BEFORE THE HAWKE'S BAY REGIONAL COUNCIL

IN THE MATTER	of the Resource Management Act 1991
AND	
IN THE MATTER	of an application by various applicants ('the applicant group') for taking and use of Tranche 2 Groundwater from the Ruataniwha Basin

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JOINT WITNESS STATEMENT

GROUNDWATER MODELLING

11 October 2022

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1. This joint witness statement (JWS) has been prepared as part of expert conferencing on the topic of groundwater modelling, in relation to the application for resource consents made by the Applicant Group to Hawke's Bay Regional Council (**HBRC**). The applications relate to proposed abstraction of Tranche 2 groundwater from the Ruataniwha Basin for use to irrigate land and for augmentation of rivers and streams.

2. The expert conference was held on 11 October 2022 at the offices of Pattle Delamore Partners Ltd (PDP), Christchurch, and via video communication. The focus of this conferencing was groundwater modelling and the predicted effects of abstraction and augmentation on groundwater levels and surface water flows.

3. The groundwater modelling experts who attended the conference were:

    (a) Neil Thomas, PDP, engaged by HBRC (in person);

    (b) Julian Weir, Aqualinc Research Ltd (Aqualinc), engaged by the Applicant Group (in person); and

    (c) Nick Dudley Ward, SEPCO Technologies, engaged by the Applicant Group (via video).

4. This JWS is prepared in accordance with Section 4.7 of the Environment Court Practice Note 2014.

5. It is confirmed that all attendees have read the Environment Court Practice Note 2014, and agree to abide by the Code of Conduct.

6. This JWS sets out:

    (a) Those matters which are agreed between the experts;

    (b) Those matters which are not agreed and for the reasons stated.

7. Items set out below include those set out in the Panel's Memorandum 1 to Participants dated 22 September 2022, generally falling into the topics of calibration, uncertainty and utility. Other items have been put forward by HBRC and the Applicants for discussion.

Questions and Responses

Preliminary Comments

The objectives of the Ruataniwha Basin model are to quantify the changes in river flows and groundwater levels from the proposed Tranche 2 activities with a particular focus on dry periods (low flows and low groundwater levels). Throughout the document we will refer to these objectives.

The model report Weir (2022)[1] has been updated after the lodgement of Mr Thomas' evidence in chief (EIC) (dated 8 August 2022). Some matters of concern that Mr Thomas raised in his EIC have now been addressed in this latest model report.

Consideration of uncertainty has been solidly focussed on the uncertainty associated with adverse effects. While this is important, there also needs to be consistency with the concepts and balance in the consideration of uncertainty. It is therefore worth noting that there is also uncertainty associated with the positive effects (e.g. it is possible that the positive consequences are greater than predicted).

The review of the modelling is based solely on the latest modelling report (Weir, 2022). The electronic modelling files have not been reviewed or circulated between the different technical experts.

Model Calibration Methodology

Q1: Is the method of calibration appropriate and best practice? Have impacts of declining groundwater levels been accounted for?

The experts agree that the level and method of calibration and documentation is comparable to other well-developed models from New Zealand and around the world. The level of calibration is appropriate for the data available at the time the model was developed and the modelling objectives.

To clarify this, the use of a steady state model is a commonly used technique to rapidly progress calibration of hydraulic parameters before the subsequent use in the transient model. While both steady state and transient versions of the model were used, model calibration is based on the transient model.

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[1] Weir (2022): *Ruataniwha Basin. Tranche 2 Groundwater Modelling (Revised 2).* Report prepared for Various Collaborative Participants. WL18045. 28 September 2022.

The approach reasonably allows for declining groundwater levels by fully accounting for existing allocation.

Q2: What sites have been used for model calibration and are these appropriate?

Calibration of the most recently updated model has included the use of all available monitoring data, as follows:

- Groundwater levels, including new data up to early 2021;
- River flows from the five low-flow monitoring logger sites (noting that data from two of these sites is synthesised by HBRC);
- Intermittent gaugings of river flows at sites located throughout the basin (noting that these are typically gauged during low flows); and
- River flow gains and losses between the same gauging sites where concurrent surveys have been conducted.

The experts agree that all available data (up to 2021) has been appropriately used in model calibration.

Q3: Does the model adequately account for river/stream gains and losses, and is this important to the overall decision making?

The updated model makes a significant improvement to replicating river gains and losses where these are measured (compared to previous versions of the model). As demonstrated by the consistent predictions of changes in river flows (between updated versions of the model), this has little consequence on the model predictions that feed into the decision making process.

The predictions from the updated version of the model do not differ appreciably from the earlier versions of the model. This is important for decision making because it indicates that further model development will not change the model predictions appreciably.

Therefore, the experts agree that the model adequately accounts for river gains and losses.

Q4: Has full water use been appropriately represented in the model?

The experts agree that synthesising water use data is the most appropriate method for estimating water use where records do not exist, that the modelled water use is generally consistent with the allocation limit, and that the status quo scenario includes full development of existing allocation. Therefore the experts agree that this represents the likely maximum response of groundwater levels to abstraction (i.e. the lowest seasonal groundwater levels).

Q5: Is the model adequately calibrated for the purpose of decision making?

Models are a numerical representation of a complex system. Furthermore, data is incomplete and has its own errors. Therefore, no model will perfectly represent observed data. Despite inevitable differences between measured data and modelled outputs in the updated model, these do not significantly impact predictions given the uncertainty analysis carried out (discussed in Question 6). Furthermore, calibration statistics are well within industry standards. Since the status quo model represents full existing use, model calibration has been appropriately targeted.

The experts agree that the updated model is a significant improvement on earlier versions and its calibration is consistent with achieving the model objectives (matching low river flows and low groundwater levels).

Model Uncertainty and Accuracy

Q6: How has the model predictive uncertainty been investigated, what are its consequences, and are there any outstanding uncertainties?

The experts agree that calibration of any model will always be constrained by the available data and the model's limitations. Furthermore, a range of model parameters can generate equally good fits to calibration data. Therefore, it is always necessary to investigate the predictive uncertainty, and this has been estimated using sensitivity analysis and Monte Carlo methods. These are industry-standard techniques. The assessment includes estimates of the uncertainty associated with model parameters and groundwater pumping.

This uncertainty analysis indicates that model predictions of differences in flows and groundwater levels due to the proposed Tranche 2 activities are relatively insensitive to variations in model parameters. The 95% confidence intervals of predicted changes in groundwater levels and river flows presented in Weir (2022) encompass a relatively narrow band around the best fit predictions.

The model simulates augmentation discharging directly into rivers. However, two applicants propose to discharge via injection wells and one applicant proposes to discharge into a small, unnamed tributary of the Tukituki River. The experts agree that the efficacy of these indirect discharges needs to be demonstrated on a case-by-case basis. This may be addressed by a condition of consent. The experts also agree that appropriate monitoring and analysis is required to demonstrate the efficacy of the overall flow augmentation scheme proposed. We recommend that this includes recording the augmentation discharge flows. Suitable monitoring sites (which may include existing monitoring sites) will need to be chosen in consultation with other stakeholders.

As some of the applicants' bores have not been drilled, the aquifer properties and well yields at these locations are not well characterised. Consequently, the precise impacts of these takes cannot be quantified at this time. We expect that this issue can be managed through appropriate conditions of consent (as proposed in the latest set of draft conditions).

The experts agree that the uncertainty analysis has provided estimates of the model's predictive uncertainty. These estimates indicate that the uncertainty envelopes are narrow.

Model Suitability for Decision Making

Q7: Is the level of uncertainty analysis adequate to inform decision making?

The experts agree that there has been as much uncertainty analysis as can be practicably expected for a catchment-scale groundwater model and the methods follow standard practice. Given the narrow uncertainty bounds discussed above, the experts agree that the model provides a reasonable basis for decision making.

However, the experts acknowledge that model predictions are likely to be different to reality (due to many possible causes). This is the case with any model and has been partially compensated for by specifying parameter values and scenarios that are expected to overpredict the effects for the intended use. Groundwater abstraction has been modelled on a reasonable use basis accommodating climatic variability. Given the expected irrigation demand, this results in an estimated maximum range of effects.

The experts agree that any residual uncertainty can likely be managed through conditions of consent, which should include appropriate monitoring and analysis of the data.

Implications of Staged Development

The experts agree that the collaborative nature of the proposed Tranche 2 activities is required to fully mitigate effects on low river flows (in that effects from one applicant will be offset by flow augmentation from another applicant, at least in part). Asynchronous development has the potential to misalign effects and mitigation at times. However, as bores are, or are proposed to be, deep the onset of effects in surface water bodies is expected to be delayed several years. Therefore, the implications of asynchronous are expected to be minimal. Any residual concern can be alleviated by monitoring and review in the early stages of the consents (if granted).

Concluding Comments

The model has been updated using all pertinent data and has been thoroughly interrogated. It has been used to predict the changes in river flows and groundwater levels as a result of the proposed Tranche 2 activities. Predictions of changes from the updated model are not appreciably different from earlier versions. The experts agree that, considering the uncertainty estimates discussed above, the updated model can be used to assess drawdown and stream depletion effects. The experts agree that residual uncertainty remains and can be managed through conditions of consent, which should include appropriate monitoring and analysis of the data.

Dated 11 October 2022

Neil Thomas

Julian Weir

Nick Dudley Ward