Memorandum

To:	Tranche 2 Applicants	**Of:**	Ruataniwha Basin
From:	Julian Weir	**Date:**	27 January 2021
Reviewed by:	Hilary Lough and Neil Thomas	**Job no:**	WL18045
Subject:	**Meeting Notes and Actions Points - PDP's Preliminary Review of Groundwater Model**		

Hawke's Bay Regional Council (HBRC) have engaged Pattle Delamore Partners Ltd (PDP) to provide technical review of the Ruataniwha Basin Tranche 2 groundwater modelling as documented by Weir (2020)[1]. Due to workload commitments, PDP completed a preliminary review of this work and documented their initial response in the memorandum PDP (2020)[2]. The expectation is that the items in this preliminary review would be responded to before a final (or more comprehensive) review is completed.

Groundwater modelling experts Julian Weir (Aqualinc), Hilary Lough (PDP) and Neil Thomas (PDP) met on 20 January 2021 (at Aqualinc's premises) to discuss PDP's preliminary review and for PDP to view the model. This meeting was both helpful and constructive. Conclusions and associated action points from this meeting are discussed below. The item numbering aligns with the same numbering in PDP's review memorandum.

In summary, PDP wish to view more model structure and outputs, and field data, before they can fully assess the model's suitability as a tool to inform decision making. This includes brief sensitivity analyses to explore the soundness of using the model to predict changes in river flows. Further work may be required based on the outcomes of the action points set out in this memorandum. The experts expressed a desire to reach agreement on as much of the modelling work as feasible prior to any future decision making and/or consent hearing. This reduces uncertainty for both HRBC and the applicants, and will aid the decision making process.

1. *Model uncertainty and new monitoring data*

Modern groundwater modelling techniques often include an assessment of predictive uncertainty. Uncertainty analyses should not be treated as a substitute for robust model construction. However, they are helpful to consider the uncertainty and/or parameter sensitivity associated with the model predictions. Conversely, when taken to an extreme, uncertainty results can confuse decision makers by muddying the information needed to make key decisions (uncertainty analyses are often subjective). Comprehensive predictive uncertainty techniques also take a long time to generate and require large computing power.

The model developed for the Tranche 2 assessments has been constructed thoroughly over many years, and is a sound simulator of past response (particularly river flows). Furthermore, using the model to predict *changes* in river flows (rather than absolute values) removes much of the model uncertainty. PDP have requested simple sensitivity analyses in this first instance to test if this is

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[1] Weir, J (2020). *Ruataniwha Basin Tranche 2 Groundwater Modelling.* Prepared for Various Collaborative Participants. WL18045. 05/11/2020. Aqualinc Research Ltd.

[2] PDP (2020). *Ruataniwha Basin Tranche 2 Groundwater Modelling – Preliminary Comments*. Memorandum prepared for Hawke's Bay Regional Council. 15 December 2020.

the case.

Action point: Aqualinc to complete sensitivity scenarios where all riverbed conductances and aquifer horizontal and vertical hydraulic conductivities are (firstly) simultaneously increased by one order of magnitude (x10), then reduced by one order of magnitude (x0.1). Changes in river flows as a result of the proposed Trance 2 takes and augmentations would then be compared to the original calibrated model results. This only needs to be completed for the final optimised Scenario 4. If the outputs from these sensitivity analyses indicate that there is a large potential range in model predictions, more comprehensive uncertainty analyses may be required so that the range in predictions can be better constrained.

HBRC and PDP have advised that there is additional groundwater level monitoring data now available. Furthermore, it is expected that there is also additional river flow monitoring data. Although this new data is beyond the model run period, it may be useful to test the model's response in areas where there has historically been little data, if relevant.

Action point: Aqualinc to request new groundwater level data, river flow data (including any concurrent gauging data as a check on approximate river flow losses), and estimates of river bed conductivities from HBRC. The model would then be assessed against this new data, allowing for the differences in modelled versus measured dates.

2. *River bed conductivities*

Concurrent flow gauging data can only be used to estimate river bed losses if the difference between river stage and the underlying groundwater is also measured. Where this is not measured, approximate values may be estimated from monitoring bores and/or model outputs, but this is highly uncertain.

Action point: If additional field data is available (to be requested from HBRC under item 1 above), compare these to model parameters (where relevant).

3. *Model run period*

The work required to extend the model run period is extensive, and there are years within the model simulation period that were very dry. PDP agreed with this, but did note that replication of recent dry years may be informative. Rather than investing in extending the model to present date, more recent river flow monitoring data (as per item 1 above) can be assessed in this first instance to see how frequent restrictions and augmentation would have occurred in these recent years, and compare this to the run period already modelled.

The downward trend apparently missed in some model outputs towards the end of the simulation period (2013) is not what it appears. Two model scenarios were constructed for calibration – a 'No irrigation' scenario and a status quo ('6,000 ha' of irrigation) scenario. These two scenarios represent 'bookends' (or an envelope) within which the measured values would fall if the model was perfectly calibrated. Time-varying land use and irrigation development means that measured groundwater levels would transition between these scenarios over time. This is what is observed with the lowering groundwater levels towards the end of the current simulation period. A good example of this is bore 4702, shown in Appendix A of Weir (2020). Other influences (particularly local pumping interference) mean that the modelled responses do not precisely match measured (e.g. bores 4696, 4697 and 5445). This is normal and expected.

Action point: Assess recent restrictions (for new data, requested under item 1 above) and compare these to restrictions under the historical model period. Extend plots to include most recent measured groundwater levels in the plots in the modelling report (the modelled levels do not need to be extended at this stage) and provide comments where relevant on model suitability in light of recent data. This may include explanations on local pumping interference effects, for example, in areas where significant increases in abstraction have occurred.

4. *River flow calibration data*

For model calibration up to 2013, Aqualinc was supplied with measured river flow data from HBRC for the period 1987-1990 for the Waipawa River at SH2 and Tukituki River at Tapairu Rd. There may be more recorded data available now for more recent years, beyond the model simulation period. If so, this will be assessed for lengths of dry periods (given the trigger flows) and compared to both the 1987-1990 data and to model outputs over the longer period.

Action point: Compare the dry periods in more recent river flow data to both 1987-1990 data and model outputs over the longer simulation period.

5. *River flows under model scenarios*

PDP requested more information on the changes to flow regimes under the different scenarios.

Action point: Present hydrographs of river flows for relevant model scenarios, rather than just tabulated statistics, and provide a brief discussion.

6. *Climate change*

Climate change predictions are highly uncertain. However, a high-level qualitative assessment of predictions out to 2040 (the approximate duration of these Tranche 2 consents) will be provided in the model report.

Action point: Provide a brief, high-level, qualitative assessment of climate change, considering east-west weather patterns and potential consequence to water demands for augmentation and irrigation given HBRC's 9-in-10 year allocation method. HBRC may have this information already.

7. *Cumulative depletion effects from year to year*

The transient model scenarios all have initial groundwater levels set from outputs of a steady state model of the equivalent scenario (using long-term average inputs). Therefore, the effects of the proposed activities are included in the model right from the beginning of the transient scenario. Each transient scenario also runs continuously over the 40-year simulation period, and therefore any residual effect from one year to the next will be automatically included in the results. A water balance shows how the system rebalances between pre- and post- takes. This can be provided for steady state model scenarios.

Action point: Present pie-graph (or tabulated) water balances for the No abstraction, Current and Scenario 4 steady state models.

8. *Water year*

It was discussed how the intention of delaying the augmentation water year by one month after the irrigation water year was intended to acknowledge that effects from irrigation are delayed. Alignment of water years is best addressed through further discussion with the Applicants' legal and policy representatives, and HBRC. Aqualinc and PDP are happy to participate as needed.

Action point: Janeen, Bal and/or Applicant representatives to discuss 'water years' with HBRC.

9. *Effects on other river sites*

The model simulates river flows at many reaches within the basin, but only a few have measurements with which to calibrate. There are also several smaller streams and drains that are too small to model at the basin scale of the model. Furthermore, it is not feasible to augment into every stream, so there may be some reaches that are depleted and do not receive augmentation water until further downstream, below a confluence with another stream that does. Aqualinc would like guidance from HBRC and the Applicants (and their consultants) as to which sites are important for further assessment. It could be that many sites go dry naturally in summer, and/or have little instream value. It is not feasible to present effects on every reach, so it may be that a few sites are chosen (in different areas) as proxy sites to represent the effects in other reaches.

Effects on wetlands could be assessed by considering the change in groundwater level predicted by the model at the wetland location and, with local knowledge, derive an estimated impact (if any), even only at a qualitative level at this stage.

Action point: Use local knowledge (HBRC, Applicants, and their consultants) to select representative stream and wetland sites for initial consideration, and undertake simple assessment of effects from relevant model outputs. This may require an assessment of the instream value of the water body.

10. *Effects on streams upstream of augmented rivers*

This is the same as item 9 above.

Action point: As per item 9.

11. *Present flows as percentage change*

This can be added to the model report, where relevant.

Action point: Add percent change to predicted changes in modelled average and MALF flows in the model report.

12. *How augmentation flows are modelled*

Aqualinc discussed how the rivers are modelled using MODFLOW's SFR2 package. River flows are routed downstream from reach to reach, losing to groundwater or gaining from groundwater as it goes (depending on the relative differences between river stage and underlying groundwater levels). Augmentation flows are added (as a model input) to the river reach nearest the proposed discharge site, and the model adds these flows to the calculated river flow for that reach, and the combined flow is then routed downstream. Some of this augmentation water may drain to groundwater and some may remain in the river and flow down to lower reaches. The interaction between river and groundwater is automatically calculated by the model – this is not user specified. PDP were happy with this explanation.

Action point: None.

13. *Model boundaries*

Aqualinc demonstrated the model to PDP and the various model boundaries were explored. PDP were happy with this.

Action point: None.

14. *Effects at Red Bridge*

PDP and HBRC have expressed interest in the effects of the proposed Tranche 2 takes on the flows at Red Bridge. Due to the large distance between the basin outlet and Red Bridge and the associated complexity of the hydrogeology along the Heretaunga Plains, this is nearly impossible to derive. That is why the proposed Tranche 2 activity targets full mitigation of low flows out of the basin – given this, the low-flow reliability of downstream users would not be made worse by the proposed Tranche 2 takes. However, PDP are still interested in assessing the potential change at Red Bridge assuming the change in flow out of the basin is seen directly at Red Bridge. Therefore, PDP requested that the change in river flows out of the basin be added (or subtracted) from the measured flows at Red Bridge, and any change in reliability assessed.

Action point: Collect Red Bridge flows (from HRBC), and alter the flow based on the modelled flow change out of the basin. Then, assess the change in reliability given low-flow triggers at this location. This is a coarse-scale assessment, and it will be assumed that there is no delay between the basin and Red Bridge (i.e. effects will be seen at Red Bridge within the 1-day timestep of the model).

15. *Irrigation demand*

Aqualinc explained how the irrigation demand is modelled using IrriCalc, which calculates crop water demand and associated irrigation requirements based on climate, soil, crop type and irrigation methods. This is completed at daily intervals, and the time-varying response is largely driven by rainfall and evapotranspiration. This was applied to both the existing takes and the proposed Tranche 2 takes, assuming full irrigation development over the consented areas over the full model period. PDP were happy with this explanation.

Action point: None.

16. *List of existing consent holders subject to minimum flows, and the size of their takes*

This list may help PDP assess who are the key potentially affected parties (if any), and the scale of the effect. Compiling this list is something that HBRC may be able to assist with, and/or the Applicants' consultants.

Action point: HBRC and/or the Applicants' consultants to compile a list of existing consent holders who are restricted, and the size of their takes.

17. *Effects on wetlands, and rationale for presenting changes in groundwater levels for 1 March 2001*

Assessing the potential effects on wetlands are noted under item 9 above. The rationale for choosing 1 March 2001 is noted on page 33 of the model report, though a typographical error is now evident on this page: the sentence immediately below Table 21 should refer to '1 March 2001' and not '1 March 2011'. This will be changed in subsequent versions of this report.

Action point: Correct typographical error on Page 33 of model report.

18. *Map scales, Appendix C*

Action point: Improve scale labels on some maps in Appendix C.

19. *Weir (2013) report not searchable*

Action point: Provide searchable copy of Weir (2013) to PDP.