Ngāti Kahungunu Iwi Incorporated
Submitter #120
27 Sept 2021

Model uncertainty vs. certainty of Council that existing levels of abstraction may continue at 2012 levels

Some examples of uncertainty follow. It is accepted all reports need to be read in context, and in full, for complete understanding.

(1) Heretaunga Aquifer Groundwater Model Development Report (May 2018)

Purpose of the Study
"..to allow technically defensible groundwater and surface water allocation and water quality limits to be established.." p8

Purpose of the study (p.9)

The overall purpose of the groundwater model is to simulate the Heretaunga Plains gravel aquifer system and associated surface water resources to allow technically defensible groundwater and surface water allocation and water quality limits to be established. A detailed discussion of the objectives is provided in Section 0.

Calibration outcome

The final calibrated model is able to replicate the observed dynamic of groundwater system (i.e. match seasonal and long-term groundwater level changes, as well as observed spring flows and river losses). Although this match is not perfect, in practice better level of fit is rarely achieved in groundwater modelling. Therefore, the model can be considered suitable for simulating the effects of groundwater pumping on river flows, along with and seasonal and long-term changes of groundwater levels.

Limitations (p.11)

Due to the possibility that the model solution developed is not unique, despite a reasonable calibration, there is a residual uncertainty remaining. This uncertainty has been explored using calibration-constrained Monte Carlo analysis and its impact on model predictions will be explored in a subsequent report.

Limitations of the model calibration also include:
- Poor match to observation data in some areas;
- Limited observation data in some areas;
- Conceptual uncertainty;
- Uncertainty related to rate of recharge during high rainfall events.

(2) Heretaunga Aquifer Groundwater Model (August 2018)

Key findings (p.9)

The key findings of the modelling scenarios are:

Increases in groundwater pumping in the past, in particular irrigation pumping, have resulted in declines in groundwater levels and substantial reductions of flows in rivers and streams, especially during summer. Such declines are an expected response of the groundwater system to the additional pumping.

However, there are signs that the aquifer is reaching a new equilibrium and further substantial reductions in river flows will not continue, provided that the pumping abstractions do not increase further. Further increases in groundwater abstraction would result in further decline in groundwater levels and reduction in stream flows.

Uncertainty analysis was undertaken on this model, and it confirms these conclusions.

Modelling of mitigation options indicates that the mitigations used in the past to protect stream flows and groundwater levels, such as pumping bans and managed aquifer recharge provide only limited benefit. Stream augmentation of lowland streams is likely to be an effective measure to partially mitigate depletion resulting from current water use, but only as a short term measure during dry periods. It is not sustainable in the long term, and will not be enough if usage increases.

Additional detail on the model set up and on scenarios is summarised below.

Uncertainty Analysis (p14)

During model calibration, model parameters are adjusted to obtain the best match to observed data. In reality, the calibration process is non-unique, in that there may be many combinations of parameters that can provide an acceptable match to the calibration dataset. A consequence of this is that predictions provided by the model are uncertain.

Uncertainty analysis has been undertaken using PEST to apply the Calibration Constrained Monte Carlo method, which allows for assessment of predictive uncertainty. The first step of the analysis was to generate a collection of model parameter "realisations", which are parameter sets that produce a satisfactory match to observations. A total of 107 realisations was generated in this step, and selected model scenarios (Historical Scenarios and Future Scenarios) were than run for each model realisation. The final step requires compilation and analysis of the results.

The analysis indicated some spread in all types of key performance indicators (stream depletion, water levels, drawdowns). The analysis also showed there is some inadvertent bias in the original calibration/verification model parameter dataset that results in over- or under-prediction of pumping impacts on some rivers, compared to other model realisations.

However, the uncertainty analysis does not modify the conclusions of the analysis. Even when including uncertainty and bias, the results indicate there is significant impact from groundwater pumping on streamflow and groundwater levels historically and in the future.

(3) Rebuttal evidence for Pawel Rakowski (19 May 2021

1.8 I developed a groundwater model for Heretaunga Aquifer system, completed in 2018, as documented in the following publications:
(a) Rakowski P . and Knowling M. (2018a). "4997 Heretaunga Aquifer
Model Groundwater Model Development Report." HBRC, May 2018.
(b) Rakowski, P . (2018b). "5018 Heretaunga Aquifer Groundwater Scenarios Report." HBRC, August 2018.

1.9 Findings from this work have led to improved understanding of the impact of groundwater abstraction on water bodies in the Heretaunga Plains.

1.10 This groundwater model forms the basis of many TANK policies, including the development of allocation limits.

4.10 The decision tree, provided by developers of WhAEM themselves, identifies that more complex problems require more sophisticated modelling tools, with MODFLOW model identified as appropriate for the most complex cases.

4.11 In the Heretaunga aquifer system, all variables listed in the decision tree are present and important: nearby river and streams, complex geometry on the aquifer, well interference, multilayer aquifer system, with other complexities including transient flow conditions, variable (spatially and temporally) groundwater flow direction and gradient, and heterogeneity of the aquifer. Therefore, in my opinion, MODFLOW should be the preferred tool for SPZ delineation in the Heretaunga Aquifer.

4.12 The analytical method used to define SPZs for HDC abstractions is one of the simplest methods that could be applied. The analytical method does not take into account the known complexity of the system, including key elements such as spatial gradient, flow direction changes and well interference.

(4) Supplementary evidence for Pawel Rakowski (4 June 2021)

4.5 In general, it is very difficult or impossible to measure stream depletion directly, therefore modelling may be the only practical way to estimate stream depletion.

7. Uncertainty

7.1 Despite large volumes of available geological and hydrological data that enabled good model calibration, there is still residual uncertainty. This is a common issue in all groundwater models. In particular, there is uncertainty related to the conceptual setting in several areas, such as the peripheral parts of the Aquifer System, including the Paritua/Karewarewa and Moteo Valley areas. Despite this uncertainty, in my opinion there is enough evidence to indicate relatively high connection to the rest of the Heretaunga Aquifer System, even though the exact nature of connection (and therefore the exact degree of stream depletion) may be uncertain."

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Model uncertainty vs NPSFM 2020 hierarchy

1.6 Best information

A requirement in this National Policy Statement to use the best information available at the time is a requirement to use, if practicable, complete and scientifically robust data.

In the absence of complete and scientifically robust data, the best information may include information obtained from modelling, as well as partial data, local knowledge, and information obtained from other sources, but in this case local authorities must:

(a) prefer sources of information that provide the greatest level of certainty; and

(b) take all practicable steps to reduce uncertainty (such as through improvements to monitoring or the validation of models used).

A person who is required to use the best information available at the time:

(a) must not delay making decisions solely because of uncertainty about the quality or quantity of the information available; and

(b) if the information is uncertain, must interpret it in the way that will best give effect to this National Policy Statement.

2.1 Objective

(1) The objective of this National Policy Statement is to ensure that natural and physical resources are managed in a way that prioritises:

(a) first, the health and well-being of water bodies and freshwater ecosystems

(b) second, the health needs of people (such as drinking water)

(c) third, the ability of people and communities to provide for their social, economic, and cultural well-being, now and in the future.