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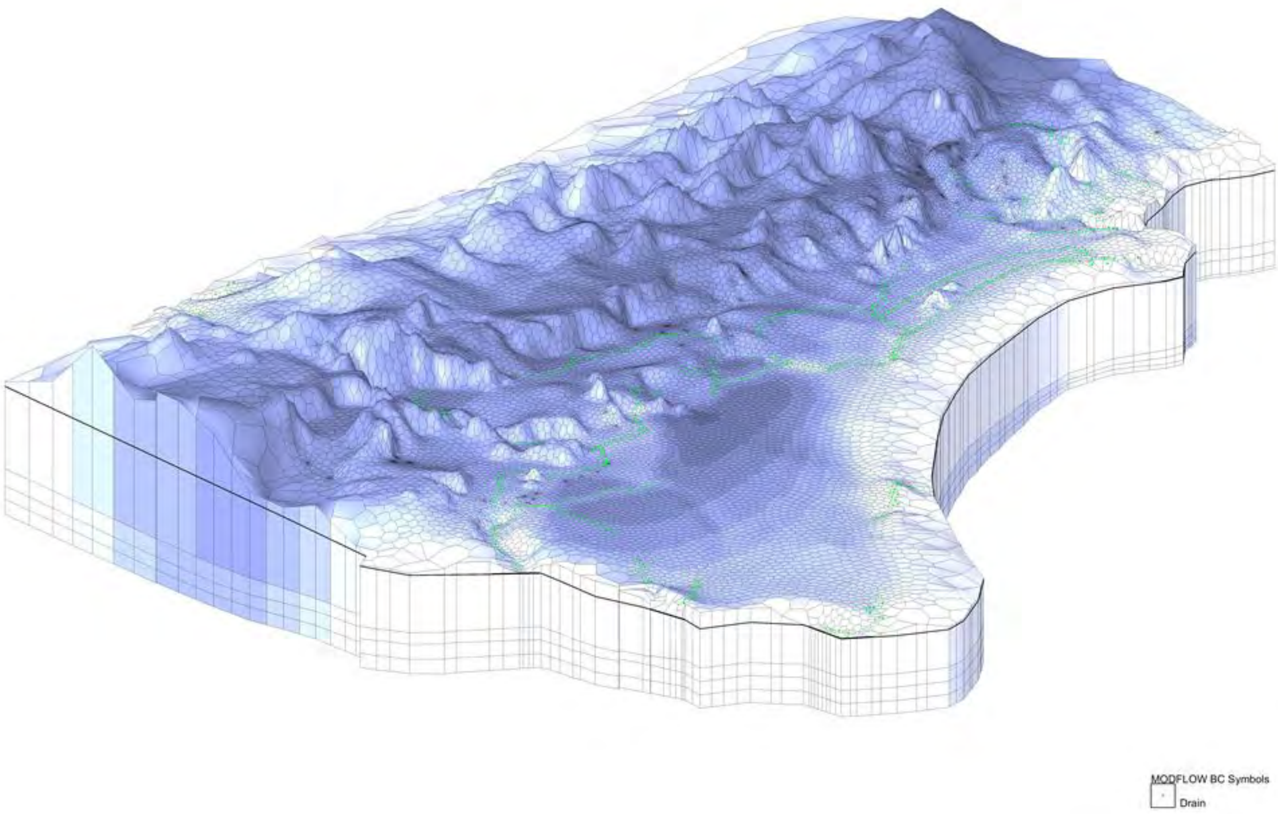
Irrigation Water Supply
Groundwater Take Consent Application

MOTUTANGI WAIHARARA WATER USER GROUP

WWA0026 | Final - Rev. 4

30 August 2017



Motutangi Waiharara Water User Group

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Document history and status

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1	28 April 2017	Draft for WUG approval	Jon Williamson	Jon Williamson	WWA
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1	28 April 2017	Draft for WUG approval	
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4	30 August 2017	Brydon Hughes (Land & Water People on behalf of Northland Regional Council).	

Contents

1. Introduction

1.1 History and Scope

The Northland Regional Council (NRC) were inundated with consent applications for groundwater takes for avocado orchard irrigation during the course of 2016 and had issued RMA section 92 requests for additional information to each applicant. The s92 requests were essentially seeking the same information, which required a comprehensive assessment of effects from each of the applicants. The NRC indicated they would likely hear all the applications at the same time and would require the effects to be assessed through the development of a groundwater model that was to include results from new test pumping information in both Motutangi and Waiparera sub zones. The groundwater model would also need to consider the cumulative effects of the existing consents and the applications that are subject to this application.

The Motutangi-Waiharara Water User Group (MWWUG) was formed to collectively fund the development of the groundwater model and Assessment of Environmental Effects (AEE) report. The membership of the MWWUG and the individual details of each applicant are summarised in **Section 2**.

This document comprises the summary AEE report and a companion technical reports documents the groundwater model developed.

1.2 Out of Scope

This document does not describe each water take individually and therefore does not include estimations of irrigation requirements or demonstrations of efficient use. The use requirements were provided by each applicant on the basis of historical usage or advice from Ian Broadhurst, who is the MWWUG coordinator and local orchardist. Typically, the average daily yield requirement for avocados in this area has been measured on local orchards in this area by Ian Broadhurst at 25 m^3 per canopy ha per day, and we understand this is the basis of the applicant’s water requirements in Error! Reference source not found..

1.3 Report Structure

This document outlines the potential effects on the environment as a result of the proposed groundwater takes, and is structured in the following manner:

- **Section 2** - describes the proposed activity including a summary of the proposed irrigation requirements.
- **Section 3** - outlines the assessment of the potential environmental effects resulting from the proposed abstractions;
- **Section 4** – provides a discussion on a proposed Groundwater Management and Contingency Plan framework to form part of the consent conditions; and
- **Section 5** - provides the conclusions.

2. Description of the Proposed Activity

2.1 Motutangi Waiharara Water User Group

This document has been submitted on behalf of the MWWUG, which consists of 18 individual applicants. All applicants are seeking a groundwater take resource consent from the Northland Regional Council. No applicants require a resource consent from the District Council.

For each applicant **Table 1** summarises:

- Their full name;
- Contact details;
- Postal address; and
- Owner/ occupier of land / water body.

Table 2 outlines the property location to which each resource application relates.

The address for service of documents for all applicants is as follows:

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Table 1. List of all applicants in the Motutangi – Waiharara Water User Group and their contact information

Applicant	Full Name	Email	Postal Address	Owner / occupier of land / water body
APP.038610.01.01	Mapua Avocados Ltd, C/o Murray Forlong	paula.chapman@touchcut.com	Mapua Avocados Limited, PO Box 302 608, North Harbour, Auckland 0751	Mapua Avocados Ltd.
APP.038471.01.01	Honeytree Farms Limited, C/o Tony Hayward	tonybigmountain@outlook.co.nz	64 Te Maika Road, Whangarei, 0173	HoneyTree Farms Limited
APP.038410.01.01	Georgina Tui and Mate Nickolas Covich	pirini.covich@xtra.co.nz	2786 Far North Road, Waiharara, RD4 Kaitaia 0484	Same as applicant name
APP.038420.01.01	Largus Orchard Ltd Partnership, C/o Murray Forlong	paula.chapman@touchcut.com	Largus Orchard Ltd. Partnership, PO Box 302 608, North Harbour, Auckland 0751	Largus Orchard Ltd. Partnership
APP.039332.01.01	Candy Corn Ltd, C/o Bryan Candy	bryaniancandy@gmail.com	3167 Far North Road, RD 4, Kaitaia, 0484	Candy Corn Ltd.
APP.038454.01.01	Elbury Holdings Limited, C/o Kevin and Fiona King	elbury@xtra.co.nz	345 SH1, RD2, Kaitaia 0482	Elbury Holdings Limited
APP.038328.01.01	Bernard Kim & Sheryl Dianne Shine	k-s.shine@vodafone.co.nz	231 Kaimaumau Road, Waiharara, RD 1, Awanui 0486	Same as applicant name
APP.027391.01.02	Ivan Anthony Stanisich	ias1@xtra.co.nz	40 Kaimaumau Road, RD 1 Awanui 0486	Same as applicant name
APP.038589.01.01	Neil & Alma Violet Thompson and Steven & Josephine Suzanne Thompson	motutangi@xtra.co.nz	38 Turk Valley Road, RD 4, Kaitaia 0484	Same as applicant name
APP.038650.01.01	Tony and Diane Hewitt	torch@xtra.co.nz	17 Camp Road, Waiharara 0484	Same as applicant name
APP.038591.01.01	Cypress Hills Ltd, C/o Alan Anderson & Carolyn Dawn Smith	andersmith10@hotmail.com	27 Turk Valley Road, RD 4, Kaitaia 0484.	Cypress Hill Ltd.
APP.039345.01.01	Ian McLarnon & Jason McLarnon	ianandgail@ihug.co.nz	100 Whalers Road, RD 4, Kaitaia 0484	Same as applicant name
APP.38732.01.01	Kathy Valadares	bellavitakb@gmail.com	3633 Far North Road, R.D.4 Kaitaia 0484	Norm Bryan (027 452 5762)
APP.038380.01.01	Daimen & Katherine Holloway	katherinebroadhurst73@hotmail.com	PO Box 18, Awanui 0451	Same as applicant name
APP.039381.01.01	Johno and Carol Brien (Lamb Road)	carol@stihlshopkaitaia.co.nz	3994 Far North Road, RD 4, Kaitaia 0484	Same as applicant name
APP.038513.01.01	Te Runanga o Ngai Takoto, C/o Rangitane Marsden	rangitane@ngaitakotoiwi.co.nz		Same as applicant name
APP.39244.01.01	Kevin and Dani Thomas	Dani@ihug.co.nz	565c Kimberley Road, RD 4, Kaitaia 0484	Same as applicant name

Table 2. Location of the property to which each application relates

Full Name	Property Address	Locality	Legal Description
Mapua Avocados Ltd, C/o Murray Forlong	3547 Far North Road	Motutangi / Pukenui	Lot 2, DP 373078 Sections 47,48,53,66,67,79,87,89-91 PT 13,51
Honeytree Farms Limited, C/o Tony Hayward	2642 Far North Road	Waiharara	Lot 2, Section 53, Blk IV Opoe SD, NA 82C/244
Georgina Tui and Mate Nickolas Covich	2786 Far North Road	Waiharara	Sections 5,9,10,16,19,27,30 - 32,34,39, Block IV Opoe SD
Largus Orchard Ltd Partnership, C/o Jason McLarnon	416 Heath Road	Waiharara	Secs 53 ,118 Pt Sec 38 Blk V Opoe SD
Candy Corn Ltd, C/o Bryan Candy	3167 Far North Road	Pukenui	Lot 1 DP 452703
Elbury Holdings Limited, C/o Kevin and Fiona King	226 Kaimaumau	Kaimaumau	Lot 2 DP 13971 Lots 1 4 DP 22761 BLK V Opoe SD Blk IV Ranganunu Sd
Bernard Kim & Sheryl Dianne Shine	232 Kaimaumau Road	Waiharara	Part Lot 1 DP 13971 Kaimaumau Road
Ivan Anthony Stanisich	479 Heath Road	Waiharara	Lot 1 DP 129554 Sec18,73,101 Pt Secs 75, Lot 1 DP 322899, Secs 47, 50, 61, PT Sec 41, Blk V Opoe SD
Neil & Alma Violet Thompson and Steven & Josephine Suzanne Thompson	38 Turk Valley Road	Waiharara	Lot 2 DP 178824 BLK III Opoe SD
Tony and Diane Hewitt	17 Camp Road	Waiharara	Lot 1 & Lot 2 DP 194160 BLK V OPOE SD
Cypress Hills Ltd, C/o Alan Anderson & Carolyn Dawn Smith	27 Turk Valley Road	Waiharara	Lot 10 DP 178824 BLK III Opoe SD. Lot 8 DP 178824 BLK III Opoe SD. Lot 1 DP 336507, BLKS III IV Opoe SD
Ian McLarnon & Jason McLarnon	43 Burnage Road	Pukenui	Lot 2 DP 177332
Kathy Valadares	3633 Far North Road	Motutangi / Pukenui	Lots 1-3 DP 477138, Lot 1 DP 195379 Sec 81 Blk XV Houhora SD
Johno and Carol Brien (Hukatere Road)	110D Huketere Road	Pukenui	Lot 2 DP 325173, Lot 15 DP 113250, Lot 16, DP 113250
Daimen & Katherine Holloway	305 Kaimaumau Road	Waiharara	Lot 1 DP 193935 Kaimaumau WAIHARARA 0486
Johno and Carol Brien (Lamb Road)	Elingamtie Drive	Pukenui	Lot 3, DP 425051
Te Runanga o Ngai Takoto, C/o Rangitane Marsden			Lot 6 DP 405064 Kaimaumau
Kevin and Dani Thomas	Elingamite Drive	Pukenui	Lot 1 Deposited Plan 505956

2.2 Proposed Water Takes

Each application is for a groundwater take for irrigation purposes between the months of October to April. Some applicants already have a resource consent and seek to increase the consented volume, while others are applying for new resource consents. **Table 3** outlines the proposed rates and volumes for each applicant. The maximum annual volume was calculated from the irrigation scheduling work described in a supplementary report, referred to as “the Groundwater Modelling Report” in this document.

The proposed take locations and the catchment characteristics are described in detail in the Groundwater Modelling Report, hence is not repeated herein.

Table 3. Resource consent application details of proposed new water allocations for each applicant in the MWWUG.

Application Number	Full Name	Consent Status	Area (ha)	Maximum Inst. Rate (L/s)*	Maximum Daily Volume (m^3/d)	Maximum Annual Volume (m^3/yr)
APP.038610.01.01	Mapua Avocados Ltd, C/o Murray Forlong	New	160	116	5,000	745,000
APP.038471.01.01	Honeytree Farms Limited, C/o Tony Hayward	New	110	81	3,500	521,500
APP.038410.01.01	Georgina Tui and Mate Nickolas Covich	New	70	35	1,500	223,500
APP.038420.01.01	Largus Orchard Ltd Partnership, C/o Murray Forlong (Changed from Matijevich)	New	60	30	1,300	193,700
APP.038513.01.01	Te Runanga o Ngai Takoto, C/o Rangitane Marsden	New	60	30	1,300	193,700
APP.038454.01.01	Elbury Holdings Limited, C/o Kevin and Fiona King	New	30	18	763	113,700
APP.039332.01.01	Candy Corn Ltd, C/o Bryan Candy	New	20	12	537	80,000
APP.027391.01.02	Ivan Anthony Stanisich	Increase	17	10	430	64,070
APP.39244.01.01	Kevin and Dani Thomas	New	16	9	400	59,600
APP.038589.01.01	Neil & Alma Violet Thompson and Steven & Josephine Suzanne Thompson	New	9	7	320	47,680
APP.038591.01.01	Cypress Hills Ltd, C/o Alan Anderson & Carolyn Dawn Smith	New	9	7	280	41,720
APP.038650.01.01	Tony and Diane Hewitt	New	10	6	270	40,230
APP.038328.01.01	Bernard Kim & Sheryl Dianne Shine	New	10	6	268	40,000
APP.039345.01.01	Ian McLarnon & Jason McLarnon	New	6	5	200	29,800
APP.38732.01.01	Kathy Valadares	New	8	4	150	22,350
APP.038380.01.01	Daimen & Katherine Holloway	New	4	2	100	14,900
APP.039381.01.01	Johno and Carol Brien (Lamb Road)	New	4	2	100	14,900
TOTAL				**380**	**16,418**	**2,446,350**

Notes: * assumes 12 hours pumping.

2.3 Activity Status

The current resource management plan of Northland Regional Council is the Regional Water and Soil Plan for Northland, operative since 28 August 2004.

Rule 25.03.01 of the plan states that "The taking, use or diversion of groundwater from an aquifer, and any associated discharge of groundwater onto or into land or into water, which does not meet the requirements of the permitted, controlled or non-complying activity rules is a discretionary activity."

In this regard, a Discretionary Activity consent is sought for the proposed groundwater takes as the takes are not for domestic or stock watering use (Rule 25(A)) and exceed the daily volume of 10 m^3/d and instantaneous rate of 5 L/s per bore for a permitted activity (Rule 25.01.01).

Northland Regional Council has developed a draft new Regional Plan, which is currently under review. The proposed Regional Plan is due to be notified mid-2017. The draft Regional Plan Rule C.5.1.9 states that the taking and use of fresh water is a discretionary activity unless it is one of the following:

1. a permitted activity under C.5.1.1 'Water for stock drinking and reasonable domestic needs – permitted activity', or
2. a permitted activity under C.5.1.2 'Minor takes – permitted activity', or
3. a permitted activity under C.5.1.3 'Water take from an off-stream dam – permitted activity', or
4. a permitted activity under C.5.1.4 'Water take from an artificial water course – permitted activity', or
5. a permitted activity under C.5.1.5 'Water take associated with bore development, bore testing, or dewatering – permitted activity', or a controlled activity under C.5.1.6 'Existing dairy shed use – controlled activity', or
6. a controlled activity under C.5.1.7 'Re-consenting water takes – controlled activity', or
7. a restricted discretionary activity under C.5.1.8 'Transfer of a water permit – restricted discretionary activity', or
8. a non-complying activity under C.5.1.10 'Water take that will exceed a water quantity limit – non-complying activity'

In summary, the proposed groundwater takes do not conform to one of the activities above and therefore a Discretionary Activity consent would be required under both the current and proposed Regional Plan.

3. Assessment of Environmental Effects

3.1 Introduction to the Assessment of Effects

To assist in the assessment of environmental effects of the proposed water takes, a numerical groundwater model was developed using the MODFLOW Unstructured Grid (MODFLOW-USG) modelling system. The model is described in detail in a supplementary report (Zhao and Williamson, 2017), referred to as “the Groundwater Modelling Report” in this document. The model itself is referred to as “the groundwater model” in this document.

Three predictive model scenarios were simulated with the groundwater model, described as follows:

- ***Scenario 1: Base case*** – represents the current situation and includes the current 35 consented groundwater takes at a peak abstraction rate of 11,810 m^3/day.
- ***Scenario 2: Proposed Extraction*** – includes current and proposed groundwater extraction totalling a combined peak rate of 16,780 m^3/day. This was applied through 24 new groundwater take bores in addition to the 35 existing bores.
- ***Scenario 3: Future Allocation*** - a set of simulations to assess the effect of future potential groundwater allocation from maximum development. This was represented through 263 fictitious bores placed over a 500 m by 500 m grid within the area of the model domain that is currently in farmland and has potential for future conversion to orchard (see Figure 20 in the Modelling Report). The rate of abstraction from the 263 fictitious bores (over and above Scenario 2) was progressively increased in each simulation as summarised in **Table 4**.
- ***Scenario 4: Alternative Leakage*** - a set of three simulations where the permeability within model Layer 2 was progressively reduced by one order of magnitude for each simulation, to investigate the potential sensitivity in drawdown in the deeper shellbed layer.

Table 4. Daily future allocation used in the scenario 3 simulations.

Scenario	Future allocation (m^3/day)
3a	Proposed + 20,000
3b	Proposed + 40,000
3c	Proposed + 80,000

The predictive model scenarios were simulated based on a climate data record from the last 60 years. In effect, the climatic conditions of the last 60 years have been utilised to simulate the next 60 years. Based on the rainfall record and simulated groundwater response in the base model, the end time of a dry period was selected for the assessment of effects. The date selected was 30/04/2010, which is the end of the irrigation season that required the largest volume of irrigation as determined from a simulated actual water use record.

The groundwater model setup has not captured the existence of hard pan layers that act as a flow barrier between the groundwater system and the surface drains and wetlands. There was insufficient information on the spatial extent and thickness of the hard pans to be represented in the groundwater model (see Section 2.3 of the Groundwater Modelling Report). As a result, the base models likely over estimates the effects of the proposed abstraction on the groundwater levels in the shallow aquifer and flow impacts at the surface.

As indicated above, the sensitivity of the groundwater model with respect to leakage from the shallow aquifer was tested using three scenarios that were setup with incrementally decreasing hydraulic conductivity (K_x =10^{-5}, 10^{-6}, 10^{-7} m/s) applied to Layer 2 to effectively progressively confine the deeper aquifer. The sensitivity analysis was designed to understand the relative quantum of increased in drawdown in the deeper aquifer that would occur with the progressive confinement.

The three alternative leakage scenarios were not calibrated, and are therefore considered only appropriate to illustrate relative (rather than absolute) changes in groundwater level.

The impact on surface water resource reduces with progressive confinement of the deeper aquifer, but this was not the focus[1] since i) the calibrated base models provide the most conservative response with regard to surface water impacts, and ii) the surface water effects that were simulated from the base models were considered no more than minor.

3.2 Effect on the Groundwater Resource

3.2.1 Groundwater Levels

The effects of the proposed pumping on groundwater levels were investigated by calculating the drawdown in the deep and the shallow aquifer from the groundwater levels simulated with the groundwater model for the two driest periods with the greatest irrigation requirement within the 60-year record. The analysis therefore represents effects resulting from abstraction at the maximum rate/volume.

Compared to the current situation (base case), the proposed extraction shows a maximum of 0.8 m drawdown in the deep shellbed aquifer (see Figure 24 of the Groundwater Modelling Report). The location of the proposed bores and their adjacency to each other lead to cumulative effects on the aquifer to different extents. The largest drawdown is centred near the Motutangi and Waiharara areas due to the concentration of the bores with relatively large proposed groundwater extraction.

Sensitivity analysis of the calculated effects was undertaken on the assumption that the amount of leakage to the shellbed may vary, and in particular we considered a scenario at the opposite end of the spectrum, whereby leakage was cut-off by inclusion of a low permeability unit to represent potential hard pan layers in the shallow aquifer. The sensitivity analysis showed that the upper bound to drawdown in the deeper shellbed aquifer in response to the proposed extraction is 2.2 m, which is considered to be of similar order of magnitude to the 0.8 m simulated with the calibrated model.

The shallow aquifer is less affected by the proposed pumping than the deep aquifer; however, there is some drawdown effect simulated based on the current model set-up. For the proposed extraction scenario, the maximum drawdown is 0.4 m in the shallow aquifer (see Figure 29 of the Groundwater Modelling Report). However, as stated in Section 3.1, the model likely exaggerates the effect on the shallow aquifer given that it does not capture the existence of hard pan layers.

For the future allocation scenarios, the simulated maximum drawdown in the deep aquifer is 1.3 m, 2.0 m and 3.4 m, respectively (see Figures 26-29 in the Groundwater Modelling Report). In the shallow aquifer, the simulated maximum drawdown is 0.8 m, 1.3 m, and 2.3 m, respectively (see Figures 30-32 in the Groundwater Modelling Report).

The simulated drawdown for all scenarios as a percentage of the saturated aquifer thickness, which exceeds 110 m in most locations, ranges from 1% to 3%.

The predicted effect of the proposed water takes and also the potential future allocation on the groundwater levels is considered <u>minor</u>.

[1] The focus of the alternative leakage scenarios being drawdown in the deep shellbed aquifer.

3.2.2 Neighbouring Bores

As discussed in **Section 3.2.1**, cumulative drawdown effects are considered no more than minor as the predicted drawdown is small compared to the total aquifer depth available. Potential interference effects between the bores of the MWWUG will be managed internally by the members.

Table 5 shows the predicted drawdown of the proposed abstraction on bores with existing consented takes that are not part of this application. The scenarios provided in **Table 5** includes the four pumping scenarios and the three reduced leakage sensitivity scenarios (which use the Scenario 2 pumping rate).

As mentioned above, the calculated drawdown represents the effects resulting from pumping at maximum consented rates and seasonal volumes.

The maximum drawdown anticipated from the pumping scenarios (<3.5 m) and the leakage sensitivity scenarios (<2.1 m) is no more than minor in the context of the available drawdown, given the saturated thickness of the aquifer (>100 m). Provided bores are adequately constructed to utilise the full available saturated thickness of the aquifer (e.g. following the advice provided in Policy 10.5 in the Water and Soil Plan), interference effects will be no more than minor.

Comparison of the aquifer drawdown effect from Scenario 2 (application) with the reduced leakage scenarios (Scenarios 4a to 4c) shows an increase in the maximum drawdown from 0.7 m to 2.1 m. This range reflects the sensitivity in the calculation results expected given lower leakage hydraulic properties assignments in the model.

In summary, the interference effect on other users in the context of available drawdown for the aquifer is considered no more than minor.

Table 5. Predicted maximum drawdown on existing groundwater users for various pumping and sensitivity scenarios.

Bore Owner	Pumping Scenarios (m^3/day)				Leakage Scenarios (K_x[m/s])		
	2	3a	3b	3c	4a	4b	4c
	16,780	Sc2 + 20,000	Sc2 + 40,000	Sc2 + 80,000	Sc2 + 1e-5	Sc2 + 1e-6	Sc2 + 1e-7
KSL Ltd	0.4	0.8	1.2	2.0	0.5	0.9	1.6
Hine & Associates Ltd	0.3	1.0	1.6	3.0	0.3	0.6	1.1
Wagener Houhora Heads Properties Limited	0.1	0.6	1.1	2.1	0.2	0.5	0.9
Longbeach Trust	0.2	0.9	1.6	2.9	0.2	0.5	1.0
Trebcombe Limited	0.3	1.0	1.6	3.0	0.4	0.7	1.2
RB Freeman	0.3	0.9	1.5	2.8	0.4	0.7	1.2
Matalaka Trust	0.3	0.9	1.5	2.8	0.4	0.7	1.2
Trebcombe Limited	0.3	0.9	1.6	2.9	0.4	0.7	1.2
Ongare Trust	0.3	1.0	1.6	3.0	0.4	0.7	1.2
I M Fulton	0.6	1.0	1.4	2.2	0.7	1.1	2.0
LL & DF Rasmussen	0.1	0.6	1.0	2.0	0.1	0.3	0.6
Tomo Orchard Ltd	0.3	0.9	1.6	3.0	0.3	0.6	1.0
The Alligator Pear Partnership	0.4	1.0	1.7	3.1	0.4	0.7	1.1
Shirttail Orchards	0.3	0.8	1.2	2.0	0.4	0.8	1.5
Ongare Trust	0.3	0.9	1.5	2.8	0.3	0.6	1.1
RB Freeman	0.3	1.0	1.6	2.9	0.4	0.8	1.3
EJ Wagener	0.4	1.0	1.6	2.8	0.5	0.9	1.5
Far North Avos Limited	0.3	0.9	1.6	2.9	0.3	0.6	1.1
J P Broadhurst	0.6	1.0	1.4	2.3	0.7	1.2	2.0
S127 change to consent for groundwater take	0.3	1.0	1.6	2.9	0.4	0.7	1.1
JR Avocados Ltd	0.5	0.8	1.2	2.0	0.5	0.9	1.7
B C Smith	0.3	0.9	1.6	3.0	0.3	0.6	1.0
E J Williams	0.3	0.9	1.6	2.9	0.3	0.6	1.1
I J & B M Broadhurst	0.7	1.0	1.4	2.2	0.7	1.2	2.1
Whaler's Rd, Houhora	0.7	1.3	1.9	3.0	0.8	1.3	1.9
McQuarrie	0.3	1.0	1.6	2.9	0.4	0.8	1.3
Whispering Pines Ltd	0.3	0.9	1.6	2.8	0.4	0.7	1.2
IA Stanisich	0.7	1.4	2.1	3.5	0.8	1.3	2.1
Honeytree Farms Ltd	0.3	0.9	1.6	2.9	0.3	0.6	1.1
Soltysik-Freeman Fam Trust	0.7	1.3	1.8	2.9	0.8	1.2	1.9
Subritzky	0.3	0.7	1.2	2.0	0.4	0.8	1.5
I M Fulton	0.6	1.1	1.6	2.5	0.7	1.2	2.0
Far North Avos Limited	0.3	0.9	1.6	2.9	0.3	0.6	1.1
De Bede	0.4	0.8	1.1	1.9	0.4	0.9	1.6
Min	**0.1**	**0.6**	**1.0**	**1.9**	**0.1**	**0.3**	**0.6**
Max	**0.7**	**1.4**	**2.1**	**3.5**	**0.8**	**1.3**	**2.1**

3.2.3 Groundwater Availability

The effect of the proposed pumping on groundwater availability was assessed by comparing the proposed take volume to the total volume available.

Flow budgets were extracted from the groundwater model for each of the simulated scenarios. A comparison of the average flow budget over the simulated 60-year model time period is provided in **Table 6**. The shaded row (yellow) indicates the volumes and proportions of total flow in the system extracted from the bores (wells). (Note: The flow budget values are average values over the entire simulation period. The values for the bores are therefore lower than the peak extraction rate, as pumping only occurs during the irrigation season).

Table 6. Average flow budget for the 60-year model time period.

Scenarios		Scenario 1 (Base Case)		Scenario 2		Scenario 3a		Scenario 3b		Scenario 3c	
Components		Flow (m^3/d)	Prop (%)	Flow (m^3/d)	Prop (%)	Flow (m^3/d)	Prop (%)	Flow (m^3/d)	Prop (%)	Flow (m^3/d)	Prop (%)
Inflow	Storage	64,407	22.3	66,637	22.9	69,264	23.6	72,362	24.4	78,924	26.1
	CH	0	0	0	0	0	0	0	0	0	0
	Recharge	223,908	77.7	223,908	77.1	223,908	76.4	223,908	75.6	223,908	73.9
	Lake Waiparera	3	0	3	0	3	0	4	0	4	0
	Total inflow	**288,318**	**100**	**290,548**	**100**	**293,175**	**100**	**296,274**	**100**	**302,836**	**100**
Outflow	Storage	67,738	23.5	69,621	24.0	71,757	24.5	74,352	25.1	79,871	26.4
	Shallow Coastal Discharge (CH)	153,424	53.2	151,978	52.3	149,960	51.1	147,910	49.9	143,702	47.4
	Deep Coastal Discharge (GHB)	20,759	7.2	20,542	7.1	20,075	6.8	19,602	6.6	18,638	6.2
	Wells	426	0.1	5,196	1.8	10,883	3.7	16,570	5.6	27,943	9.2
	Drains (DC)	35,381	12.3	33,484	11.5	31,473	10.7	29,492	10.0	25,628	8.5
	Wetlands (DC)	10,641	3.7	9,776	3.4	9,075	3.1	8,395	2.8	7,099	2.3
	Total outflow	**288,370**	**100**	**290,597**	**100**	**293,223**	**100**	**296,321**	**100**	**30,2876**	**100**
Discrepancy (%).		-0.02		-0.02		-0.02		-0.02		-0.01	

The abstraction derives water from the coastal discharges (CH/GHB), surface drains (DC) and some accession from storage. The proposed pumping (Scenario 2) accounts for 1.8% of the total water budget, which represents only a very small proportion of the total water budget. Therefore, the effects on groundwater availability are considered no more than minor.

For the three potential future allocation simulations, the percentage of water being extracted from the system is 3.7%, 5.6% and 9.2% of the total water budget, respectively. These volumes also represent only a small proportion of the total water budget. This indicates that the proposed pumping will not impede future development options.

3.2.4 Saltwater Intrusion

An assessment of the effect of the proposed abstraction on the position of the freshwater/saltwater interface was undertaken using the Ghyben-Herzberg equation (see Groundwater Modelling Report for details). Two possible mechanisms for saline intrusion were investigated: i) upconing and ii) lateral migration along the shell bed interface.

Upconing

In the upcoming investigation, six cross-section profiles were extracted from each model simulation (see Figure 36 to 41 of the Groundwater Modelling Report) and the depth to the freshwater/saltwater interface was calculated based on the simulated groundwater level at the selected date at the end of a dry period (30/04/2010) following the Ghyben-Herzberg equation.

The estimated position of the freshwater/saltwater interface varies depending on the geographical distribution of the new groundwater take bores and the proposed abstraction volume. There was no significant saltwater upconing observed for cross sections A'-A and B'-B (see Figures 36 and 37 of the Groundwater Modelling Report).

For the proposed abstraction (Scenario 2), the largest rise of the freshwater/saltwater interface was estimated to be 101 m at cross-section C'-C (see Figure 38 in Groundwater Modelling Report), which is induced by the cumulative groundwater take from the three Forlong bores. The second largest rise of the freshwater/saltwater interface was about 61 m at cross-section E'-E (see Figure 40 of the Groundwater Modelling Report).

However, while a considerable potential rise of the interface is estimated, there remains a minimum distance of approximately 390 m between the base of the sedimentary (shellbed) aquifer and the freshwater/saltwater interface. This indicates that the risk of saltwater upconing and subsequent contamination of the groundwater due to the proposed abstraction is less than minor.

For the potential future allocation (Scenario 3), the rise of the freshwater/saltwater interface becomes more pronounced across the model domain. However, the distance between the base of the shellbed aquifer and the freshwater/saltwater interface is still more than 300 m. This indicates that the risk of saltwater upconing into the pumping bores located in the shellbed aquifer is negligible and the proposed abstraction will not impede future development.

Shellbed Interface Lateral Migration

A salinity lateral migration analysis was undertaken based on the premise that aquifer hydrostatic pressure is required at the coast to withstand in the landward advancement of saline water along the interface between the high permeability shellbed and the low permeability basement rocks.

Points were placed around the coastal margins at approximately 500 m intervals and the groundwater elevation or pressure required to withstand saline lateral migration (trigger level) was calculated for each point. Simulated groundwater levels were extracted from the model for each of the pumping scenarios and the sensitivity scenarios and interpolated to a daily interval. A 90-day rolling average was calculated from the simulated groundwater level to reflect that the mechanism of saline intrusion is a very slow process and therefore any management triggers need to be cognisant of this slow process (i.e. groundwater level need to beheld lower than the saline intrusion trigger for an extended period of time for the initiation of saline intrusion landward). The 90-day rolling average groundwater levels were compared to the calculated trigger level at each location over the entire simulation prior (1956 to 2016).

Simulated groundwater levels were significantly above the trigger level for the vast majority of the time for each pumping and sensitivity scenario (Figure 45, Groundwater Modelling Report). However, at the driest time in the 60-year run (April 1978) simulated groundwater levels came close to the trigger level at two points along the coast (Houhora Heads and East Beach to Kaimaumau) for the maximum pumping scenario (3c) (shown in Figure 43, and Table F1 and Table F2 in Appendix F of the Groundwater Modelling Report). These points represent locations where the land protrudes into the ocean (headlands) and the area is therefore naturally surrounded by sea water. All other areas where the groundwater flow path to the coast has a longer fetch maintain groundwater pressures significantly above the trigger level.

The modelling results indicate that it is unlikely that salt water would migrate inland along the interface of the shellbed and basement, even under much higher pumping scenarios than that sought in this consent. Therefore, prolonged saline intrusion effects of this consent application are considered unlikely and thus to be no more than minor.

3.3 Effects on Surface Waterways

An analysis of the effect of the proposed abstraction on flow in the farm drains and the Kaimaumau Wetland was undertaken for low-flow situations.

3.3.1 Drain Flows

In order to assess the effect of the proposed abstraction on flow in the farm drains, annual minima in daily drain flow were obtained from the global flow budget for all drains combined for each time step exported from the groundwater model. Annual recurrence intervals were calculated from this table of data for each scenario (see Table 12 and Figure 21 of the Groundwater Modelling Report).

The results indicate that the proposed abstraction (Scenario 2) may reduce the mean annual (1-year) low flow by a maximum of 5%, and the 5-year low flow by 7%. However, as stated earlier, the model likely exaggerates the effects on the shallow aquifer which feeds the drains, and these values should be treated as conservative upper estimates. Thus, the effects of the proposed abstraction on farm drain flows are considered minor.

For the potential future allocation, the reduction in drain flow is estimated to 7% for the annual (1-year) low flow, and 15-37% for the 5-year low flow. Again, given the lack of hard pans in the model, these values should be considered conservative upper estimates.

3.3.2 Kaimaumau Wetland

In order to assess the effect of the proposed abstraction on flow in the Kaimaumau Wetland, annual minima in daily wetland discharge were obtained from the flow budget for each time step exported from the groundwater model. Surface discharge from the wetland was converted to specific discharge by dividing the discharge by the wetland area. Annual recurrence intervals were calculated, and the reduction in flow was computed for each scenario (see Table 13 in the Groundwater Modelling Report).

The results indicate that the proposed abstraction (Scenario 2) has the potential to reduce mean annual low-flow discharge by a maximum of 7%, and 5-year low-flow discharge by 11%. However, as stated earlier, the model likely exaggerates the effects at the surface as it does not capture the hydraulic separation between the shallow aquifer and the wetland by hard pan, and these values should be treated as conservative upper estimates. Thus, the effects of the proposed abstraction on wetland flows are considered minor.

For the potential future allocation, the reduction in wetland discharge is estimated to 9-10% for the annual (1-year) low flow, and 19-43% for the 5-year low flow. Again, given the lack of hard pans in the model, these values should be considered conservative upper estimates.

In addition to the modelling study, a field investigation and groundwater isotope study using Radon has been undertaken to address the connectivity between groundwater and the wetland (see Section 2.3.1 of the Groundwater Modelling Report). Results indicate that the deeper groundwater has a significantly different Radon signature than the surface water. It is considered unlikely that the deep shellbed aquifer has a strong hydrological connection with the surface drains and wetlands. This reiterates that the proposed pumping is unlikely to have a significant effect on the wetland.

3.3.3 Lake Waiparera

Lake Waiparera is perched above the regional aquifer, thus it is hydrologically disconnected from the groundwater system. No change is expected in the hydrological functionality of the lake due to the proposed abstraction from the deep shellbed aquifer.

3.4 Effects on Land Subsidence

The potential for land subsidence as a result of simulated levels of drawdown were not specifically investigated in this study because the King Avocado Orchard AEE (SKM, 2007) undertook a detailed geotechnical modelling assessment of subsidence and found subsidence to be negligible. Since the soil and landuse characteristics of the area, and magnitude of potential drawdown predicted in this area are similar, potential subsidence is considered similarly negligible and therefore less than minor.

The work undertaken in SKM (2007) included subsidence analysis using PLAXIS (Version 8) - a finite element package designed for two-dimensional analysis of deformation and stability. The analysis used a conservative uniform drawdown of 2 m across the entire area, which resulted in a total subsidence of 50 mm. The calculated level of subsidence is not considered to be significant given the rural location in which the subsidence is occurring and the remote likelihood of ground-movement sensitive buildings or infrastructure construction occurring in this location.

3.5 Socio-Economic Effect

The avocado orchard development will result in a tangible impact on the local community, which can only fully materialise with the irrigation water being sought under this application. This includes the creation of full time jobs in addition to continuation of seasonal jobs. The involvement of two large horticultural ventures (Honeytree Farms Limited and Mapua Orchards Limited) in the group will provide a blueprint for the local community to further develop horticulture ventures and also for Iwi to develop their lands.

Table 7 provides a high-level summary of the potential socio-economic benefits scaled for each model scenario from the orchard development plan provided by Honeytree Farms Limited.

For Scenario 2, which represents approximately 670 ha of orchard development, it is expected that approximately 70 additional full time equivalent jobs will be created, along with spending in the district of approximately $2M per annum on orchard operations.

The overall socio-economic impact to the region is considered to be a significant benefit.

Table 7. Summary of community impact of the proposed groundwater take.

		Scenario			
		Sc. 2	Sc. 3-1	Sc. 3-2	Sc. 3-3
	Peak Vol. (m3/day)	16,775	36,775	56,775	76,775
	Area (ha)	671	1,471	2,271	3,071
Number of local employees (FTE's)	This is a seasonal, but would grow and become less seasonal with the orchard development.	70	150	230	310
Estimate of annual spend on local suppliers ($/PA)	Irrigation	$670,000	$1,470,000	$2,270,000	$3,070,000
	Fertiliser	$1,340,000	$2,940,000	$4,540,000	$6,140,000
	Equipment	$470,000	$1,030,000	$1,590,000	$2,150,000
	Repairs and maintaining equipment	$270,000	$590,000	$910,000	$1,230,000
	Training and personal development	$130,000	$290,000	$450,000	$610,000

3.6 Other Considerations

3.6.1 Efficient Use

Avocado trees have shallow root systems and are particularly sensitive to root rot, which is the most common cause of avocado failure. Therefore, it is important to not over water and/or grow in soils that are well drained. Trees that receive too much water will drop fruit and excess water will leach nutrients from the soil around the roots, which is expensive for the grower to replace.

Avocado growers are therefore acutely aware of the importance of water use efficiency in terms of both plant survival and minimising fertiliser wastage (i.e. only applying the exact amount of water required by the plant, using wood shavings as mulch to buffer the soil from atmospheric evaporative demands). Soil moistures are regularly checked by growers through soil moisture monitoring in order to ensure that the soil is not too wet or dry, which then enables them to regulate their irrigation applications accordingly.

3.6.2 Shallow Water Quality

Avocado orchardists in this area tend to apply fertiliser efficiently via fertigation as part of their irrigation water using a small dosage regular frequency approach, which is driven by both the soil conditions (i.e. high permeability and lacking in organic matter and nutrients) and economic considerations. Combined with efficient irrigation that avoids root rot as explained above, excessive leaching of fertilizer and pant nutrients is unlikely. Therefore, adverse effects on shallow water quality are not expected.

3.6.3 Alternative Sources of Water

The Houhora-Motutangi to Waiharara area is dominated by sandy soils that are highly permeable, with the majority of rainfall infiltrating into the ground. For this reason, there are few streams. However, some farmers and orchardists have water take consents from local drains and streams, although we understand the water quality within these water bodies is problematic during summer and also the yields can be unreliable. Hence, groundwater is strongly preferred over surface water because of the more reliable yield, better water quality, and also because in this area groundwater is almost guaranteed anywhere you choose to drill.

3.7 Consultation

No specific consultation has been undertaken as part of the water take consents AEE process. Given the applicant group includes a large portion of the community including some Iwi, it was felt that a more efficient process would `be through limited notification to any parties Council considered necessary to consult with.

4. Proposed Consent Monitoring Conditions

Due to the variable nature of the geological/hydrogeological setting, there will always be some uncertainty regarding the potential effects of abstraction. While we consider these likely to be no more than minor given the quantum of abstraction applied under this application, monitoring and contingency planning should be implemented to assess the effects in practice and respond should anything adverse occur.

It is proposed that the MWWUG work collaboratively with the Northland Regional Council to develop a Groundwater Monitoring and Contingency Plan (GMCP) for the management zone encompassed by the MWWUG.

In our opinion, the placement of consent conditions on individual applicants beyond standard conditions requiring groundwater level and water metering within the pumping bores, would not be an efficient method to monitor and manage the effects of the proposed developments. This is largely because the key adverse environmental effect appears to be saline intrusion, which requires significant time to develop and is dependent on cumulative drawdown over broad key areas (as demonstrated by the model). In the geological setting of this area, saline intrusion could be monitored near the coastline or on the seaward side of land that should be safeguarded from saline intrusion (i.e. areas of development or where other water users reside). This monitoring would negate the requirement to monitor for saline intrusion specifically at individual bores.

In this regard, it is proposed to develop a network of two to three sentinel bores on the coast adjacent to the key development areas, which would be used as monitoring points to establish triggers for the determination of saline intrusion.

The proposed sentinel piezometer locations are shown in Figure 42 of the Groundwater Modelling Report. These have been selected on the basis of i) adjacency to high development centres and ii) access likely to be manageable (i.e. easy terrain). The final location of the sentinel bores will be agreed with NRC and the MWWUG, with the intention that the sites selected balance technical hydrogeological requirements and capital cost outlays (i.e. cost expediency – using existing bores if possible, such as Waterfront@Houhora).

The modelling work has provided data for the establishment of trigger levels, which may or may not need to be updated once the monitoring boreholes are constructed.

It is envisaged that sentinel piezometer monitoring could be added to the NRC routine monitoring round in the Far North and comprise:

- Monthly groundwater levels; and
- Monthly electrical conductivity (EC) concentration – following establishment of a relationship between chloride and sodium, and EC using more frequent data.

The GMCP would be premised on the following:

- the exercising of the consent is subject to maintenance of aquifer conditions that do not induce ongoing declining groundwater levels and increasing saline water quality indicators;
- groundwater level monitoring at the pumping bores is proposed to ensure that steady decline in groundwater levels does not occur;
- groundwater level monitoring at the three sentinel bores is proposed to ensure aquifer pressures at key coastal locations are maintained above the pressure "trigger level" required for withstanding saline intrusion;
- groundwater chemistry monitoring in the form of electrical conductivity (EC) at the sentinel bores is proposed to ensure saline intrusion is not occurring - increasing concentration of Cl^- and SO_4^{2-} (which can be indicated by increasing EC) is a more convenient diagnosis of the initiation of saline intrusion than measuring the analytes themselves;
- *trigger levels* for groundwater level and a water quality (X mS/m) representative of initiation of saline intrusion will be specified for each sentinel bore;

- the groundwater trigger levels will be based on the 90-day rolling average, reflecting the premise that saline intrusion is a slow process;
- in the event of continuously declining groundwater levels or rising salinity indicators, and/or EC exceeding the *trigger level,* a sequence of escalating actions must be implemented (likely to include):

  a) Notification of the relevant NRC compliance team leader as soon as possible;

  b) Sampling of the sentinel monitoring bores in accordance shall immediately be upgraded to a weekly frequency for four weeks following the first exceedance of a trigger level and results reported to the relevant NRC compliance team leader.

  c) If after four weeks since the trigger level was breached the initiation of seawater intrusion and/or water level decline cannot be discounted to the satisfaction of the relevant NRC compliance team leader, then, within three months of the initial breach, the WUG shall prepare and submit to the relevant NRC compliance team leader for written approval of a Groundwater Trigger Exceedance Report. The Groundwater Trigger Exceedance Report shall assess the significance of the exceedance in terms of saline intrusion of the aquifer or ongoing declining groundwater levels. The Report shall include a review of all of the available data, including groundwater levels, groundwater use and groundwater quality, and shall be completed by a suitably qualified hydrogeologist to assess why a trigger level has been breached. The Report shall recommend a programme of response, what remedial actions should be taken, and timeframes for actions. The actions may include, but not be limited to, a series of incremental reductions in the daily quantity taken, as a percentage of the average daily pumped volume.
- A Mitigation Plan will be formulated when and if required following the findings recommended in a Groundwater Trigger Exceedance Report.

A draft table of contents for the suggested GMCP is provided as follows.

5. Conclusions

The MWWUG propose to take a combined maximum daily volume of 16,775 m^3/day from the shell bed aquifer in the Houhora-Motutangi to Waiharara area for avocado orchard irrigation between October and April. The maximum annual volume sought is 2,499,475 m^3/year and the combined peak rate of abstraction is 388 L/s.

Investigations have been undertaken into the hydrogeology and aquifer parameters of shell bed aquifer within the Houhora-Motutangi to Waiharara area and the groundwater-surface water interactions at Kaimaumau wetland, including:

- Test pumping of three bores;
- Radon isotope survey within the drains passing through and discharging from the Kaimaumau wetland;
- Development of a comprehensive groundwater model.

The groundwater model constructed used the latest available data to advance the work of the previous groundwater model developed in 2015. The model considered three pumping scenarios, and undertook sensitivity analysis on one of the pumping scenarios. The sensitivity analysis considered an alternative geological arrangement to that of the base model – that being one of limited leakage from the shallow aquifer to the deeper shellbed aquifer, whereas the base model comprised a leakier system.

The modelling exercise was used to assess the potential effects of the proposed abstractions on aquifer sustainability, aquifer levels, neighbouring well users and nearby surface water bodies.

The proposed abstractions (Scenario 2) are not expected to result in any significant adverse environmental effects given the key findings were as follows:

- Extent of Depressurisation (Drawdown)
  - Deep Aquifer - Compared to the current situation (base case), the proposed extraction shows a maximum of 0.8 m drawdown in the deep shellbed aquifer. In the context of the available saturated thickness of the aquifer, which is typically greater than 100 m, this represents a very small reduction in groundwater levels and is considered no more than minor;
  - Shallow aquifer - is less affected by the proposed pumping than the deep aquifer; however, there is some drawdown effect simulated based on the current model set-up, although the model exaggerates the effect on the shallow aquifer given that the model configuration does not capture the existence of hard pan layers. Sensitivity analysis was undertaken using a model with a greater degree of confinement and therefore likely increased depressurisation in the deeper aquifer during pumping, yet while drawdowns did increase, the magnitude of the increase did not alter the conclusion that the drawdown effect is considered no more than minor.
- *Neighbouring Bores* - The drawdown effects on neighbouring bores from the proposed pumping range from 0.1 to 0.7 m, which is small compared to the saturated thickness available in the aquifer (>100 m). Therefore, the drawdown effects on other users is considered minor.
- *Aquifer Water Budget* - The proposed pumping accounts for 1.8% of the total water budget, which represents only a very small proportion of the total water budget. Therefore, the effects on groundwater availability are considered minor.
- *Saline Intrusion* - There remains a minimum distance of approximately 390 m between the base of the sedimentary (shellbed) aquifer and the freshwater/saltwater interface. This indicates that the risk of saltwater upconing and subsequent contamination of the groundwater due to the proposed abstraction is less than minor. Analysis of the lateral migration potential along the basal interface between the shellbed and the basement rock indicated the likelihood of saline intrusion occurring under this mechanism is also very low. The analysis indicated the areas of greatest potential vulnerability being the Houhoura Heads and the southern end of East Beach to Kaimaumau. Nevertheless, even under the maximum future pumping scenario, the pressure required at the coast to withstand saline intrusion was exceeded in all locations.

Sensitivity analysis on Scenario 2 (this application) indicated that with less leakage and increased drawdown in the shellbed aquifer, prolonged saline intrusion at the coast would be unlikely to occur. Thus, the potential saline intrusion effects are considered no more than minor.

- *Drain Flows* - The proposed abstraction may reduce the mean annual (1-year) low flow by a maximum of 5%, and the 5-year low flow by 7%. However, the model exaggerates the effects on the shallow aquifer that feeds the drains, and these values should be treated as conservative upper estimates. Thus, the effects of the proposed abstraction on farm drain flows are considered minor.
- *Wetland Discharges* - The proposed abstraction has the potential to reduce mean annual low-flow discharge by a maximum of 7%, and 5-year low-flow discharge by 11%. However, as stated earlier, the model likely exaggerates the effects at the surface as it does not capture the hydraulic separation between the shallow aquifer and the wetland by hard pan, and these values should be treated as conservative upper estimates. Thus, the effects of the proposed abstraction on wetland flows are considered minor.
- *Lake Waiparera* - is perched above the regional aquifer, thus it is hydrologically disconnected from the groundwater system. No change is expected in the hydrological functionality of the lake due to the proposed abstraction from the deep shellbed aquifer.
- *Land Subsidence* - The potential for land subsidence is considered less than minor on the basis of the work undertaken in a previous application (SKM, 2007) that undertook a detailed geotechnical modelling assessment of subsidence, where the geological conditions and magnitude of drawdown were similar.
- *Socio-Economic Benefits* - it is expected that approximately 70 additional full time equivalent jobs will be created, along with spending in the district of approximately $2M per annum on orchard operations. This is considered a significant positive impact.

Consent monitoring conditions have been proposed on a sub-regional scale that reflect the combined allocation of the resource. These conditions would likely require further conferencing between experts and the MWWUG to finalise a working set of conditions that meet with the requirements of both parties.

The work undertaken also considered a range of possible future allocation scenarios, anticipating the current strong growth in the NZ avocado industry and overseas demand to continue. The scenarios considered show that significant additional allocation is available and over what was requested in this application, and it would be our recommendation to Council that an allocation limit for the Houhora-Motutangi-Waiharara Management Zone of the aquifer be set at limit of 48,590 m^3/day. This represents the current allocation of 11,810 m^3/day, the currently proposed allocation of 16,780 m^3/day and a future allocation of 20,000 m^3/day (i.e. Scenario 3a). To place this in context, this represents 22% of the mean daily recharge (223,908 m^3/day – Table 12, Groundwater Modelling Report) in the management zone.

6. References

Sinclair Knight Merz, 2007. King Avocado Orchard Groundwater Take Consent Application. Report prepared for King Avocado Limited.

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