BEFORE AN INDEPENDENT HEARING PANEL

IN THE MATTER	Of the Resource Management Act 1991
AND IN THE MATTER	Of applications to Hawke's Bay Regional Council for resource consents to take and use Tranche 2 groundwater

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EVIDENCE OF NEIL THOMAS
ON BEHALF OF HAWKE'S BAY REGIONAL COUNCIL

GROUNDWATER

8 August 2022

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1. QUALIFICATIONS AND EXPERIENCE

1.1 My full name is Neil Malcolm Thomas

1.2 I am a principal hydrogeologist with Pattle Delamore Partners Limited (PDP) and have been employed in that role since 2011. I hold the qualifications of Bachelor of Science (Hons) (Geological Sciences) from the University of Leeds (UK) and Master of Science in Hydrogeology from the University of Leeds (UK). I am a member of the New Zealand Hydrological Society. I have over 15 years of experience as a hydrogeologist specialising in groundwater resources.

1.3 Prior to working at Pattle Delamore Partners Limited I was employed by Entec UK Ltd (now AMEC) in the United Kingdom for 5 years (from 2005 to 2010) as a hydrogeologist specialising in groundwater modelling.

1.4 My role at PDP involves working on a wide range of groundwater management issues including assessments of groundwater quality and quantity within the Hawke's Bay region, and elsewhere in New Zealand. These include the effects of land use, abstractions and discharges on groundwater and the interaction between groundwater and surface waterways. I have extensive experience of groundwater models including detailed uncertainty analysis, gained both in New Zealand and in the UK. I have worked with Hawke's Bay Regional Council on reviews of several groundwater consent applications within the Ruataniwha Basin over several years and I am familiar with the area.

1.5 I have read the Code of Conduct for Expert Witnesses as contained in the Environment Court Practice Note 2014 and have complied with it in preparing this evidence. I confirm that the issues addressed in this evidence are within my area of expertise and I have not omitted material facts known to me that might alter or detract from my evidence.

2. SCOPE OF INVOLVEMENT

2.1 I was engaged by the Hawke's Bay Regional Council (**HBRC**) in 2020 to review the technical material provided in relation to the revised consent applications for abstraction of Tranche 2 groundwater.

2.2 The key documents that I have referred to in preparing my evidence include:

(a) Weir, J., 2022. Ruataniwha Basin Tranche 2 Groundwater Modelling (Revised). 30 June 2022.

(b) Durney, P., 2022. Independent Review of Aqualinc's Rutaniwha Groundwater model Used in Support of Tranche 2 Takes. 30 May 2022.

(c) Rabbitte, S., 2022. Final Addendum – Letter Report: Review and Update of Ruathaniwha Basin Tranche 2 Consent Application - Assessment of Well Interference Effects. 11 July 2022.

2.3 I have also referred to other documents provided with the application including responses to requests for further information. Where relevant I have referenced these documents and list of references is provided in Section 14 of my evidence.

2.4 I have set out my conclusions relating to that involvement in this statement of evidence. I particularly focus on the groundwater effects of the proposed abstraction and associated discharges.

3. SUMMARY OF EVIDENCE

3.1 My evidence covers the following key areas of the applications as they relate to groundwater.

(a) A description of the hydrogeological setting of the Ruataniwha Basin.

(b) An outline of my understanding of the proposed abstractions and associated discharges.

(c) A description of the assessments carried out by the Applicants including my comments on those assessments.

(d) My assessment of the potential effects on groundwater that could arise as a result of the applications.

(e) My conclusions with respect to the applications on the groundwater environment.

3.2 A brief summary of the key points from my evidence are provided below, which highlights my concerns regarding the assessment that has been completed and where I believe potentially significant effects could occur.

3.3 The Ruataniwha Basin represents a closed inland basin from which groundwater and surface water discharge via the Waipawa and Tukituki Rivers. Groundwater is used extensively throughout the basin for irrigation and water supply purposes and as a result of the closed nature of the basin, all groundwater abstraction will eventually deplete flows in the surface waterways that exit the basin.

3.4 The Applicants have applied to take up to 15 x 10^6 m^3/year of deep groundwater, which represents the Tranche 2 groundwater allocation volume that is available from the basin. The decision defining the Tranche 2 groundwater volume also specified that the water can only be allocated if the effects on surface water flows are mitigated via flow augmentation.

3.5 Flow augmentation is proposed as part of the applications for Tranche 2 water. This flow augmentation is proposed to also be sourced from deep groundwater and therefore the taking for augmentation also creates a depletion effect. The Applicants have used a numerical groundwater model to assess the impacts of their abstractions for both irrigation and augmentation and the discharges on both the patterns of groundwater flow and on the surface water flow regime. The assessment of effects relies heavily on the outputs from the groundwater model.

3.6 In general, I agree that a numerical groundwater model is an appropriate tool to use to understand the potential effects of large scale groundwater abstraction. However, I have a number of concerns regarding the use of the groundwater model, in particular where it has been used to calculate precise changes in groundwater levels and flows.

3.7 The approach by which the groundwater model has been calibrated is unusual and, in my opinion, leads to a relatively wide range of uncertainty in its predictions. Whilst some assessment of the uncertainty of the model has been provided by the Applicants, it is limited and does not cover the full range of possible effects that could occur as a result of the Tranche 2 abstractions.

3.8 I agree with the Applicants that the model can be used to demonstrate the effect of the Tranche 2 abstractions and augmentation discharges on flows in the Waipawa River and Tukituki River at the basin outlet. The model results indicate that the average flows will reduce, but that effects on minimum flows can be mitigated as a result of targeted augmentation, except in very dry years (i.e. outside a 1 in 10 year dry event) when there is insufficient augmentation volumes to continue mitigation. This means unmitigated effects from the Tranche 2 takes on low flows will occur at times in very dry years, with the additional depletion from the Tranche 2 abstractions exacerbating the magnitude, frequency and duration of low flows.

3.9 I also note that the mitigation relies on the augmentation water reaching the low flow sites, which may not be the case for some sites/methods of discharge depending on downstream losses or the connection between proposed augmentation bores and the rivers.

3.10 The drawdown interference assessment is based on the model outputs, together with other assumptions, and in my opinion, does not adequately capture the potential impacts of the proposed abstraction, which may be greater than estimated by the Applicants, leading to potentially adverse effects on existing bores.

3.11 The Tranche 2 abstractions will create a year round reduction in surface water flows across and exiting the basin. Augmentation is proposed to occur during periods of low flow to mitigate effects during these periods. The thresholds have been set higher than the minimum flows to mitigate effects more appropriately on existing users tied to minimum flow restrictions (by allowing for the predicted magnitude of depletion effect). However, the flow augmentation will only mitigate against Tranche 2 depletion effects during periods of low flow below the point of the augmentation discharge. While existing users tied to low flow restrictions may benefit, reaches of river and streams upstream of the augmentation discharge points, together with streams and rivers not receiving augmentation discharges will experience a reduction in flow as a result of the abstractions that will be unmitigated.

3.12 Effects on flows in the smaller streams that cross the basin have been assessed based on the results of the groundwater model. Due to the uncertainties in the model, I do not believe that the Applicants' assessment provides a realistic estimate of the potential worst case effect on these streams and in my opinion, greater reductions in flows could occur. Comments on the ecological impacts of these changes in flows are provided in the evidence of Laura Drummond, together with drawdown impacts on wetlands. I note that climate change could increase the impact of the Tranche 2 takes compared to effects under the current climate.

3.13 Overall, my opinion of the assessment of effects on groundwater provided in the application is that:

(a) Effects on flows at the basin outlets are reasonably quantified and the effects on low flows can be offset by the proposed augmentation (up to the 1 in 10 year level but not in drier years);

(b) Greater effects on groundwater levels could occur than predicted by the Applicants, which could lead to adverse effects on some shallow and deeper bores; and

(c) Effects on smaller streams and rivers within the basin could be greater than predicted by the Applicants, potentially leading to adverse effects on those streams.

4. HYDROGEOLOGICAL SETTING

4.1 The Ruataniwha Plains represent an actively fault controlled, and fault bound inland basin where uplift and erosion occurs in the west of the basin, and subsidence and deposition in the east of the basin. The resulting strata that make up the basin fill are therefore complex and heterogenous with numerous lenses of more and less permeable strata that do not always interconnect. The basin is bounded by lower permeability strata including greywacke and mudstones that restrict groundwater movement to within the basin.

4.2 In very broad terms, groundwater in the basin is recharged via seepage from the major rivers in the west, together with rainfall recharge across the plains. Groundwater discharges via natural seepage to rivers, particularly in the east of the basin, together with artificial abstraction of groundwater via bores. As a result, the dominant groundwater flow direction is from west to east across the basin.

4.3 As the basin is bounded by low permeability strata, all groundwater (not taken by consumptive groundwater abstractions) eventually discharges into the surface waterways that drain the basin. The main surface waterways that drain the basin are the Tukituki and Waipawa Rivers.

4.4 The pattern of long term groundwater levels in a bore provides information on the balance of recharge to, and discharge from, a groundwater system. Long term stable groundwater levels indicate that recharge and discharge are in balance. A pattern of declining groundwater levels indicates that discharge from a groundwater system exceeds recharge whereas a pattern of long term increases in groundwater levels indicates that recharge to the groundwater system exceeds discharge.

4.5 The Hawke's Bay Regional Council monitors groundwater levels in several bores across the Ruataniwha Basin and a summary of the long term trends in those records is available in the latest State of the Environment report (Hawkes Bay Regional Council, January 2020). This report indicates that for monitoring bores with a suitable long term record (i.e. at least 10 years up to 2018), a downwards trend was indicated in the data in a majority of bores. The median rate of groundwater decline varied between around 0.29 m/year in the 10 year period from 1999 to 2008 to 0.37 m /year in the period 2009 to 2018, implying that the rate of decline has increased since 2009 in those bores with a decreasing trend.

4.6 The SoE report indicates that these declines are likely the result of increases in groundwater abstraction, which reportedly increased from around 5 x 10^6 m^3/year in 1998 to 20 x 10^6 m^3/year in 2008. Further information provided by HBRC (Paul Barrett, pers. comm) indicates that actual groundwater use (based on metered data) has varied since that time, as illustrated in Figure 1 below.

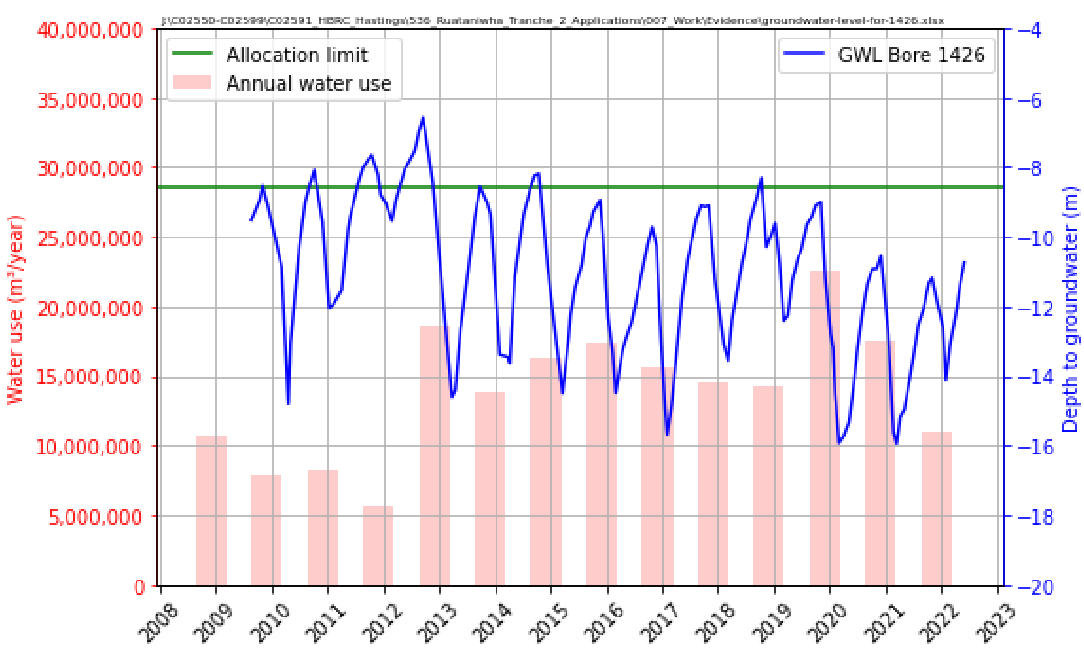

Figure 1: Groundwater levels in bore 1426 compared to annual water use across the Ruataniwha Basin

4.7 Figure 1 also shows a plot of groundwater levels in bore 1426 (screened from 38 m below ground level (bgl) to 44 m bgl and located around 2.5 km west of Ongaonga). Groundwater levels in bore 1426 appear to generally follow the pattern of groundwater abstraction, with lower levels occurring following periods of increased groundwater abstraction, such as 2019/2020. The total decline in winter recovery groundwater levels in bore 1426 since 2008 appears to be around 2 m. It is not possible to comment on the pattern of summer declines in bore 1426 because it is used for irrigation. I note that the effects on this bore have been modelled in the Aqualinc report (Weir, 2022), as shown in Figure 28 of that report, which indicates, as expected, a decrease in both winter and summer levels.

4.8 The current level of available groundwater allocation for the Ruataniwha Basin (the Tranche 1 allocation) is also shown in Figure 1. Between 2008 and 2022, the full allocation of groundwater has not been used and therefore the current pattern of decline could continue or increase in bores across the basin. As I will describe further in my evidence, an increase over time in Tranche 1 abstractions has not been provided for in the assessment of effects. The proposed Tranche 2 groundwater takes would also increase groundwater use within the basin and therefore I would expect the current pattern of groundwater level declines to continue or increase.

5. TRANCHE 2 PROPOSAL

5.1 In this section of my evidence, I set out my understanding of the Tranche 2 proposal and how it is intended to operate. I also note some key areas of potential effects on groundwater as a result of the proposed takes, which are discussed in more detail in subsequent sections of my evidence.

5.2 The applications propose to take and use deep groundwater (Tranche 2 groundwater defined in the decision on Plan Change 6 for the HBRC Regional Plan) from bores in the Ruataniwha Basin. The decision defining Tranche 2 groundwater also specifies that the water can only be allocated if the consent holder augments surface water flows with the intention to ensure that stream depletion effects that could arise as a result of groundwater abstraction are mitigated.

5.3 All groundwater is ultimately sourced from the ground surface and eventually discharges back to the ground surface. Groundwater abstraction via bores will lower groundwater levels and either increase the rate of seepage from nearby streams/rivers into groundwater or reduce the rate at which groundwater discharges into nearby streams/rivers. However, the rate at which this process occurs will depend on factors including the aquifer and streambed parameters around the bore and the stream.

5.4 Abstraction from shallow bores can result in a rapid depletion effect on nearby streams and therefore restricting these takes based on the flow in the river can be an effective means of addressing the effects on surface water flows, as the flow recovery is also rapid when the groundwater abstraction ceases. Abstraction from deeper bores typically results in a relatively slow connection to surface waterways, which is distributed through time and space and takes time to develop. As a result, while it may result in some degree of flow recovery, applying low flow cutoffs to abstraction from deeper bores does not fully address the impacts, because the time between stopping abstraction and recovery of stream flows may be large, often in the order of several weeks or more. This means the effects of deeper abstractions are usually better managed via allocation limits designed to protect surface water flows.

5.5 In the HBRC regional plan for the Tukituki catchment (Plan Change 6) deep bores are classified as those that are more than 50 m deep and these bores are not managed via minimum surface water flow restrictions. The Applicant has proposed that all the bores associated with Tranche 2 will be at least 50 m deep. The impacts on stream flows are therefore expected to be delayed and smoothed through time i.e the effects will generally represent the average long term pumping rate rather than showing strong short term variations.

5.6 The mitigation via augmentation of surface water flows as proposed by the Applicants is intended to offset the longer term depletion effects of the Tranche 2 abstraction on the reliability of existing users tied to minimum flow restrictions downstream of the augmentation points.

5.7 The augmentation rates for each Applicant are based on the results of modelling intended to determine the optimal augmentation rates to offset the effects of groundwater abstraction on surface water flows. My interpretation of the information provided with the applications is that the augmentation rates for each individual abstraction will not offset each individual’s stream depletion effects, but the combined augmentation will offset the combined stream depletion effects. Therefore, the mitigation relies on all the Applicants operating together.

5.8 Table 1 lists the Applicants together with their proposed take and augmentation volumes based on the information in the June 2022 Aqualinc report. In addition, Table 1 highlights where the Applicants have proposed existing bores to be used as part of the consent, if granted, and where new bores are proposed as part of the application. I have also noted whether the discharges for augmentation are proposed as a direct discharge to surface waterways, or where the discharge is via a bore.

5.9 I note that an AgFirst report provided on 27 July 2022 indicates some changes to the irrigation and augmentation volumes shown in Table 1, with some of the properties now requiring less water. The Applicants are now proposing the residual water (the balance of the 15 million m^3/year sought) could be used for other purposes but have not yet provided locations for this abstraction or an assessment of the effects of the taking or use of that water.

5.10 The application indicates that augmentation discharges will occur when low flow thresholds are reached in specific streams and rivers and the Applicants have proposed that higher thresholds will be used compared to those specified in the HBRC regional plan to allow for the magnitude of the Tranche 2 depletion effect. In addition, the application indicates that the full augmentation rates will always be applied (where water is available) including at times when the irrigation takes are not in operation (except for the Tukituki Awa discharge). However, I note that the augmentation volumes are based on a 1 in 10 year dry event and therefore there will be times when river flows drop below the minimum flow thresholds but no augmentation water is available. The Applicant has not provided an assessment of the effects on other users or ecology at these times.

Table 1: Tranche 2 Applicants[1]							
Application Number/s	**Applicant Name/s**	**Total Tranche 2 Volume (m^3/year)**	**Irrigation Volume (m^3/year)**	**Augmentation Volume (m^3/year)**	**Number of bores (including augmentation take)**		**Discharge method/location**
					Existing	**Proposed**	
WP140512T	Te Awahohonu Forest Trust (TAFT)	4,914,920	2,841,220	2,073,700	4[2]	2	SW discharge to Mangaonuku Stream
WP140555Tb APP-124498	Papawai Partnership	1,475,517	1,010,817	464,700	2		GW discharge to existing shallow bore adjacent to Waipawa River
WP150044T	Tukituki Awa Ltd	636,600	607,000	29,600		Up to 5	SW discharge to Tukutuki River
WP160193T	Plantation Road Dairies	3,751,225	2,418,225	1,333, 000	1	3	SW discharge to Kahahakuri Stream
WP150016T	Springhill Dairy Partnership	1,005,213	588,313	416,900	6		SW discharge to Mangaonuku Stream
WP170155T APP-124500	I&P Farming Limited	1,200,010	916,010	284,000		1 or more	SW discharge to unnamed tributary to Tukituki River
WP170166T	Buchanan Trust No. 2	1,145,794	786,594	359,200	1	3	SW discharge to Ongaonga Stream
APP-125281	Purunui Trust	554,921	370,321	184,600		3	GW discharge to existing shallow bore 200-300 m from Waipawa River
Totals		**14,684,200**	**9,538,500**	**5,145,700**	**14**	**17 or more**	

Notes: 1. The volumes shown in this table reflect those in the modelling report provided with the application (Weir, 2022). I am aware that the volumes have been altered since that report was produced, but the effects assessment has not bene updated to reflect the new volumes. I have relied on these volumes in my evidence.

2. Two of these bores (16952 and 16953) are listed as 'Exploratory' in the Weir (2022) report and may not be used as the final production bores.

5.11 Pumping from deep groundwater and augmentation of surface water flows will result in a number of effects on the environment including:

(a) impacts on river and stream flows

(b) impacts on existing bores including those in the deep and shallow strata

(c) potential water quality effects as a result of differences in water quality between deep groundwater and surface water.

5.12 The effects on stream flows and on existing bores have been assessed by the Applicants largely based on the results of a numerical groundwater model of the Ruataniwha Basin. Given that the numerical groundwater model is a key part of the assessment, the following section of my evidence discusses the model and how it has been developed for the purposes of assessing the potential effects of the Tranche 2 applications.

6. RUATANIWHA BASIN GROUNDWATER MODEL

6.1 The Ruataniwha Basin groundwater model was developed by Aqualinc Research Limited originally for the Tukituki Plan Change 6 hearings in 2012 to provide information around the possible scale of sustainable groundwater abstraction from the Ruataniwha Basin. The model was developed as a regional scale simulation of groundwater flows using the MODFLOW-NWT code. The model has since been updated and refined to model these proposed Tranche 2 groundwater takes.

6.2 Geological strata in the basin are represented through 10 model layers and the model is based on a 200 x 200 m grid. The model is transient and runs from 1972 until 2012 on a daily timestep. Surface waterways are represented in the model using the MODFLOW SFR package and land surface recharge to the model is provided via an Irricalc model, which represents groundwater recharge from rainfall and irrigation. Flow rates in the rivers that cross the upstream model boundary (i.e. the western model boundary) are estimated from a rainfall runoff model. Exchanges between groundwater and surface water within the basin are estimated through the groundwater model.

7. GROUNDWATER MODEL CALIBRATION

7.1 From the various modelling reports that form part of the application, I understand that groundwater abstraction is included in the model but the abstraction rates are not based on metered data. The simulated abstraction rates are based on the Irricalc model. The reason for this is reportedly due to a lack of data available in 2012, when the model was originally developed. However, I note that at that time, HBRC developed a parallel model of the Ruataniwha Basin which was based on metered data, suggesting that some metered data was available.

7.2 Likewise, Weir (2013) indicates that surface water abstraction is also included in the model (simulated as diversions from the streams) with abstraction rates based on the Irricalc model rather than metered data.

7.3 Typically, a transient groundwater model would be calibrated to the long term patterns of groundwater levels across a model area. However, a reasonable record of abstraction rates would be required to accurately represent long term groundwater level patterns across the basin and given the reported absence of such data, the Applicants have not attempted to match the observed long term groundwater level patterns across the basin. The Applicants have therefore used an alternative approach to calibrate the groundwater model.

7.4 Instead of using metered data, the Applicants have estimated groundwater and surface water abstraction rates based on the estimated irrigated area across the basin and calculations of irrigation demand from the Irricalc model. Information on the area of land across the basin that was historically irrigated is not easily available and the Applicants have not attempted to reconstruct historic irrigation patterns across the basin. As an alternative, the Applicants have calculated the irrigation requirements of abstractions across the model as though 6,000 ha of irrigation were taking place for the whole model period, with volumes varying depending on the climatic pattern between 1972 and 2012. 6,000 ha is intended to represent the ‘status quo’, or the currently irrigated area.

7.5 Calibration of the model has then followed a multistage approach:

(a) Initially a steady state model was calibrated to average groundwater levels and average surface water flows. This model uses average groundwater abstraction rates based on 6,000 ha of irrigation. Based on the most recent report (Weir, 2022), the model appears to use 72 bores for calibration and was calibrated using an automated software package (PEST (Doherty, 2021)).

(b) I note that the selection of ‘average’ levels and flows (and their respective weighting in PEST) is likely to have strongly influenced the resulting calibration of the model, particularly in light of the declining pattern of groundwater levels observed in several bores across the basin. The bores across the basin include data from a wide range of times and do not all cover the same timeframes; many of the bores recently installed by HBRC only have data from the last few years, while other bores have a much longer timeseries of available data.

(c) Consequently, the use of ‘average’ abstraction rates is not likely to be appropriate to match ‘average’ groundwater levels in all bores. The report also does not indicate if the steady state model was calibrated to river flows. As a result, there is likely to be considerable uncertainty in the calibration of this model in that a range of different parameter values could result in an equal fit to the observed data. I have commented further on this uncertainty in subsequent paragraphs of my evidence, together with the Applicants’ work to address the model uncertainty.

(d) Subsequently, two transient model runs were undertaken using the calibrated aquifer parameters from the steady state model. The first transient model run included no abstraction and aimed to represent winter groundwater levels, which typically represent times when no, or very little, abstraction for irrigation occurs. The results of this model run therefore represent an upper bound to modelled groundwater levels across the basin.

(e) The second transient model run includes abstraction which was set at rates assuming 6,000 ha is irrigated (i.e. the ‘status quo’), where the simulated abstraction rates varies through the model run depending on the irrigation demand calculated by Irricalc for any particular timestep. The results of this model intended to represent the long term effect of groundwater abstraction at approximately current rates.

(f) Both the transient models were manually calibrated to adjust the modelled storage parameters. Weir (2022) also indicates that the naturalised model (i.e. that without abstraction) was also calibrated to winter groundwater levels (which typically represent times of limited groundwater abstraction) as well as river flows, with a particular focus on low flows. I note that low flows occur typically towards the end of summer and are most influenced by groundwater abstraction and therefore it is not clear that this approach is appropriate. However, calibrating the model with abstraction to the observed low flows would be equally inappropriate because the groundwater abstraction values in the model are synthetic and may not represent actual abstraction. In my experience, actual abstraction rates rarely match estimates based on soil moisture demand models such as Irricalc. This aspect of the model calibration leads towards additional uncertainty in the model results and predictions.

(g) The results of the two transient model runs provide an 'envelope' of modelled groundwater levels (and modelled river flows) showing the potential impacts from abstraction and should capture the range of observed groundwater levels. This is because historical groundwater level records extending back to 1992 represent times where limited groundwater abstraction took place (i.e. reflecting the 'No irrigation' model run), whereas groundwater levels in 2012 represent a time when around 6,000 ha of land across the basin is irrigated using groundwater (reflecting the model run with irrigation).

7.6 The calibration of the model is unusual. Whilst I appreciate the reasons that the method was adopted, in my opinion this has led to relatively large uncertainty in the model predictions because the inputs to the model are not well constrained by the calibration exercise i.e. the values of aquifer parameters used to calibrate the model fall into a reasonably wide range; therefore any predictions from the model, such as the impacts of groundwater abstraction on small streams and rivers within the basin, could also fall in a wide range.

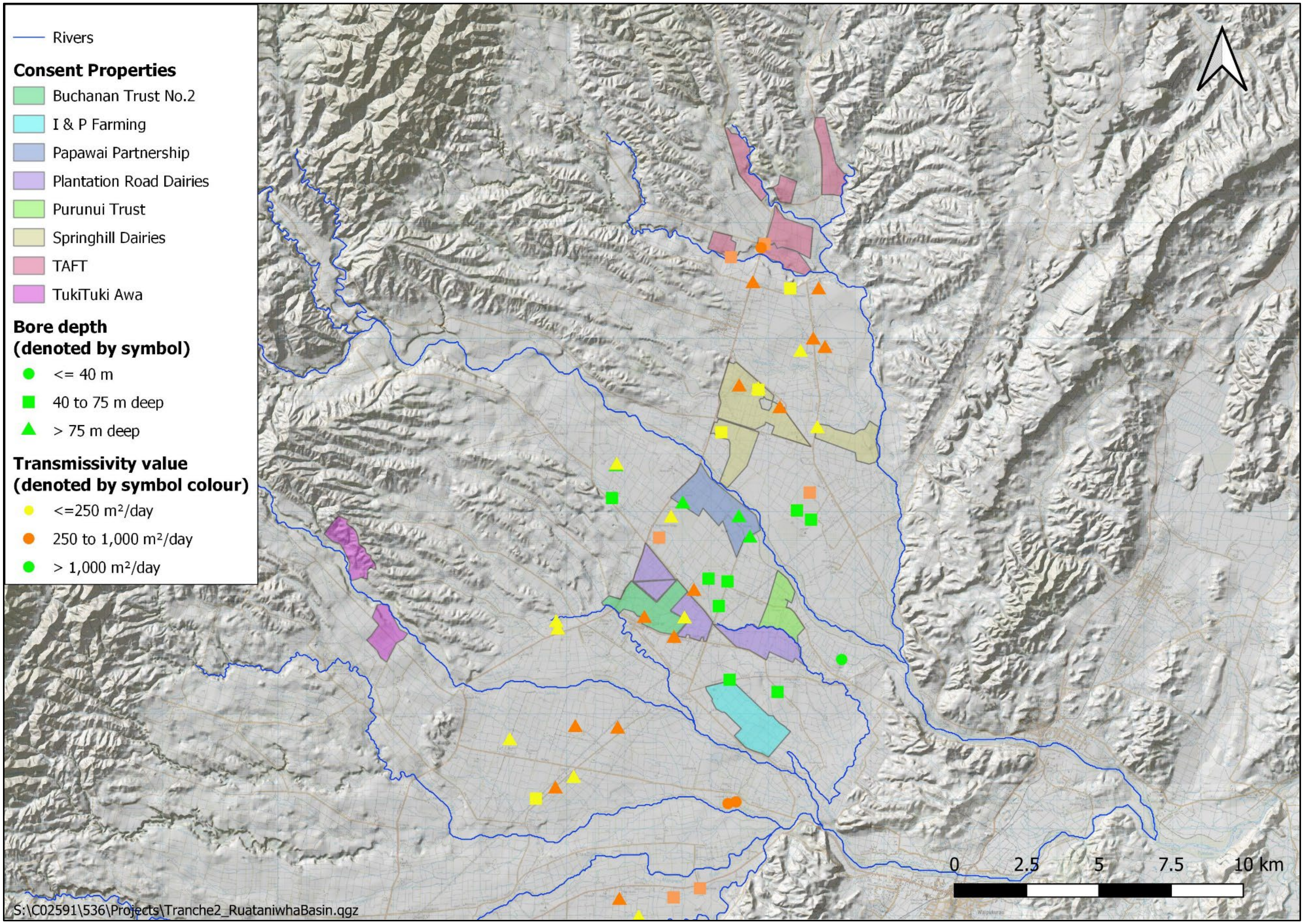

Figure 2: Location of Applicants' properties compared to the location of nearby pumping tests.

7.7 I note that some data from pumping tests has been used in the model construction which may help to constrain the modelled aquifer parameters and a map showing the location of pumping test data compared to the location of the Applicant's properties is provided in Figure 2. In some areas, for example the Papawai Partnership property, there appear to be several aquifer tests available, which help to constrain the model to observed data in that area, but in other areas, such as around the I & P Farming property and the Purunui Trust property, there is less nearby data. However, it should be noted that the results from the pumping tests typically represent a relatively small area around the bore, both vertically and horizontally. In the model, these results have been applied to the whole thickness of the strata at that location, which will vary in reality, leading to uncertainty in effects. For example localised effects such as well interference will vary depending on the aquifer properties at the depth of the Tranche 2 bores and the existing bores. I have the following key concerns with the model calibration:

(a) In terms of flows, the model is only calibrated to streams flows close to the downstream edge of the basin (i.e. the basin outlets). The model is not calibrated to flows in streams that occur within the basin.

(b) Although information regarding the pattern of streamflow gains from, and losses to, groundwater within the basin is available (from HBRC), this information was not used to calibrate the model. A comparison between the modelled representation of these data are presented in Weir (2022) which indicates that the model tends to over represent the observed scale of losses from streams within the basin and under represents the scale of observed gains to streams within the basin. Overall, these discrepancies make little difference to calibration of the model at the basin outlet points (i.e. they will cancel each other out) but these differences will affect estimates of the aquifer and streambed parameters within the basin. In turn, this will affect the estimates of stream depletion effects in local streams due to pumping within the basin.

(c) I have also compared the pattern of modelled gains and losses within the rivers and streams in the model to observed data. Observed data for gains and losses is available from HBRC (Johnson, 2011) and, for example, indicates that the Tukituki River consistently loses throughout its length within the basin. However, in the Applicant's steady state average model, the Tukituki River variably loses and gains along its length within the basin. Whilst any model will include some areas of mismatch particularly along small individual reaches, I would expect the steady state model to reasonably represent the typical pattern and direction and magnitude of loss or gain across longer average reaches, on average. This does not appear to be the case which is likely due to the fact that the model is not calibrated to flows within the basin, despite this data being available.

(d) With regards to groundwater levels, the steady state model is calibrated to average groundwater level observations from a range of bores across the basin but it appears that not all of these groundwater levels observations were captured at similar times. For example, some bores that were recently installed by HBRC have a dataseries from around 2015 to the present data, whereas others include data from the 1980s to 2012. Therefore, it is not clear what the 'average' groundwater levels represent. Given the current declining trend in groundwater levels in many of the long term bores, calibration to 'average' groundwater levels in bores with such a wide range of groundwater level data may be inaccurate and will lead to uncertainties in the model parameters and subsequent predictions.

(e) I note that the groundwater abstraction rates used in the steady state model are estimates and it is not clear exactly how they are calculated (I have assumed that this is via the Irricalc model), or whether they realistically represent the abstraction rates that correspond to average groundwater levels (to which the model is calibrated). Weir (2022) indicates that groundwater abstraction represents around 10% of the total water balance in the model and is therefore an important aspect. This uncertainty in the inputs to the model (i.e., groundwater abstraction rates) will create further uncertainty in the model predictions.

(f) For example, in Weir (2022) the steady state water balance indicates the modelled long term average groundwater abstraction is around 0.8 m^3/s, or around 25 x 10^6 m^3/year. In comparison, the actual water use data between 2012 and 2022 shown in Figure 1 of my evidence is around 15 x 10^6 m^3/year. Therefore, this input to the groundwater model is not likely to reflect actual groundwater use and calibrating the groundwater model to observed groundwater levels that, in reality, reflect a lesser degree of abstraction is likely to result in errors in the model parameters and uncertainty in any further predictions.

(g) A similar issue is likely to arise with respect to surface water abstractions and streambed conductance parameters.

(h) Calibration of the transient model is strongly influenced by the calibration of the steady state model. As noted above, the transient models only represent a range of groundwater levels based on estimated groundwater abstraction rates. Based on the information provided by the Applicants, in some cases the observed groundwater levels appear to fall within the range predicted by the model, but in other cases, the model fails to represent the observed range of groundwater levels with the observed range of groundwater levels much greater than the modelled range. In my opinion, this does not provide confidence that the model can represent the impacts of groundwater abstraction on groundwater levels in all areas.

(i) The Applicants have provided sets of calibration statistics for the model and indicate that these demonstrate that the overall model is suitably calibrated. Whilst the statistics are helpful, I also note that there have been several iterations of the model during the application process. All the model versions have been presented as showing a satisfactory calibration based on the statistics but use a range of different model parameters. Again, in my opinion, this does not provide confidence that the model can provide robust predictions of groundwater abstraction impacts if a range of aquifer parameters can be used to calibrate the model, unless it is shown that this range does not impact on the model predictions. I comment further on this aspect of the model in subsequent paragraphs of my evidence.

(j) I also note that on a number of plots provided by the Applicant (Weir, 2022) that compare the modelled and observed groundwater levels, a note is included commenting that changes in stockwater race flows may have contributed to a decline in groundwater levels that is not shown in the model. In my opinion, if the stockwater races are a sufficiently large component of recharge to the groundwater system to change groundwater levels in bores such as 1426 (screened from 38 m below ground level (bgl) to 44 m bgl and located around 2.5 km west of Ongaonga), they should be included in the model recharge package. However I also note that the bores where the cessation of stockwater race flows are noted show a steady decline with no obvious change before or after the stock water races are reportedly switched off.

(k) In Figure 3 of my evidence I have shown a plot of the modelled and observed flows at the Tukituki River Tapairu Road monitoring site (i.e. at the basin outlet). This plot was generated by the HBRC surface water science team. The flows are shown as a flow duration curve, i.e the percentage of time that a flow is exceeded across a flow record. These plots are a standard means of assessing whether a model represents an observed flow record. As Figure 3 shows, the match is not particularly good, particularly between the 20th and 90th flow percentiles, even allowing for up to 30% errors in the observed flows. I have shown this plot to highlight that the statistics as presented by the Applicants do not always show the whole picture of model to observed misfits.

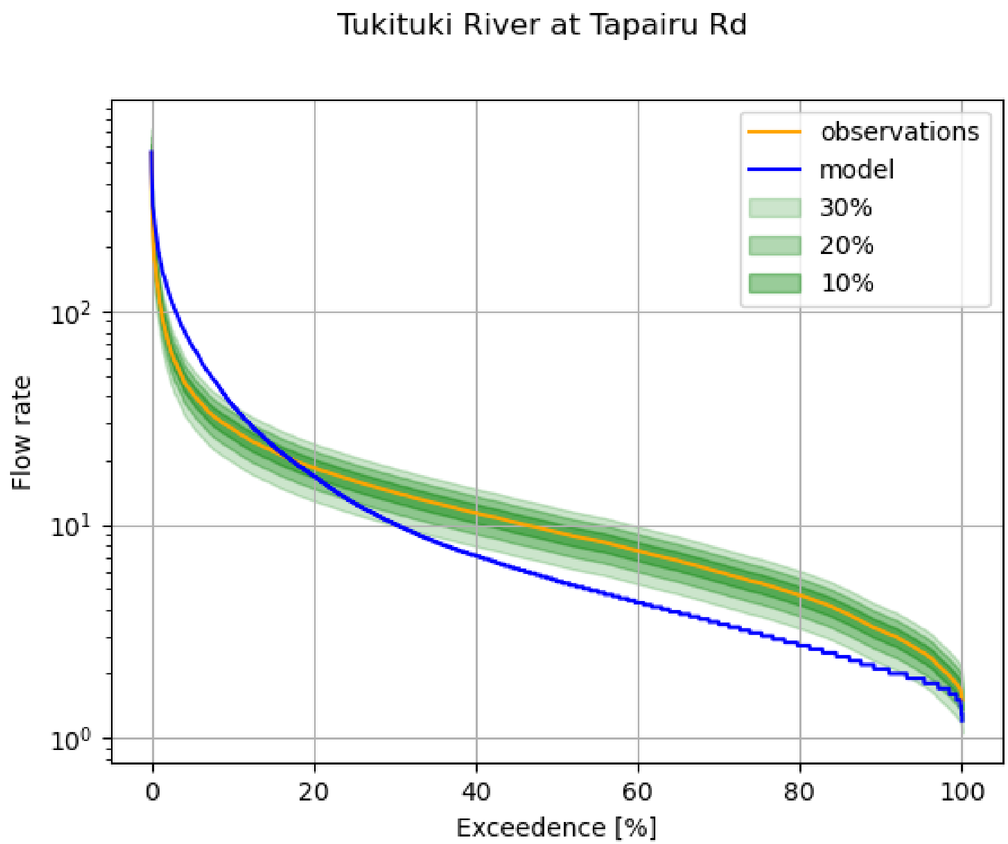

Figure 3: Comparison of modelled and observed flow duration curves for the Tukituki River at Tapairu Road. Flow rates are shown in m^3/s.

7.8 Because of the mismatch between actual abstractions and the abstraction rates used in the model, the model is not, in my opinion, calibrated to the extent that it can reliably predict groundwater levels or stream flows within the basin. Even where the model appears to match the observed data there will be uncertainty because the model is based on inaccurate abstraction data.

7.9 The Applicants have undertaken some analysis to help quantify the level of uncertainty in the model, but this does not extend to predictions from the model (i.e. the impacts of the Tranche 2 abstractions).

7.10 The uncertainty analysis carried out by the Applicants (described in Weir, 2022) based on the steady state model is helpful and indicates that the model calibration exercise has reduced the uncertainty of some parameters and, consequently that the range of possible groundwater levels and flows due to the uncertainty in the parameters is also reduced. However, I note that this uncertainty assessment does not allow for the uncertainty in the abstraction rates applied to the model; it appears to only allow for uncertainty in the model hydraulic conductivity, riverbed conductance and general head boundary terms. In my opinion, this is a key shortcoming of the uncertainty assessment. Furthermore, the uncertainty assessment is only based on the steady state model and does not consider the uncertainty within the transient model and does not assess the predictive uncertainty of the model.

7.11 The Applicants note that the uncertainty assessment shows that that predictive uncertainty in average groundwater levels is between ±0.2 to 1.3% and that the predictive uncertainty in average river flows is between ±0.9 to 1.7%. It is important to highlight that

(a) These estimates are based only on a steady state model that is calibrated to groundwater levels reflecting actual abstraction, while the model uses estimates of abstraction based on an Irricalc model.

(b) These estimates are only applicable to the groundwater level observation sites used for model calibration. These estimates cannot be extrapolated to other locations within the model area where the uncertainty could be much greater and has not been assessed by the Applicants.

(c) As noted above, the uncertainty assessment also does not allow for the inaccuracies in the abstraction volumes assumed for the model and in my opinion, these uncertainty estimates are likely to result in underestimates of the true uncertainty within the model.

7.12 I agree with the Applicants that using the model to estimate changes in groundwater levels and river flows reduces the uncertainty. However, I do not agree that the uncertainty is largely eliminated. For example, in broad terms the uncertainty analysis carried out by the Applicant set a possible range of parameter values for the uncalibrated model (although the range was based in part on the calibrated model), then looked at how model calibration reduced the possible range of model parameter values and then used that reduced range to estimate model uncertainty. However, because the uncertainty in groundwater abstraction rates was not included, the uncertainty analysis implied that calibration of the model reduced the range of possible parameter values by more than actually occurred. Therefore, the subsequent estimates of uncertainty presented by the Applicant are smaller than they should be and the modelled change in groundwater levels and surface water flows therefore still suffers from uncertainty that, in my opinion, is greater than required for these assessments.

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7.13 The Applicant has also undertaken some sensitivity analysis to investigate the effect of a wider range of aquifer parameters on the changes in flows at the basin outlets. This work included applying global multipliers to the model parameters of 0.1 and 2. In general, although the exact magnitude of the effects varied as a result of applying the global multipliers, the direction of effect on low flows at the basin outlets remained similar. These results help to provide confidence in the ability of the model to predict the effects of the Tranche 2 abstractions and augmentation on flows at the basin outlets. However, this is reliant on the augmentation water reaching and remaining in the receiving waterways above the low flow sites.

7.14 In my opinion, the model can effectively be used to:

(a) Estimate changes in the low flow regime at the surface water calibration points at the basin outlets, because the model appears to reasonably simulate low flows at those locations (noting Figure 2, above).

(b) Provide some information on the likely direction of changes in flows in other tributaries across the model area which are not represented as calibration points in the model or not represented in the model. I do not believe that the model can be relied on to provide specific estimates of the magnitude of the changes in flows in those tributaries.

(c) Estimate the general effect of increased groundwater abstraction on groundwater levels across the basin. However, I do not believe that the model results should be used to provide specific values of the drawdown interference effects arising from the Tranche 2 applications at specified locations, unless this matches well with local aquifer test data.

7.15 I note these comments are in line with those of the external peer review of the model (Durney, 2022).

8. ASSESSMENT OF EFFECTS

8.1 The assessment of effects provided by the Applicants covers the following areas with respect to groundwater related effects:

(a) Effects on existing bores due to drawdown interference
(b) Effects on river flows

8.2 I have discussed each of these effects in the following sections of my evidence.

9. EFFECTS ON EXISTING BORES

9.1 To determine effects on existing bores, the Applicant has used the following overall approach.

(a) They have calculated the difference between the top screen elevation in the bore and the static water level to provide an initial estimate of the available head in each bore. The static water level elevation appears to be as provided on the drillers log for the bore.

(b) From this initial estimate of available head, 1 m is deducted to allow for the length of a pump in the bore, together with an estimate of seasonal water level variations to provide an estimate of the remaining head in the bore.

(c) The predicted drawdown due to the Tranche 2 takes is deducted from the remaining head. Where the predicted drawdown is greater than 20% of the remaining head, the bore was deemed ‘affected’.

9.2 Where some data was not available, assumptions were made, for example where data regarding the top screen elevation was missing the total bore depth was used and where no static water level information was available, this was estimated from nearby bores.

9.3 I note that use of the static water level information as provided by HBRC on the well card means that static water level information is based on a wide variety of dates and times of year. Where a static water level was provided based on data from winter in the early 1990’s, for example, that would result in a greater available drawdown compared to a bore where the static water level was derived from a recent measurement in a recent summer. No consideration of this error has been provided by the Applicant. In my opinion, it would be better to use a more consistent approach, for example basing this on water levels from a piezometric survey across the basin.

9.4 In my original review of the application documents I raised some key concerns regarding the drawdown interference assessment. These included:

(a) Estimating drawdown interference due to the Tranche 2 takes based only on the model results and based on two model layers (whereas affected bores occur within a range of different model layers). All bores less than 50 m deep are treated as though they are in model layer 1, while all bores more than 50 m deep are treated as though they are in Layer 6 of the model.

(b) Inaccurate estimation of seasonal water level changes to estimate available drawdown in existing bores

(c) No consideration of cumulative effects from the existing Tranche 1 takes

(d) Use of an arbitrary threshold of 20% for drawdown interference effects.

9.5 The Applicants have provided some further information regarding these points, particularly around estimating drawdown interference based on a representative model layer and also undertaking drawdown interference assessments on some existing bores based on site specific parameters.

Direct drawdown interference effects

9.6 The further information provided by Aqualinc (October, 2021) regarding site specific parameters and also estimating drawdown interference effects due to the Tranche 2 takes in representative model layers is helpful but it is only provided for a subset of bores; it would be helpful if it were provided for all the bores that are assessed to provide a consistent assessment. The most recent assessment provided by the Applicant (Rabbitte, 2022) does not appear to include this information.

9.7 For example, in the Applicants' drawdown interference assessment provided in 2020 (and not updated in Rabbitte, 2022) the direct drawdown interference effect in bore 16880 (screened from 25.2 m to 26.2 m, located just north of Ongaonga) due to pumping from the Tranche 2 takes is 0.16 m. However, in the most recent modelling report (Weir, 2022), drawdown interference effects due to the Tranche 2 takes in bore 16880 in summer are shown as around 2 m or more. Bore 16880 is not cited in the additional information provided by Aqualinc in October 2021. These inconsistencies mean that this aspect of the drawdown interference assessment is uncertain and further information should be provided to help confirm the drawdown interference forecast for different bores. This issue occurs across the Ruataniwha Basin, but I note that many bores in Ongaonga are around 20 to 40 m deep, and therefore it seems likely that the drawdown interference effects in this area may have been underestimated.

9.8 Aqualinc also notes that they have used peak flow rates from each bore, which represent extreme effects that are unlikely to occur. Although that may be correct, it is important to highlight that those are the effects that, if granted, the consents would enable. Therefore, to characterise these effects as extreme and less likely to occur is considered inappropriate in the context of assessing the potential environmental effects of the proposed take.

9.9 I also note that many of the bores that may be used for the Tranche 2 abstractions are from bores that are not yet drilled. The depth and exact location of these bores are therefore unknown and cannot be assessed with accuracy until they are installed. Therefore, any estimated effects, particularly based on a numerical model are not well defined unless they occur close to existing bores with pumping test data included in the model. I note a condition is proposed to require a pumping test on new bores drilled and a well interference assessment, but it is not clear what will occur if the results of the assessment are inconsistent with the assessment presented here. It also only covers bores within 2 km of the pumped bore which is a relatively small radius considering the magnitude of these takes and that the model indicates effects will occur across the basin.

Seasonal water level changes and cumulative effects.

9.10 The Applicants indicate (Rabbitte, 2022) that the seasonal drawdowns observed in monitoring bores are an accurate reflection of the cumulative effect due to pumping throughout the basin. This is correct at the location of the monitoring bore, however at locations away from the monitoring bores, cumulative pumping effects (i.e. outside natural seasonal water level changes) may be greater than observed at individual locations. This is not considered in the drawdown interference assessment and therefore the available drawdown in individual bores may be much less than estimated by the Applicants. In addition, as outlined above, no allowance has been provided for increases in the use under existing Tranche 1 groundwater consents.

9.11 In some cases the estimated seasonal and cumulative drawdown effects estimated by the Applicants could also be less than estimated by the Applicants. This is important as because in some cases the Applicant has identified ‘inefficient’ bores based on a negative available head on the basis of estimated seasonal and cumulative drawdown. This issue is also compounded by the use of a range of static water level measurements for bores, as noted in my evidence above (paragraph 9.3). Therefore, in some cases bores may be incorrectly identified as ‘inefficient’.

9.12 To determine the seasonal water level change and cumulative effect at different depths across the basin, the Applicant has used HBRC monitoring bores of different depths across the basin. For example, they have used six bores in the 0 to 9 m depth range to extrapolate seasonal variations and cumulative effects across the basin. A map showing the locations of the six bores is shown in Figure 4.

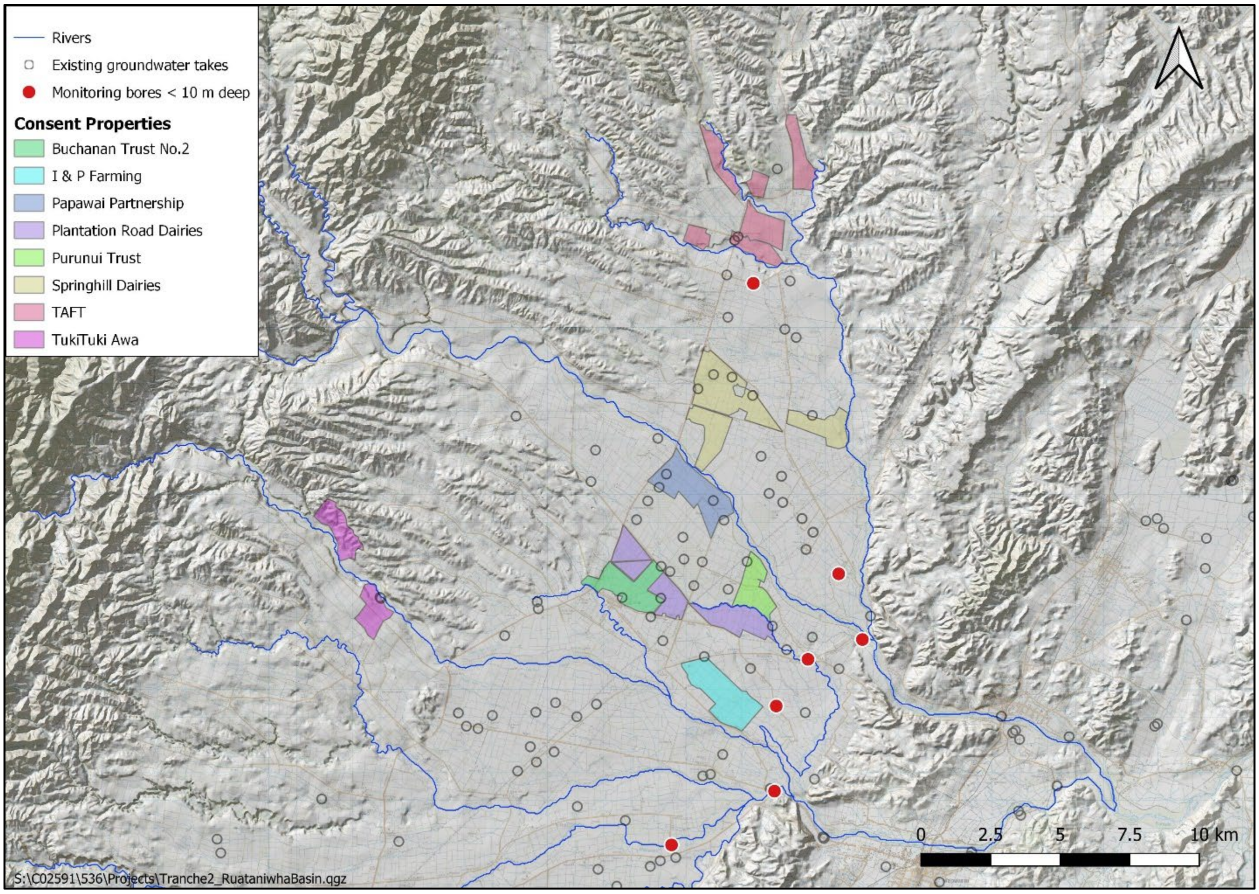

Figure 4: Location of monitoring bores between 0 and 10 m deep.

9.13 As is readily apparent from Figure 4, extrapolating the observed seasonal changes in the monitoring bores between 0 and 10 m deep to other shallow bores across the basin is not appropriate because of the large intervening distances and will lead to incorrect estimates of the seasonal and cumulative changes in other shallow bores located away from the observation bores.

9.14 Similar issues are present with bores assigned to other depth intervals although I note that there are generally more observation bores that represent strata that is more than 50 m deep (Figure 5). However, there are concentrations of abstractions where no deeper monitoring bores are present (for example north of the Waipawa River) and where the seasonal and cumulative drawdown effects are not likely to be correctly estimated using the Applicants approach.

9.15 In my opinion, the well interference assessment has some crucial flaws and is not likely to have identified bores that could be adversely affected by the Tranche 2 takes. I note that a condition is proposed where an interference assessment is required for new bores, although it is not specified how this would be carried out. I also note from the proposed conditions (Condition 5) that the Applicant has offered to contribute to improving security of supply for up to 10 shallow bores and 10 shallow bores not recorded on the HBRC well database as a means of mitigating drawdown interference effects. I agree that this could be helpful for some shallow bores but would not help those deeper bores impacted by the Tranche 2 takes, nor is it clear that the number of bores that may be assisted will be adequate.

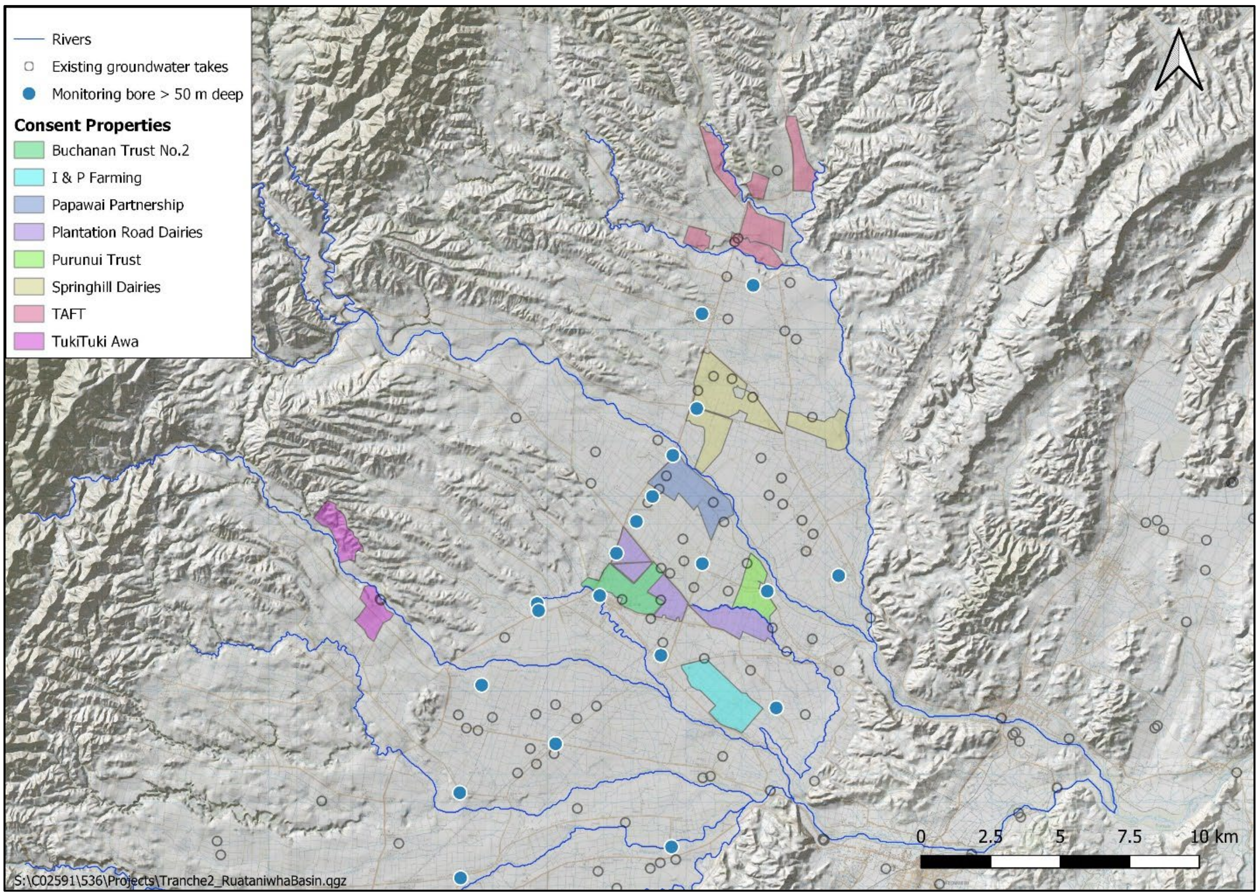

Figure 5: Location of monitoring bores >50 m deep.

20 % threshold of effects

9.16 As noted above, the Applicant has used a 20 % threshold to determine whether effects from the Tranche 2 takes are more than minor or warant further investigation. They note that the 20% threshold is based on the approach used by Environment Canterbury. However, the approach used by Environment Canterbury is not the same as used by the Applicant and is generally more conservative.

9.17 For example, under the Environment Canterbury approach 20% of the available drawdown in a bore is reserved for cumulative interference effects. The available drawdown is determined as the difference between the static water level and the top of the screen plus a two metre allowance for a pump (compared to 1 m allowed by the Applicants here). For small domestic supplies a 1 m allowance for a pump is probably reasonable, but for larger takes, a 2 m allowance would be more appropriate.

9.18 The cumulative drawdown effect from all existing bores is explcitly calculated based on local aquifer parameters and this cumulative drawdown effect is deducted from the 20% of available drawdown for interference effects before the direct effects from a new take are considered. In contrast, the Applicant's approach is to allow 20 % of available drawdown exclusively for the effects of the Tranche 2 applications.

9.19 Therefore, whilst the additional information is helpful, it does not address all of the concerns raised in our review from September 2021. As a result, concerns on the appropriateness of the drawdown interference assessment remain. In my opinion, these effects, particularly on shallow bores, are not defined with sufficient certainty for the magnitude of these applications.

9.20 The Applicants have also provided some further information regarding the bores that they have identified as being potentially affected by the proposed abstractions (Rabbitte, 2022). In the comments provided, the Applicants have noted that where effects are identified in some bores, the pumps in the bores could be lowered to be within the screened interval of the bore, which may be a means of mitigating the impact of the drawdown interference assessments.

9.21 I do not believe that it is appropriate to suggest this mitigation approach. In general, a pump is located above the screened interval of a bore. Setting the pump into the screened interval of a bore is generally not recommended because it can result in high flow velocities into the pump intake. The high flow velocities can lead to cavitation issues which can cause significant damage to a pump impeller (Sterret, 2007) Practically, the screened interval of a bore can also be narrower than the cased interval, which means that the submersible pump may not fit. In some cases these issues can be addressed, but any solution would be on a case by case basis and may not be suitable for all bores.

9.22 In addition to the information provided by Aqualinc, some further information has also been provided by Bay Geological Services to assess the proposed discharge of augmentation water by Papawai Partnership. Papawai Partnership have proposed to discharge augmentation water to a 1.2 m diameter bore located around 560 m from the Waipawa River. The s92 request requested information on mounding effects and how effectively the proposed discharge would augment flows in the Waipawa River. An assessment of mounding effects has been provided, but no assessment of how the discharge will impact flows in the Waipawa River has been provided.

9.23 The mounding assessment is based on a simple analytical solution using Theis and based on local aquifer parameters. In general, this style of assessment is likely to result in a conservative estimate of mounding effects as the effect of the Waipawa River is not accounted for. The assessment indicates that mounding effects could reach around 0.4 m in existing shallow bores, which, based on a reported depth to water of around 4 to 5 m is not expected to result in adverse effects on or near those bores. We note that it would be helpful if the groundwater levels in the existing bores were compared with the likely stage elevation in the Waipawa River to confirm whether the river is likely to lose or gain in this reach. If the river loses water in this reach, the discharge may be less effective at maintaining low flows. I note that in the groundwater model, the discharge is simulated as occuring directly into the the river.

9.24 Likewise, Purunui Trust have also proposed to discharge their augmentation water via a shallow bore and similar issues with their discharge could occur. However, no assessment of the potential for mounding effects has been provided for their discharge.

Effects on registered drinking water supplies

9.25 I have also considered the potential effects on the registered drinking water supplies in the area and Table 2 summarises the supplies (as provided by HBRC).

Table 2: Registered Drinking Water Supplies				
Supply Name	**Supplier**	**Supply Population**	**Supply Source**	**HBRC Comment**
Tikokino School	Tikokino School	60	Bore	Neighbourhood - Specified self-supplier. From HBRC well no. 16011, screened from 56.79 m, and 60 m deep.
Ongaonga School	Ongaonga School	150	Bore	Small - Specified self supplier Unclear which HBRC well is used: Assumed to be HBRC well no. 5359, drilled 2005 to 37.5m in depth.
Ongaonga Hall & Playcentre	Central Hawke's Bay District Council	40	Bore (Bridge St bore)	Neighbourhood- Specified self supplier Assumed to be from HBRC well no. 10929, screened from 9 m in depth.
Takapau (TAK001)	Central Hawke's Bay District Council	570	Bore (Meta Street bore)	On-demand supply for Takapau Township From HBRC well no. 1762 under AUTH-121511-01. Well 1762 is 48.9 m deep, screened from 31.08m.

9.26 The effects due to the Tranche 2 on the bore for Tikokino School (16011) are estimated as up to 5.64 m, which is expected to leave around 30 m of available head in the bore based on the Applicants assessment. Generally, smaller self supply bores do not use large volumes of water or pump at high rates and I would expect that whilst the drawdown interference effect of 5.64 m is large, it will not restrict the use of the bore. However, I note the uncertainties around cumulative effects from the Tranche 1 abstractions as estimated by the Applicant, as well as natural seasonal variations and it could require that the pump in the bore is lowered to accommodate the lower water pressure, assuming that this is practical.

9.27 The Ongaonga School bore (5359) is 36 m deep with a static water level of around 6.5 m below ground level. Because this bore is less than 50 m deep, the Applicant has estimated drawdown interference effects of up to 0.16 m due to the Tranche 2 takes. The drawdown interference effects on this bore may have been underestimated by using the shallow layer drawdown, but generally, interference may be accommodated within the available drawdown in the bore. However, the pump may need to be lowered (if this is practical) and similar issues as outlined above with the Tikokino bore also need to be considered.

9.28 Ongaonga Hall & Playcentre has a bore (10929) which is relatively shallow. Drawdown interference effects in this bore are predicted by the Applicant to be around 0.17 m, which may not restrict the use of the bore. However, there is limited available head in the bore so this may still be adversely impacted.

9.29 The supply for Takapau township is from bore 1762 and limited drawdown interference effects are predicted in this bore due to its depth just under 50 m. However, the bore is located towards the south of the basin and away from the main areas of abstraction (including the Tranche 2 takes) and in general, I would not expect significant drawdown interference effects due to the separation distance to the Tranche 2 abstractions.

10. EFFECTS ON MAIN RIVERS AND STREAMS

10.1 As discussed in section 7 of my evidence, the model is not calibrated to flows within the Ruataniwha Basin. It is only calibrated to flows at the basin outlets, together with some groundwater levels within the basin. Furthermore, the model only generally represents groundwater levels within the basin, such that the model represents observed levels within an 'envelope' of pumped and unpumped model scenarios. It is not calibrated such that it can necessarily represent the effect of pumping on flows in smaller streams and rivers within the basin with a reasonable degree of certainty.

10.2 Aqualinc (Weir, 2022) have provided a table of modelled stream depletion effects on the major streams and rivers within the basin, both upstream and downstream of the augmentation locations and noted that generally, these are locations that are expected to experience the greatest and least (respectively) stream depletion effects. They have commented that the negative flow differences in the 7 day MALF are 'very small (1 to 10 L/s), less than both model and measurement precision' and represent 'negligible' differences.

10.3 However, in the context of the streams that are affected, these effects could represent a significant proportion of the flow. For example, Aqualinc (Weir, 2022) have estimated stream depletion effects on the Mangaoho Stream upstream of the augmentation due to pumping from the Springhill Dairies abstraction as up to 8 L/s, yet based on NIWA flow modelling, the 1 in 5 year low flow in this reach of the Mangaoho Stream is around 50 L/s. I note that the effect from Springhill Dairies would be in addition to any existing effects.

10.4 Therefore, in my opinion, there is uncertainty in the assessments provided by Aqualinc and effects on smaller streams and rivers are potentially significant relative to the flows in those streams.

10.5 Information provided by the Applicant indicates that Ongaonga Stream goes dry at times (for example after the Applicants site inspection in March 2021). Upstream of the Buchanan Trust discharge into the Ongaonga Stream, the Applicant has predicted no effect on flows in the Ongaonga Stream and no effects are predicted downstream of the discharge. I note that the Tranche 2 takes and discharges in reality may change the pattern of drying in the stream and comment on the impacts of these effects is provided in the evidence of Laura Drummond. If the stream were dry below the discharge point, the augmentation may not be effective in mitigating effects on minimum flows at the downstream flow sites.

10.6 One further issue regarding the effect of augmentation is that the modelling carried out by the Applicants is based on all the abstractions occurring together and all the augmentation discharges occurring simultaneously. However, the augmentation volumes for each Applicant do not appear to be set to offset each individual's stream depletion effect but instead are set to offset the combined stream depletion effect of the takes. The application also notes that irrigation and augmentation volumes will increase progressively across each Applicant's property as irrigation develops.

10.7 Therefore, there is some further uncertainty in how the augmentation will work in practice as the irrigation development will be staged, but the staging is unlikely to be uniform across all the Applicants' properties. Consequently, as some of the Applicants provide a greater proportion of the augmentation water compared to others, the volume of augmentation water available will not be uniform and may not always be sufficient to address the stream depletion effects at some locations until, and if, full development occurs. Some consideration of this issue would be helpful together with an approach to address this issue should it arise.

10.8 I also note that it would make sense for Red Bridge to be included in the conditions as a flow trigger, which would be consistent with all other takes being tied to Red Bridge in addition to their more local site. The assessment undertaken by the Applicants/Aqualinc has been that the Tranche 2 takes will have no significant impact on the number of days when flows are below the trigger (assessed as 6 days over the simulated period) with mitigation based on the minimum flows at the other proposed sites. However, at those times when flows are below the minimum flow at Red Bridge and not below minimum flows at the other sites, the flows at Red Bridge would be lower than if the Tranche 2 takes were not occurring without augmentation.

11. EFFECTS ON WATER QUALITY

11.1 Deep groundwater in the basin that will be abstracted by the Applicants has different chemical characteristics compared to the surface waterways into which it will be discharged. Therefore, the is some potential for impacts on water quality due to the discharge. No assessment of effects has been undertaken by the Applicants of this effect. It is understood this is because the discharge of the water has been considered to be a permitted activity by the Applicants, however it may require separate consent as a discharge of contaminants, as identified in the Section 42A Officer's Report prepared by Paul Barrett.

11.2 Water quality data for the water abstracted by the Applicant's bore has not been provided with the applications. However, some data is available from the HBRC State of the Environment monitoring and also from other one off water quality surveys in the area.

11.3 In general, water quality from deeper bores in the area shows a more evolved chemistry compared to surface water. This means that it generally has higher concentrations of some chemical parameters including metals, particularly iron and manganese, as well as higher concentrations of nutrients such as ammonia and dissolved reactive phosphorus.

11.4 Based on sampling results from the HBRC SoE monitoring network (HBRC, 2018) and data collected as part of one off survey in the Ruataniwha Basin (Morgenstern, 2012) there are a number of parameters that show elevated concentrations in deep groundwater, including:

(a) Iron (up to 1.4 mg/L, bore 3702, 123 m deep)

(b) Manganese (up to 0.3 mg/L, bore 3702, 123 m deep)

(c) Ammonia (up to 1.8 mg/L, 1381, 58.4 m deep)

(d) Dissolved reactive phosphorus (up to 0.26 mg/L, bore 16478, 58 m deep)

11.5 Concentrations of these parameters are generally very low in surface water. In addition, the data also show that dissolved oxygen concentrations are typically relatively low in deeper bores compared to surface water concentrations.

11.6 The maximum discharge rates from the augmentation bores are up to 189 L/s (TAFT, into the Mangaonuku Stream) and 103 L/s (Plantation Road Dairies, into the Kahahakuri Stream). Relative to the flows in the major rivers (i.e. the Waipawa and the Tukituki Rivers) these discharge rates are small. However, the discharges are relatively large in comparison to the low flows in the smaller rivers and streams, such as the Kahahakuri Stream (7D MALF of 260 L/s).

11.7 The dilution effect within these smaller streams and rivers is therefore limited and it is possible that the discharges could increase concentrations to greater than the Drinking Water Standards guideline values (for example the guideline value for manganese is 0.04 mg/L). Downstream users of surface water for domestic supply could therefore be affected by the discharge.

11.8 Some assessment of the possibility of this effect should be provided. Ms Drummond provides further comment on these potential surface water quality effects and resulting ecological impacts in her evidence.

12. EFFECTS DUE TO CLIMATE CHANGE

12.1 The Applicant has provided some consideration of the potential effects due to climate change (Weir, 2022) based on alterations to some modelled inputs including the recharge input to the model (via Irricalc), abstractions from the model (via Irricalc outputs) and upstream stream / river inflows to the model (i.e. where the major rivers enter the basin).

12.2 The Applicant has then rerun the groundwater model to estimate the effects of the Tranche 2 abstraction on low flows in rivers at the basin outlets. In general, this appears to show that the proposed augmentation can minimise the change in low flows at the basin outlets although there would be greater changes in average flows because more groundwater pumping would occur. Although it is not clear from the Applicant's comments, I have assumed that there would be an overall reduction in the low flows under climate change, but the proposed augmentation to compensate for the Tranche 2 effects can minimise the change in flows.

12.3 No comment is provided with regards to the potential effects of additional pumping on groundwater levels and it would be helpful if some comment on this aspect could be provided. Under climate change, recharge to the Ruataniwha Basin is expected to reduce (Mourot, 2022) and therefore groundwater levels will reduce as well as groundwater discharge to the streams and rivers that cross the basin. The Tranche 2 abstractions will add to this reduction in groundwater levels, and possibly to a greater degree because of greater irrigation demand under climate change.

12.4 Accurately accounting for the potential impacts of climate change in the future is complex, however it is reasonable to expect that irrigation demand will increase as the Ruataniwha Basin becomes drier (Mourot, 2022). Therefore, groundwater abstractions under the proposed Tranche 2 consents may be greater than estimated by the Applicant based on their climate series from 1972 to 2012. As a result, impacts could increase beyond those currently estimated by the Applicant, compared to the current situation.

13. CONCLUSIONS

13.1 The consents for the Tranche 2 groundwater takes could, if granted, result in effects on the following:

(a) Effects on low flows in the major rivers that discharge from the basin (i.e. the Waipawa River and the Tukituki River) where minimum flow levels are set.

(b) Effects on smaller streams and rivers that occur within the basin and are tributaries to the Waipawa and Tukituki Rivers.

(c) Effects on existing bores around the proposed abstractions

13.2 In my opinion, the Applicants have adequately demonstrated that the impact of the proposed abstractions on low flows in the major rivers at the basin outlets and resulting effects on existing users' reliability can be offset by the proposed augmentation flows. Therefore, the impact of the proposed activities on existing users tied to low flows at these locations is likely to be small up to the 1 in 10 dry year event. However, in drier years, when impacts from the Applicant's abstraction would continue to occur there is unlikely to be sufficient augmentation water to mitigate the effects on low flows.

13.3 Assessments of the potential impacts of the abstractions on smaller streams within the model basin and on waterways upstream of the augmentation discharges are less well defined. The Applicants have provided estimates of the change in flow in these streams as a result of the proposed abstractions which indicate that impacts on flows in some streams could be relatively large compared to the low flow in the stream (i.e. more than 20% of the low flow in the stream). Furthermore, in my opinion, these estimates are uncertain and could be greater than shown by the Applicants. Comments on the impacts of the changes in flows on the ecology of the streams are provided in the evidence of Laura Drummond.

13.4 Effects on existing bores are uncertain and, in some cases, exceed the thresholds defined by the Applicants of 20% of the remaining drawdown after seasonal effects and considering the screened interval in each bore. In my opinion, the assessment provided by the Applicants is not sufficiently conservative given the uncertainties inherent in the data they have used and additional bores beyond those they have identified could also be adversely affected.

13.5 I also note that many (at least 50%) of the bores proposed for the Tranche 2 takes are not yet drilled and two of the discharges are proposed to occur via shallow groundwater bores located some distance from the rivers. The characteristics of these bores are unknown and the impact on stream flows is also not well defined leading to further uncertainty with regards to the effects of the proposed consents on the groundwater and surface water system.

13.6 I note that in my opinion, groundwater models are useful tools in helping to support decision making on the impacts of activities that change the groundwater environment, including related effects on surface water flows. All models are uncertain and acknowledgment and quantification of that is an important part of using a model to assist decision makers. If further information were to be provided to help address the uncertain aspects of the applications I have identified above, I recommend this should include:

(a) Updates to the model to allow for calibration to flows within the basin

(b) Further uncertainty analysis using the model to provide a more accurate range of possible effects on shallow water levels and deeper groundwater levels. This should explicitly include the uncertainties inherent within the synthetic abstraction dataset used to calibrate the model.

(c) Further consideration of the impact of changes in flows in smaller streams relative to the flow in those streams and the uncertainty in the predicted effects.

(d) Further consideration in the drawdown interference assessment to explicitly account for cumulative drawdown effects from other pumping that is already consented, beyond natural seasonal effects.

Neil Thomas

8 August 2022

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