rainfall Intensity Duration Frequency Statistics for any point in New Zealand, available for download		Public Webpage, no registration required	40,000 hits API - 4k / day
Historical weather event catalogue	Hwe.niwa.co.nz	Catalogue of historical weather events		Public Webpage, no registration required	20,000 hits
Solarview	solarview.niwa.co.nz	Solar energy potential for any point in NZ as time series, available for download Note: This data is provided to EECA as part of commercial contract		Public Webpage, no registration required	15,000 hits 146 / day
CO2	api.niwa.co.nz	CO2 observations from Baring head		Open, but only MetService seem to use it	100 / day
Our Future Climate	ofcnz.niwa.co.nz	Climate change data available as maps and data series for regions		Public Webpage, no registration required	3,000 hits

Lakespi	Lakespi.niwa.co.nz	Lake water quality observations and indicators for ~220 lakes across NZ Note: This data is also consumed for the Council LAWA portal		Public Webpage, no registration required	700
NZ River Flow Frequencies	https://niwa.maps.arcgis.com/apps/webappviewer/index.html?id=933e8f24fe9140f99dfb57173087f27d	Flood frequencies for any river reach in NZ		Public Webpage, no registration required	8,000
Bathymetry	niwa.co.nz/our-science/oceans/bathymetry/download-the-data	NIWA's reference bathymetry datasets		Public Webpage, no registration required	20,000
Marine Biodata	nzobisipt.niwa.co.nz	Data from marine biological surveys (e.g. species occurrence) Note: Includes NIWA's NIWA Invertebrate Reference Collection (NIC)		Public Webpage, no registration required	25,000
Freshwater Biodata	gbifipt.niwa.co.nz	Data from freshwater biological surveys (e.g. species occurrence)		Public Webpage, no registration required	25,000
Ocean Data	nzodn.nz	Ocean observations from voyages		Public Webpage, no registration required	NA
GIS OpenData Portal	data-niwa.opendata.arcgis.com	NIWA makes GIS reference datasets available, for example the national river network with >600,000 streams, HIRDS v4 Rainfall Depth Surfaces New Zealand, New Zealand Marine Environment Classification Feature Layers, New Zealand River Flood Statistics App, NZ Flood Statistics Henderson Collins V2 Layer, NZ River Names, NZ Large Catchments etc., NZ 250m Bathymetry	248 public items	Public Webpage, no registration required. NIWA Staff get access to additional	Ca. 100,000 views (total/a). Individual views vary widely, most popular items (/a): REC2 (20,000),

				internal-only content	Henderson Collins V2 (10,000), Flood Stats (9,000), MEC (4,500), NZ 250m Bathy (2,500), HIRDS (1,700)
Fireweather	fireweather.niwa.co.nz	Data and forecasts for fire risk management		Public webpage + registered users FENZ and authorised parties use API	92,000 API – 80k / day
Mountain Weather	Weather.niwa.co.nz	Data and forecasts for mountain / recreational safety		Public webpage + registered users	
Commercial / Contractual Data Services					
Weather Data (commercial)	API	Raw observation from land weather stations younger than 24 hours	Weather forecasts for any point in NZ	About 2000 commercial users (under contract); especially FireService, MetService, Ballance	2,000

River flow / lake level data (commercial)	API	>350 commercially operated sites, mainly for energy companies	About 700 timeseries of over 40-year length	About 500 commercial users; especially energy clients, councils	350
Eharvest	eharvest.niwa.co.nz	Data for managing mussel harvests	Real-time environmental reports	NA	3,000

NIWA noted that there are further systems through which data is made available that it did not have easily available metrics on:

- UV: UV forecast for any point in New Zealand
- Beach cameras
- Seal levels
- Wave buoys
- Irrigation Portal
- CLIDESC
- New Zealand River Maps R-shiny
- NEON - Irrigation

Appendix E Further information on international data access

This Appendix provides further information from that in our interim report in relation to:

- the implications of reduced data provision
- efforts to support access to weather data internationally that could be drawn from
- high priority weather data.

This is not exhaustive in relation to either point but seeks to add further important components to the existing information base in our interim report.

Implications of reduced data access

We highlight two further implications from data restrictions where more can be said than what is in our interim report. These relate to limitations of:

1. weather and climate data provision internationally limiting the quality of reanalysis and as a result global weather modelling and inputs to applications in New Zealand
2. visibility over what data is available, the ease of its access and the conditions of any use will limit the ability of entities to understand climate risks and opportunities.

Global models

Certain stakeholders we interviewed indicated that if more data was made available internationally, subsequent iterations of reanalysis and global weather modelling would be more accurate and provide better coverage of New Zealand and the Pacific. They suggested this could improve the likes of storm prediction as well as other applications.

Figure 22 provides an illustration of this. It provides precipitation totals for when Cyclone Bola hit Gisborne on 6-8 March 1988. The map on the:

- left is the raw ERA5 total precipitation field. ERA5 is the fifth generation European Centre for Medium-Range Weather Forecasts (ECMWF) atmospheric reanalysis of the global climate which provides provide hourly estimates of a large number of atmospheric, land and oceanic climate variables (Copernicus Climate Change Service, 2018).
- right is the ERA5 precipitation field if further station observations available in New Zealand were included when creating their data product.

This shows that if a practitioner was to just use the original ERA5 reanalyses, they would infer precipitation totals of less than 400 mm, whereas, in reality, there were regions that experienced more than 700 mm of precipitation. Using the freely available global reanalyses would have resulted in significant under-estimation of risk because it draws on the reduced number of observations than were available for assimilation into those models.

NIWA generates its own high resolution (1.5 km) reanalysis assimilating all of the data available from the National Climate Database. All else equal, one would expect its reanalysis to be superior to ERA5 in a couple of ways:

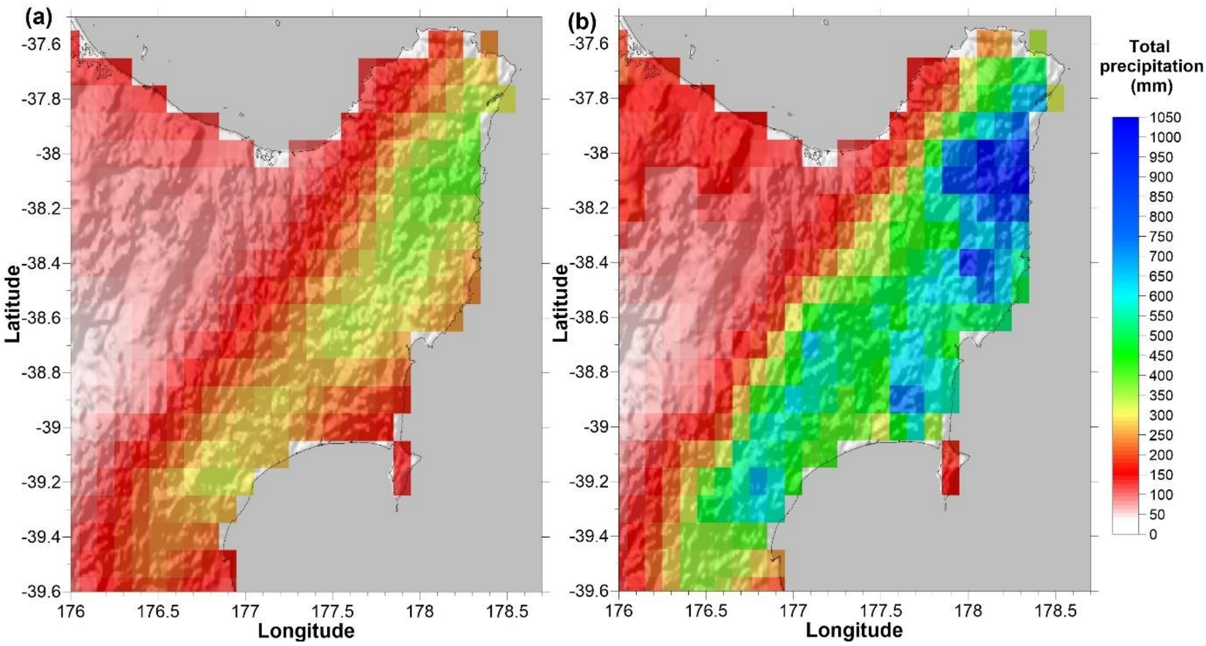
1. It will be higher resolution (1.5km cf. 10km) and therefore resolve spatial scales of climate variability that ERA5 cannot.
2. Because NIWA will have access to a far larger volume of observations, the reanalysis will be far more accurate.

However, other parties must either use:

1. the ERA5 reanalysis (or any of the other global modelling centre reanalyses), all of which do not have access to the level of station data available for assimilation
2. NIWA's reanalysis at the rates it offers this.

We understand a number of parties are unable to afford (2) and use (1) and as a result may under-estimate weather event-related risks.

Figure 22: Total precipitation over the period 6-8 March 1988 from (a) original, (b) if all available observation data is included in the reanalysis



Source: Mike Kittridge, Headwaters Hydrology

Further, MetService and NIWA draw on such global models as inputs to some of their analysis and while they are able to draw on additional observations to those made available for international models, limiting inputs provided to these global models will limit the quality of the information drawn on for their own modelling and the quality of the models developed by others more generally. The limitations provide a competitive advantage for NIWA in terms of its reanalysis but with implications for the wider market. Further, where observation information may exist in the Pacific, this could also be utilised to improve the coverage of these models in the Pacific.

Climate risks and opportunities

Certain stakeholders interviewed identified that climate risk and opportunities analysis undertaken by different parties relies on drawing on information in relation to anticipated changes in New Zealand's climate. This is important for a number of different stakeholders and a mandatory requirement for a number relevant entities under the XRB's climate-related disclosures requirements (XRB, 2023).

However, on this topic these stakeholders identified difficulties for parties (including those subject to mandatory disclosure requirements) to navigate:

- what climate or weather-related information is available
- how to access such information (including navigating the systems, obtaining the necessary information, and being able to apply it in a format that could be used for their purposes), and
- pricing and access arrangements, including being able to: know how best to utilise the information available for the types of risk analysis needed, and share the required information with advisors in order to undertake the analysis required or with decision makers in order to make use of the analysis.

As a result it was suggested that there were opportunities to achieve better effect from efforts in this space if NIWA's website outlined the information available and systems to access it, if the systems allowed information to be easily downloaded in quantities and formats that supported analysis, and if there were no or extremely few restrictions on what could be done with this information once obtained (which could well be for a fee but where access arrangements supported outcomes needed for these stakeholders).

Efforts to support access to weather data internationally

WMO

New Zealand was a signatory up to the WMO resolution 40 in 1995, which included (among other things):

> "(1) Members shall provide on a free and unrestricted basis essential data and products which are necessary for the provision of services in support of the protection of life and property and the well-being of all nations, particularly those basic data and products, as, at a minimum, described in Annex 1 to this resolution, required to describe and forecast accurately weather and climate, and support WMO Programmes" (WMO, 2020).

More recently, the WMO Unified Data Policy was adopted in 2021 which adopted the following policy:

> "As a fundamental principle of WMO and in consonance with the expanding requirements for its scientific and technical expertise, WMO commits itself to broadening and enhancing the free and unrestricted[6] international exchange of Earth system data"

It also agreed:

> "(1) Members shall provide on a free and unrestricted basis the core data that are necessary for the provision of services in support of the protection of life and property

and for the well-being of all nations, at a minimum those data described in Annex 1 to the present resolution, which are required to monitor and predict seamlessly and accurately weather, climate, water and related environmental conditions;

(2) Members should also provide the recommended data that are required to support Earth system monitoring and prediction activities at the global, regional and national levels and to further assist other Members with the provision of weather, climate, water and related environmental services in their States and Territories. Conditions may be placed on the use of recommended data"

And urges WMO members:

"(1) To undertake the necessary actions to promote the alignment of national policies and regulations concerning Earth system data sharing and exchange, nationally and internationally, with the policy promulgated through the present resolution;

(2) To provide full transparency on conditions of use and re-use when such conditions apply to exchanges of recommended data;

(3) To accommodate the need for users of recommended data to respect the conditions of use set by the owners of the data, as this will help to facilitate access to the data;

(4) To facilitate the exchange of data from all stakeholders and sectors at the international level when emergencies and natural disasters occur;

(5) To build partnerships to enhance the exchange of Earth system data among national and regional stakeholders in order to improve the integration of data across disciplines and domains, thereby helping to strengthen them all"

It also provides guidelines for data exchange between public and private sectors, which include:

"The resolution reinstates the policy of 'free and unrestricted' international exchange of core data (see Annex 1 to the present resolution for the detailed description of core data). Furthermore, the new definition of 'free and unrestricted' makes it clear that these data shall be freely available, with no conditions on use. In applying this policy for the exchange of core data:

(a) Members should ensure that users from all sectors — public, private and academic — are granted free and unrestricted access, without charge and with no conditions on use, to the declared core data;

(b)As articulated in the Geneva Declaration – 2019 (Resolution 80 (Cg-18)), engagement between public and private sectors should be conducted in a transparent way and should be aimed at enhancing mutual benefits to both public and private sectors for the benefit of society;

(c) Members should ensure that, in case of core data purchased from private sector data providers, such data sets are appropriately licensed for free and unrestricted international exchange;

(d)The technological solutions for access to the internationally exchanged core data should be fully compliant with the 'free and unrestricted' principle14;

(e) Permanent Representatives of Members, who are responsible for authorizing users of WIS (see the Manual on the WMO Information System (WMO No. 1060)), should authorize access to core data with no obstructions;

(f) Recognizing that the development of Numerical Earth system Weather-to-climate Prediction (NEWP)15 systems and the improvement of the quality of products and services depends on the availability of more Earth system data; Members are encouraged to broaden the provision of their data under the free and unrestricted principle. Moreover, the unrestricted and free access to all public data adopted by many Members and international organizations, extends significantly the availability of free and unrestricted high-quality data to all other Members."

And:

"While Members are encouraged to apply the principle of free and unrestricted international exchange to the recommended data they provide, such data sets may have conditions on their use, e.g. for commercial purposes. The originators of such conditions should follow the following general principles:

(a) Fair and transparent setting of the conditions on use;16 (b)Level playing field — same rules to apply to public and private entities using the data sets for commercial purposes;[17]

(c) Avoidance of anti-competitive behaviour (e.g. blocking access to public data with a view of creating competitive advantage for the commercial activities of the public sector entities or their spin-offs) should be regarded as a non-compliance with the high-level policy (Geneva Declaration);

(d) Members should make available a catalogue of recommended data to facilitate their use under the established conditions of use. The experience of Economic Interest Grouping of the National Meteorological Services of the European Economic Area (ECOMET) in Europe presents a good practice for such cataloguing as well as for harmonization of the conditions of use imposed by different countries in the same geographic region;

(e) In exchanging data with conditions on use, the conditions which have been posed by the originator of the data should be made known to initial and subsequent recipients."

Further it defines and sets out what is included in core and recommended data and defines:

- "free and unrestricted" as "Free and unrestricted means available for use, re-use and sharing without charge and with no conditions on use"
- "without charge" as "Without charge, in the context of this resolution, means at no more than the cost of reproduction and delivery, without charge for the data and products themselves"; and
- "conditions on use" as "In the context of this resolution, conditions on use may be applied only to recommended data; such conditions may be applied using licenses. Note that attribution is not considered a condition on data use and is strongly encouraged in all cases."

In terms of implementation, the WMO states:

- "**WMO Members** will need to work to broaden and enhance their international exchange of Earth system data, building partnerships and promoting alignment of national policies and regulations on Earth system data exchange, nationally and internationally, to support the new policy.
- **The governing bodies of WMO** are tasked with updating and in some cases strengthening relevant technical regulations, developing guidance materials, and setting up processes to engage partners and oversee implementation.
- **The Infrastructure Commission**, in particular, will - in collaboration with the Secretariat - set up systems and establish processes to support national implementation of various specific elements of the policy, so as to track progress and to monitor compliance.
- **The entire WMO community** — Members as well as the Secretariat - is expected to use the policy as a tool for their engagement with partners from the international development and climate finance communities on capacity development efforts aimed at strengthening climate adaptation, disaster preparedness and early warning systems in developing countries" (WMO, 2022).

We understand it is possible that further work to support implementation and ensure that all countries are able to reap the benefits could include the likes of templates or common platforms of tools, which could be drawn on by members to support open access and consistency of approaches. A further example of existing efforts that could be leveraged in terms of systems already in development to support open access are those in Europe discussed next.

RODEO

The RODEO project in Europe involves 11 European NMHSs, the ECMWF, and the network of 31 European National Meteorological and Hydrological Services (EUMETNET). It:

> "develops a user interface and Application Programming Interfaces (API) for accessing meteorological datasets declared as High Value Datasets (HVD) by the EU Implementing Regulation (EU) 2023/138 under the EU Open Data Directive (EU) 2019/1024."
>
> "fosters the engagement between data providers and data users for enhancing the understanding of technical solutions being available for sharing and accessing the HVD datasets"

Where

> "Surface weather observations, climate data, weather warnings, radar data and numerical weather prediction (NWP) data are defined as meteorological high valu[e] datasets."
>
> "The distribution of these datasets is going to be made available under an open licence, in machine-readable formats using APIs and bulk downloads following the FAIR principles (usability, accessibility, interoperability and reusability)."

The project aims to strength capacity by:

- "developing a user interface

- developing APIs for accessing weather observation data, climate data, weather radar data, warnings, and Artificial Intelligence (AI) datasets
- developing a data catalogue for making data discoverable
- engaging with the data owners and user communities
- supporting the deployment of national data portals and APIs
- making HVDs available from the project partners"

In terms of impacts on users, the RODEO project notes:

> "The increased availability of data boosts entrepreneurship and potentially results in the creation of new companies. New open datasets are an important resource for small and medium-sized enterprises to develop new digital products and services. Reuse of data opens business opportunities for several sectors ultimately leads attracting more investors. By making data much easier to use, resea[r]ch, academia, AI applications and many other application areas can utilize the data more efficiently.
>
> Overall, better data availability leads to better warnings, forecasts, and services to the public and weather-critical industries, and contributes to the safe and efficient functioning of society with multiple benefits across the European economy, industry, and society" (RODEO, 2023).

Separately, to these international developments, *Weather Permitting* set out domestic initiatives and policies to support open access in government and focused specifically on the issue or access to weather data in New Zealand (MBIE, 2018).

High priority weather data

Those we interviewed indicated that for international applications and reanalysis, the highest value data was synoptic sub-daily observation data with the least processing (particularly that prior to the 1970s).

As noted above, the WMO data policy sets out core and recommended data for:

1. Weather
2. Climate
3. Hydrology
4. Atmospheric Composition
5. Cryosphere
6. Oceans
7. Space Weather

Further, the RODEO project in focuses on supporting access to datasets declared as High Value Datasets (HVD) by the EU Implementing Regulation (EU) 2023/138 under the EU Open Data Directive (EU) 2019/1024 where:

> "surface weather observations, climate data, weather warnings, radar data and numerical weather prediction (NWP) data are defined as meteorological high valu[e] datasets" (RODEO, 2023).

Appendix F Interim report

The following document is a copy of the more detailed interim report, which includes a small number of updates from the copy at the stated date (for accuracy and consistency) but is otherwise superseded by the body of this report and where new information since that report is separately identified in this report or earlier Annexes to it. It nevertheless provides greater contextual background.

About Sapere

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