BRIEFING NOTE

To: Kaituna and Pongakawa-Waitahanui Freshwater Futures Community Groups

From: Andrew Millar, Senior Planner, Policy and Planning; Raoul Fernandes, Team Leader Science – Water Quantity, Science

Date: 20 November 2019

Subject: **Workshop 11: Groundwater Quantity**

20 November 2019, Pongakawa Hall, 925 Old Coach Rd, Pongakawa

1 Introduction

1.1 Purpose

In this workshop, we will talk through groundwater quantity information and implications. This will include a recap on some material already discussed by the group, as well as presentation of some new information.

The main purpose will be to explore groundwater modelling results and implications of allocation limit scenarios.

1.2 Outcomes sought

Group members consider groundwater allocation limit scenario modelling results and advise on their preferred option.

2 The Groundwater Story So Far

A three dimensional groundwater model[1], using the MODFLOW software platform, has been built for the Kaituna-Pongakawa-Waitahanui Water Management Area (WMA). The model is based on current information and data about the groundwater system.

Some information about the model was previously provided in the 'Information Sheet: Groundwater Model for the Kaituna-Pongakawa-Waitahanui Water Management Area' in Workshop 5. The information Sheet can be found at the following links:

- Kaituna Community Group Briefing Note, page 27[2]
- Pongakawa Community Group Briefing Note, page 27.[3]

More information is provided in this briefing note, and we will work through it with you in the workshop.

3 Hydrogeological Setting and Conceptual Model

Hydrogeology is the study of groundwater distribution and movement in the rock/geological layers beneath us. A conceptual model of the hydrogeological

[1] Computer model representing the groundwater system and the factors that affect it.
[2] https://cdn.boprc.govt.nz/media/670449/kaituna-workshop-5-agenda-and-briefing-papers-final.pdf
[3] https://cdn.boprc.govt.nz/media/670450/pongakawa-workshop-5-agenda-and-briefing-papers.pdf

system has been developed to represent the underlying groundwater system and factors that affect it. The three dimensional geological model (Earth beneath our feet) has been used to determine the geology in the area. The many geological units have been combined into simpler groupings called hydrogeological units for the MODFLOW model, as describe in Table 1 and shown in Figure 1.

Model layer	Hydrogeological unit	Geological unit	Description
1	Tauranga Group	Tauranga Group (alluvium)	Silts and sands with some gravels – permeable, but variable.
2	Upper volcanics	Rotoiti Formation	Jointed ignimbrite units – secondary porosity, therefore aquifer parameters are not uniform.
		Mamaku Plateau Formation	
		Rotorua Rhyolites	
		Pokai-Chimp Formation	
		Matahina Formation	
3	Mudstone	Tauranga Group (mudstone)	Lower permeability than layer 4. Not fractured, therefore secondary porosity unlikely.
4	Sand and Gravel	Tauranga Group (sand and gravel)	Permeable
5	Lower volcanics	Older volcanics	Ignimbrites and fractured lava flows. Less fractured than layer 2.
		Waiteariki Formation	
		Whitianga Group	
		Aongatete Formation	
		Kaimai Subgroup	

Table 1: Hydrogeological setting, showing how geological units have been combined as hydrogeological units and described for use in MODFLOW. Note: Layer 3 and 4 are combined into one layer for the purposes of water allocation.

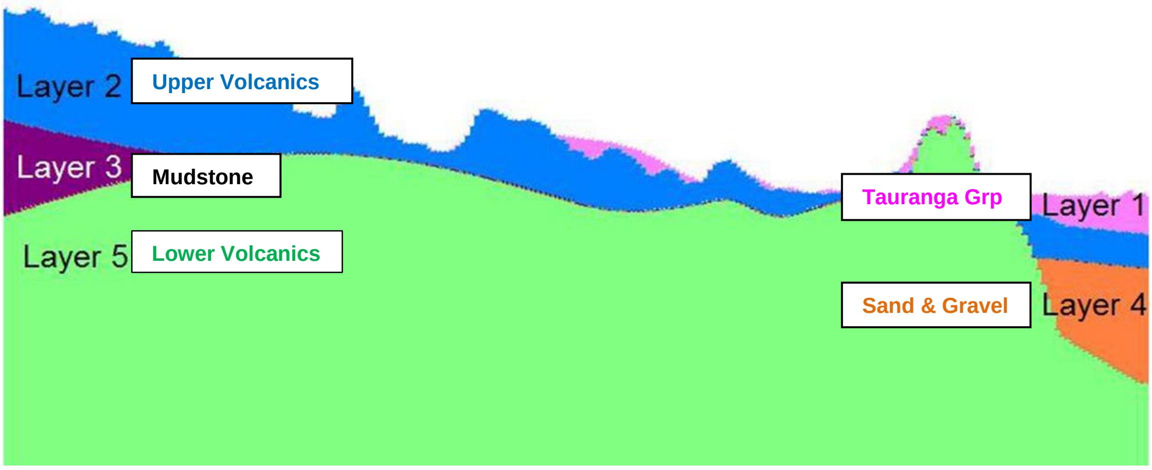

Figure 1: Cross-section (south-north) of MODFLOW groundwater model showing the hydrogeological layers

4 MODFLOW Model and Calibration

The model has been used to simulate the existing (real) hydrogeology, and calibrated to an acceptable accuracy. Calibration is the process by which parameters of the model are adjusted to reproduce or match observed (real) data. A number of assumptions have to be made in the groundwater model. All models have limitations and uncertainties, particularly where data is scarce. How well the model estimates observed data gives some indication of the level of uncertainty in model results. The Kaituna-Pongakawa-Waitahanui MODFLOW model is built to the Australian Groundwater Modelling Guidelines, Class 2 Confidence Level. It is suitable for setting groundwater allocation limits.

The MODFLOW model has been calibrated to measured groundwater levels in monitoring bores and to estimated base-flow in the major rivers that drain the overlying surface water catchment. Base-flow is the proportion of flow in the river that is not from direct rain fall run-off. It is sustained from groundwater discharging into the rivers.

Where connections exist between the groundwater system and surface water bodies in the area, surface water flows in the summer are likely to be sensitive to abstraction from groundwater. Flow from groundwater to rivers and streams in the summer, when stream flow from rainfall run-off is typically lowest, is important to safeguard the flows and ecology in streams.

The calibrated groundwater model has been used to predict results of various groundwater management scenarios. The model can be used to estimate changes to the volume of groundwater extraction and impacts on groundwater levels and base-flow in major rivers. This helps to inform decisions on sustainable groundwater abstraction limits.

5 Values and Objectives

To sustainably manage groundwater resources, the amount of water taken and used from the ground should not exceed the amount needed in the ground to:

- safeguard groundwater levels / pressure
- prevent intrusion of saline water at the coast into the groundwater system
- safeguard groundwater flows that contribute to base-flow in rivers and streams in the summer.

6 Scenarios and Results

Modellers build scenarios and run them using the calibrated model to predict what could happen to factors that affect the objectives (i.e., groundwater levels, saline intrusion and baseflow). Initially model predictions were determined for the following scenarios:

1. No abstraction (base case - i.e. equivalent to the ‘natural state’ to determine the scale of predicted change for subsequent scenarios)
2. Consented maximum abstraction volume with current climate and land use (groundwater recharge)
3. Consented maximum abstraction volume with climate change rainfall
4. Consented maximum abstraction volume with land use (groundwater recharge) change
5. Consented maximum abstraction volume with climate change rainfall and land use (groundwater recharge) change.

The following **criteria** were set:

- minimum groundwater water level of 0.5m below sea level in locations near the coast to manage the potential for saline intrusion
- maximum reduction in stream base-flow of 1% (Option A), 5% and 10% (Option B).

The model prediction results are designed to be extremely conservative. The results discussed below are preliminary and currently being finalised. They suggest the base-flow criterion of 1% reduction is just breached with current land use, climate and consented maximum allocation volumes. Under these conservative assumptions there is no potential to increase the amount of groundwater available for allocation. Base-flow reductions for major rivers assessed ranging from 2 to 5% were predicted with climate (2% less rainfall) and land use (groundwater recharge) change. Under all these scenarios groundwater levels are predicted to remain above the minimum water level criterion of 0.5m below sea level in the locations assessed. Predicted groundwater drawdown effects for these scenarios are some distance from the coast and are not expected to cause saline intrusion.

Model prediction results suggest that for the 5% and 10% base-flow reduction criteria there is potential to increase the amount of groundwater available for allocation. For the 5% and 10% base-flow reduction criteria, with climate and land use change, the current allocation and three times the current allocation respectively, are the maximum volumes of groundwater available for allocation. Under the 5% base-flow reduction criterion minimum groundwater levels are not a constraint. They are predicted to remain above the minimum water level of 0.5m below sea level in the locations assessed. Under the 10% base-flow reduction criterion minimum groundwater levels are a constraint. As a consequence the predicted base-flow reductions are less than 10%. They range from 5.9 to 9.2%.

Further modelling scenarios (Option C) have been considered to determine whether there is any potential to maximise the amount of groundwater available for allocation, minimise predicted effects on groundwater water level at the coast, and minimise reduction in stream base-flow. Previous model scenario predictions (Options A and B) described above are based on:

- A single management zone and allocation limit for the four hydrogeological layers.
- The existing distribution of consented allocation, applying a factor to uniformly increase modelled groundwater available for allocation (abstraction).

For Options C modelling scenarios the four hydrogeological layers were divided into separate spatial groundwater management zones based on the mapped aerial extent of the geological units within them. The four hydrogeological layers were divided in 22 separate groundwater management zones. An allocation limit was determined for each of the groundwater management zones.

The size of groundwater level drawdown, and proximity to connected surface water bodies and the coast influences the size of effects on stream base-flow and the groundwater level near the coast. Option C scenarios included existing consented maximum abstraction at their current locations (like Scenario A) and also included additional abstraction in locations outside the main areas of groundwater level drawdown influence. Additional abstraction was progressively increased in all of the four model layers until the minimum groundwater level and maximum base-flow reduction criteria were breached. Only current climate and land use have been considered in Option C.

Option C model prediction results indicate there is potential to increase the amount of groundwater available for allocation by 77% compared to current allocation. Under this scenario the predicted base-flow reduction for the same major rivers assessed in scenarios A and B ranged from 0.5% to 1.5%. Three additional rivers were assessed for Option C. Predicted base-flow reduction for these additional rivers ranged from 0.5% (Waitahanui) to 5.6% (Puanene). The average base-flow reduction for all rivers considered is 0.2% to 0.4% more than Option A scenario for consented maximum abstraction volume with current climate and land use. The criteria that minimum groundwater water level is 0.5m below sea level will be met in all except for one location assessed. The groundwater level at that location is predicted to be 0.6m below sea level and is expected to be an anomaly. Groundwater level in all other locations assessed for Option A (scenario - consents at their maximum abstraction volume with current climate and land use) were predicted to be above sea level. A number of additional locations along the entire coast line were assessed for Option C.

For Option C, an allocation limit was determined for each groundwater management zone, corresponding to increasing the amount of groundwater available for allocation by 45% of the current allocation. Reduction in base-flow and water levels at the coast were not reported for this scenario. However, they will be less than those predicted for increasing the allocation by 77% of current allocation.

7 Conclusions / Preferred Option

The options and scenarios are summarised below for reference. The results of model predictions help to inform our choices when setting groundwater allocation limits. They do not provide a single or preferred answer to setting groundwater limits available for allocation. The modelling scenario predictions demonstrate there is a connection between groundwater abstraction limits, the magnitude of effect on connected surface water bodies and groundwater levels at the coast. The model quantifies estimated effects of allocation on groundwater levels and base-flow in major rivers. The results demonstrate the magnitude of effects is not uniform over the whole area considered by the model. The location of groundwater takes affects the results. A number of assumptions have to be made in the model and model scenarios, which influence the results and these need to be recognised.

Council will seek community, iwi and hapu views on preferred options. In particular, feedback will be sought about the degree of stream base-flow reduction considered appropriate. Opinions on preferred options will reflect the different values people hold.

At the workshop, we will ask you ….

1. Do the assumptions seem about right to you?
2. Are there any other values and objectives that need to be considered?
3. Are there any other scenarios that need to be considered?
4. What is your preferred option?

Attachment: Summary of modelled options and scenarios

<table>
<tr><td colspan="2">Management option A:
No base-flow reduction (<1%)
No saline intrusion (minimum groundwater level 0.5m below sea level near the coast)
Existing distribution of water use
One allocation zone</td></tr>
<tr><td colspan="2">Scenario</td></tr>
<tr><td colspan="2">1. Current land use & climate</td></tr>
<tr><td colspan="2">2. Climate change (-2% rainfall)</td></tr>
<tr><td colspan="2">3. Land use change (infiltration)</td></tr>
<tr><td colspan="2">4. Climate & land use change</td></tr>
<tr><td colspan="2">Management option B:
Allow base-flow reduction (5-10%)
No saline intrusion (minimum groundwater level 0.5m below sea level near the coast)
Existing distribution of water use
One allocation zone</td></tr>
<tr><td>Scenario</td><td>Base-flow constraint</td></tr>
<tr><td rowspan="2">1. Current land use & climate</td><td>5%</td></tr>
<tr><td>10%</td></tr>
<tr><td rowspan="2">2. Climate change (-2% rainfall)</td><td>5%</td></tr>
<tr><td>10%</td></tr>
<tr><td rowspan="2">3. Land use change (infiltration)</td><td>5%</td></tr>
<tr><td>10%</td></tr>
<tr><td rowspan="2">4. Climate & land use change</td><td>5%</td></tr>
<tr><td>10%</td></tr>
<tr><td colspan="2">Management option C:
Hydrogeological units subdivided into 22 management zones with different allocation limits
Existing consented water allocation at current locations AND additional abstraction outside main drawdown areas</td></tr>
<tr><td colspan="2">Scenario</td></tr>
<tr><td colspan="2">1. Current land use & climate</td></tr>
</table>