MEMORANDUM

To: **Tom De Pelsemaeker (Policy Water & Land TL)**

From: **Amir Levy, Sam Yeo, Marc Ettema (Groundwater Scientists)**

Date: **03 October2023**

Re: **Hāwea Basin groundwater report (May 2023) – summary & recommendations for Policy**

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1. Introduction

This memorandum summarises the main Policy recommendations stemming from Lincoln Agritech's Hāwea Basin transient numerical groundwater flow modelling report (LAL, 2023). ORC commissioned LAL to develop a model for the Hāwea Basin, which expanded the knowledge from the existing steady state model (Wilson, 2012). The 2023 model incorporated time series data collected after the completion of Wilson (2012), who recommended this further monitoring. The contribution of this time series data to the 2023 model clearly illustrates the benefits of dedicated continuous monitoring for understanding, modelling, and managing Otago's aquifers.

The new transient model aimed to help address the following key management issues for the basin:

- whether the aquifers/groundwater management zones and allocation volumes identified in Wilson (2012) are still relevant and practical
- sources of groundwater recharge
- groundwater allocation limits
- the impact of groundwater abstraction by competing water demands (irrigation, domestic takes, and town supplies) on water levels
- the impact of groundwater abstraction on river flow and wetlands

The final report (LAL, 2023) was submitted to ORC in May 2023. Although the model has various limitations, it substantially improves the existing information regarding the Hāwea Basin. This memorandum summarises the main findings and provides recommendations for Policy. However, there are several matters that will need further input from Policy and the community (Section 4). Further information and details can be found in the model report (LAL, 2023).

2. Model information & methodology

2.1 Transient modelling

The previous model for the Hāwea Basin (Wilson, 2012) was steady-state, which assumes that the total storage, inflow and outflow processes are constant with time. Conversely, transient models allow the inflows/outflows to vary with time which accounts for changes in storage, pumping, and water levels. Being steady state had significant drawbacks for the 2012 model as it could not simulate and incorporate seasonal changes in pumping and groundwater levels, e.g. the recovery of groundwater levels during winter, when pumping stops. However, although the model's steady state nature was identified as its main drawback, it was built using the best available information at the time (LAL, 2022), as there was not much continuous groundwater and surface water monitoring data then. Furthermore, it was recommended to install continuous monitoring data in the basin, in order to obtain time series data, which was implemented by ORC. This provided time series data of groundwater levels from new State of Environment (SoE) bores that were installed in 2014/5, water abstraction (metering), and surface water flow from Grandview and Lagoon Creeks. This time series data was then used for the building and calibration of the LAL (2023) new transient model.

2.2 Water use data

Metered groundwater abstraction volumes from consents is a key input parameter for modelling groundwater recharge and levels, as it is a major source of outflow from the aquifer. This data is provided by consent holders to ORC as part of their consent conditions. The data was processed and analysed by Kitteridge (2022). The model used the maximum daily usage and maximum allocated daily volumes combined with the normal intra-annual variability of pumping (i.e. a typological pumping curve), with a calculated integral of 135 days. Hence, current use allocation scenarios based on the pumping curve multiplied the maximum daily usage volume X 135 days. Scenarios that tested increased or decreased allocation were based on the maximum allocated daily, rather than annual, volumes due to limitations in the water metering data. The water metering data was also used to derive the current usage of groundwater in the basin and compare it to the ORC allocations (Table 1). However, as these annual allocation volumes are based on the daily usage and maximum allocated volumes (in contrast to ORC's annual volumes), these differ from ORC's current allocation limits and existing allocation.

Allocation Zone	Maximum daily usage m^3/day	Annual average usage m^3/yr	Maximum allocated daily rate m^3/day	Annual allocation (135 x daily rate) m^3/yr*	Annual usage as a percent of allocation	Existing allocation limit
Hāwea Flat	18,509	2,446,783	68,472	9,247,500	26.5%	8,680,000
Grandview Zone	0	0	0	0	n/a	n/a
Terrace – River	2,387	303,554	10,136	c	22.2%	1,560,000
Terrace – Hill	174	45,314	1,346	181,710	24.9%	410,000
Sandy Point	56	13,233	233	31,455	42.1%	860,000
Te Awa	0	0	0	0	n/a	297,000
Maungawera Flat	0	0	0	0	n/a	570,000
Camp Hill Moraine	0	0	0	0	n/a	n/a
Maungawera Valley	1,200	130,305	4,696	675,000	19.3%	1,210,000
Butterfield Exclusion	0	0	0	0	n/a	n/a
Campbell's Exclusion	0	0	0	0	n/a	n/a

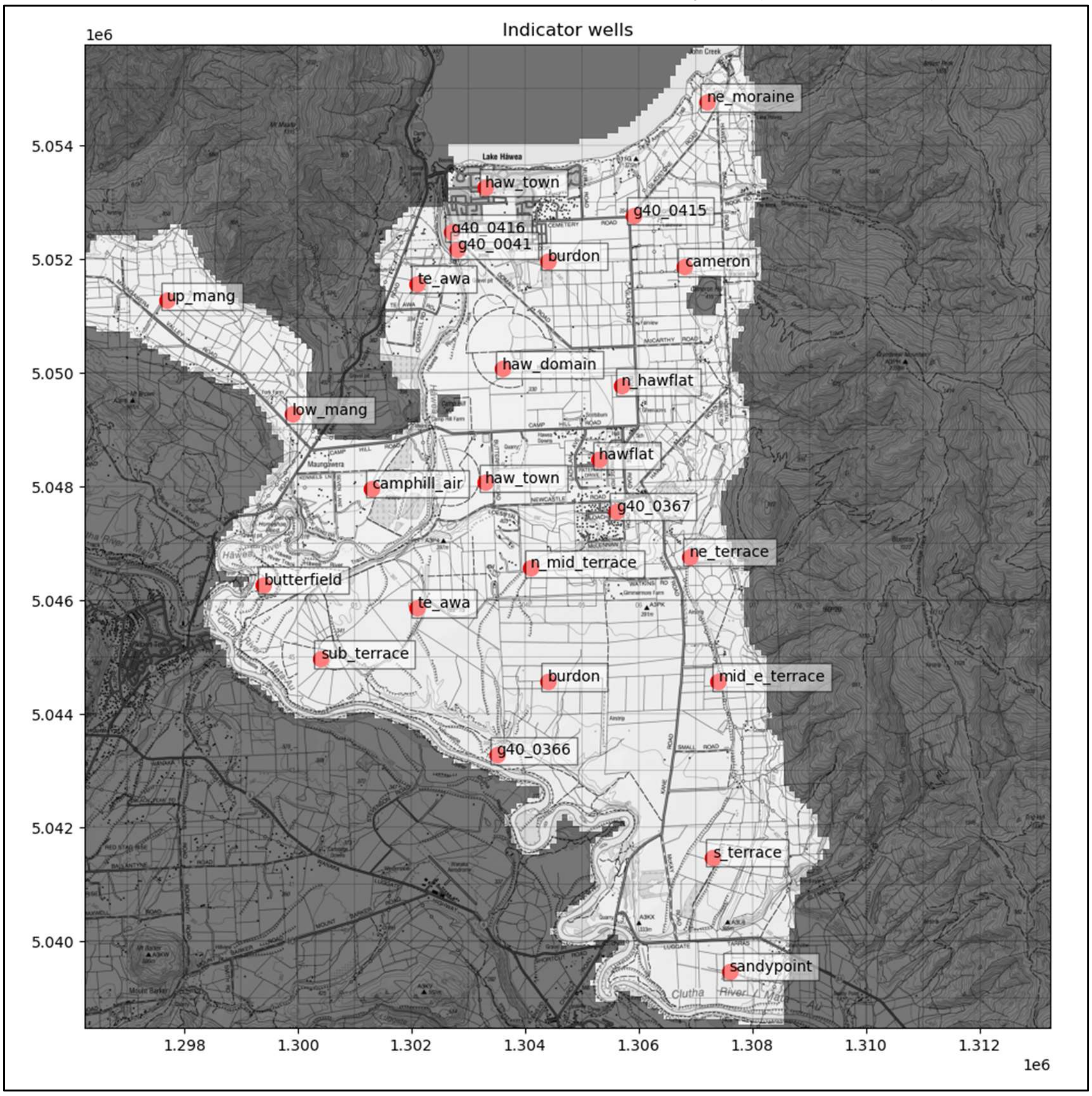
Table 1: Summary of existing zone allocation and estimated usage (from LAL, 2023)

2.3 Modelling scenarios

The impacts of the current abstraction and allocation and changes to them were assessed by numerical groundwater modelling of hydraulic heads (used as proxies for groundwater levels) in several indicator wells across the Hāwea Basin (Figure 1). The model used several abstraction scenarios, of which the most relevant are:

- **long_current scenario** presents the "current state" of abstraction. It is based on the mean weekly abstraction from the water metering data.
- **max_allocation_on_the_pump_curve (MAPC)** is the most realistic scenario for the maximum abstraction that can take place using the existing limits. It is based on the maximum daily allocation applied to the typological pump curve (developed using the metering data)
- **Increased allocation scenarios** – modelled a percentage increase of between 5 and 150% to the existing maximum daily allocation (MAPC) for the Hāwea Flat, Maungawera Flat, Te Awa, and the Terrace zones.
- **Reduction scenarios** were modelled for the Maungawera Flat zone, where the current maximum allocation was reduced by between 5 and 50%

Figure 1: Location of indicator wells used to simulate abstraction impacts (from LAL, 2023)



The results were then used to model the impact of pumping on groundwater levels and the bore users' reliability to access groundwater (bore interference). This was assessed by calculating the bores' adequate penetration depth, i.e. an indication that they are drilled sufficiently deep, calculated as the mean groundwater level in a given site minus three times the average seasonal fluctuation in groundwater level. Hence, an adequate depth must be deeper than this value. The model calculated the proportion of time when groundwater levels (i.e. hydraulic heads) in the bores are below this depth, when bore users' reliability to access groundwater is compromised and they may go dry.

However, some existing bores are likely to be shallower than this depth. The hydraulic heads were compared against adequate bore depths using two pumping scenarios:

- no groundwater pumping abstraction scenario (dryland recharge only) - long_nat
- The average weekly pumping - long_current

3. Results & main recommendations

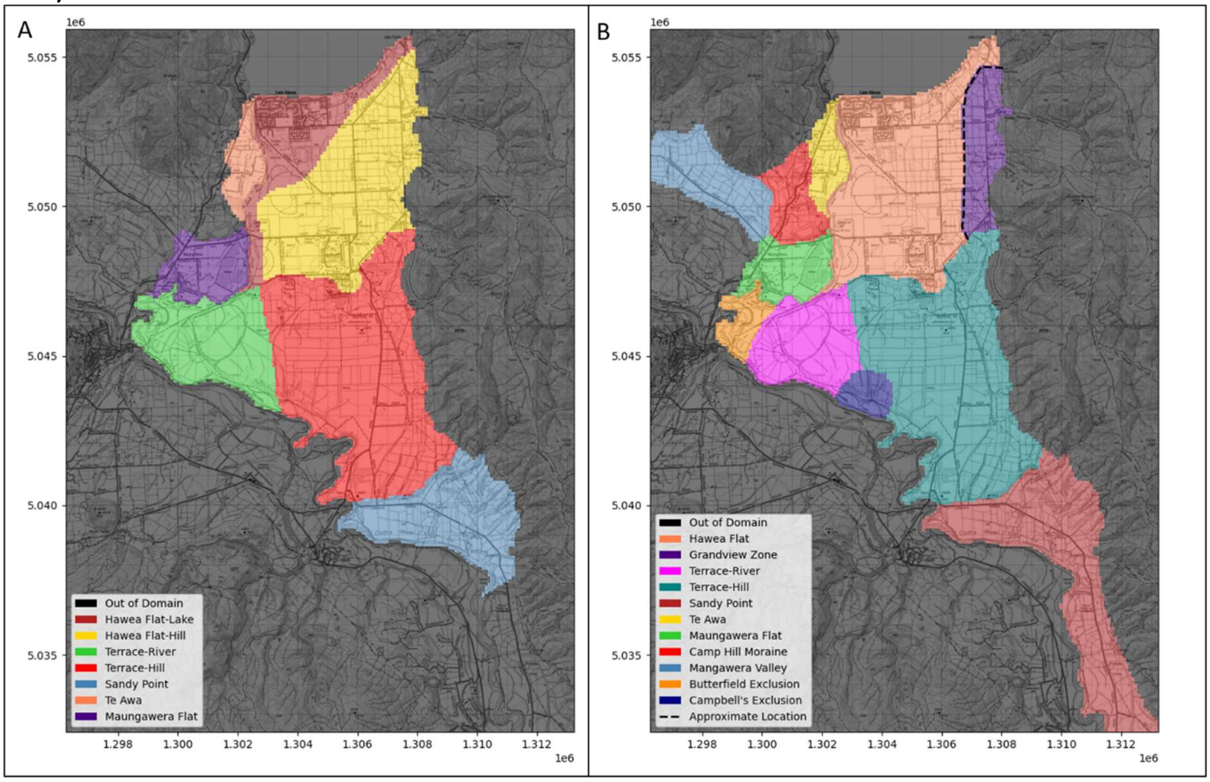
The relevant policy recommendations from the LAL (2023) report are described in the following sections, which also provide various options for allocation based on the modelling. The options are summarised in Table 2.

1) Changes to the boundaries and allocation volumes for some groundwater zones in the Hāwea basin (Section 3.1)
2) Restricting groundwater abstraction near wetlands (Section 3.2)
3) Distinguishing between bores that mainly abstract from surface water (stream depleting) and those that take from the aquifer (Section 3.3)
4) Management of Lake Hāwea levels to protect the aquifer (Section 3.4)

3.1. Changes to aquifer zone boundaries & allocation

The report suggested several changes to the existing boundaries and allocation volumes for some aquifers (groundwater zones) within the Hāwea basin. The current and proposed management zones are shown in Figure 2. The updated management zones will be incorporated to the proposed Land and Water Regional Plan (pLWRP). The recommendations for each zone are provided in Table 2.

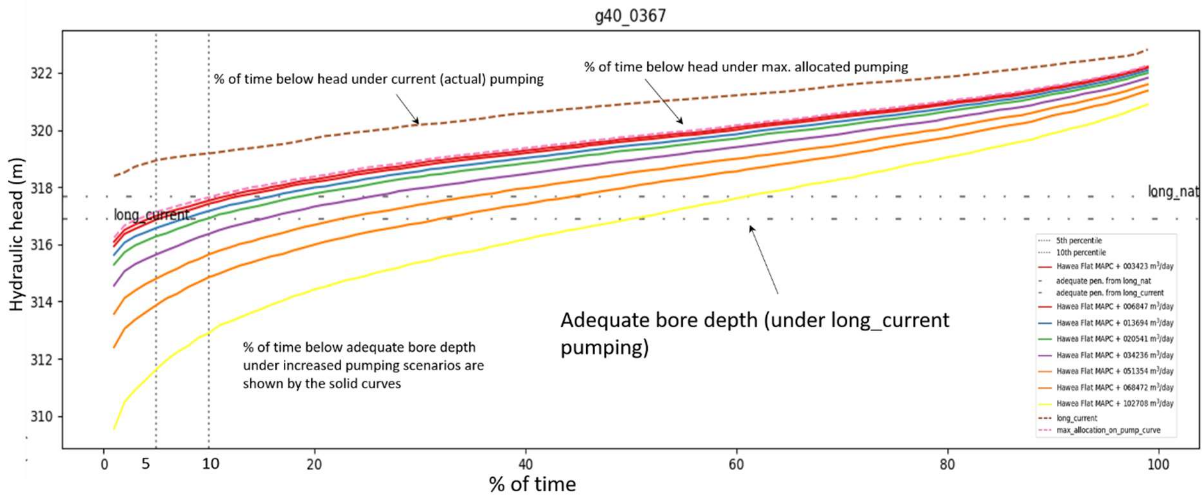
Figure 2: current (A) and recommended (B) groundwater allocation zones in the Hāwea Basin (from LAL, 2023)



a) Hāwea Flat (Lake & Hill) zone

LAL (2023) identified a strong connection between Lake Hāwea and groundwater levels in the existing Hāwea Flat – Hill and Hāwea Flat – Lake aquifers, with the lake providing substantial groundwater recharge. Based on the extent of recharge from the lake to these zones, it was recommended that the two are combined into a new, single Hāwea Flat zone with a proposed allocation based on the current two zones combined, i.e. 8,680,000m^3/year. The modelling of current and increased abstraction scenarios suggests that under the current abstraction (i.e., long_current) scenario groundwater levels in Hāwea Flat will not fall below the adequate penetration depths (Figure 3). Conversely, under the current maximum allocation (MAPC scenario) groundwater levels will fall below the adequate penetration depth for around 5% of the time, which reduces reliability of water supply for bore users. The scenarios of increased abstraction (solid horizontal curves) suggested that groundwater levels will be below the penetration depths, hence, reduced reliability, for higher portions of time. For instance, under the increased abstraction scenarios bore G40/0367, situated in Hāwea Flat, will be below the adequate penetration depth between 5 and 50% of the time. It is therefore recommended to carry forward the allocations of the two zones that comprise the newly created Hāwea Flat zone (8,680,000m^3/year).

Figure 3: Modelled hydraulic heads & percentile of time below them for bore G40/0367 under current (dashed curves) & increased (solid curves) pumping scenarios. Water levels below the adequate bore depth (horizontal line) imply lower reliability or dry bores for the corresponding portion of time [from LAL, 2023].



In addition to that, the model also suggested that the eastern edge of the basin is disconnected from the main Hāwea Flat zone by a geological fault which is likely to reduce or prevent the hydraulic connection and recharge from the lake. It is therefore recommended to designate this area near Grandview Ridge, north of Hospital Creek and between Hawea Back Road and Timaru Creek Road, as a separate allocation zone (e.g., the Grandview Zone, [LAL, 2023]). However, as there are several significant uncertainties about the location of the fault, the zone boundary and its hydrogeology several management options were suggested:

- Not allocating any groundwater from the zone apart from Permitted Activity (PA) takes
- Allocating no more than 50% of the zone's Land Surface Recharge (LSR), a component of Mean Annual Recharge (MAR), of 787,000m^3/year. The approach in the pLWRP is 35% of MAR (or LSR). However, due to the high uncertainties, it is worth considering an even more conservative approach, i.e. a lower portion of LSR.
- Require any potential takes from the Grandview zone that wish to be allocated groundwater from the Hāwea Flat zone to demonstrate that they are hydraulically connected to recharge

from the Hāwea Flat zone and Lake Hāwea (likely through groundwater monitoring and aquifer testing). Furthermore, as groundwater from the Grandview zone eventually recharges the Hāwea Flat zone, any water allocated from the Grandview zone should be subtracted from the Hāwea Flat zone allocation limit.

b) Terrace - Hillside zone

The Terrace Aquifer is distinct for several reasons: The northern edge of the aquifer is defined by glacial till that is interpreted to have low permeability; The Terrace has a distinctly higher elevation, approximately 60m, than Hāwea Flat; The elevation of basement is similar to Hāwea Flat Aquifer, hence, depths to basement are up to 115 m Below Ground Level (BGL); The depth to water is often as deep as 95 m (BGL); and the Terrace aquifer only has a few bores and only three groundwater takes that are not river-adjacent. The large river-adjacent takes mean that in practice there is very little abstraction from the Terrace Aquifer zone.

The Terrace Aquifer can be divided to two zones, each having different recharge sources. The western parts of the Terrace Aquifer (i.e. Riverside zone) are primarily recharged by Hāwea River losses originating from the riverbed downstream of Camphill Road, while the eastern flank of the aquifer (i.e. Hillside zone) is primarily replenished by hillside creek losses and LSR, substantially augmented by recent pasture irrigation. LAL (2023) defined a Terrace – Riverside zone and the remainder was delineated as a hillside zone (similar to Wilson, 2012). In addition to these zones, the model defined exclusion zones around the Regionally Significant Butterfield and Campbell Wetlands, located in the Terrace Aquifer zone (LAL, 2023).

Due to the large river-adjacent takes and the comparatively large depth to groundwater, groundwater use in the Terrace Hillside zone is light. It is also important to note that the adequate penetration depth under the long_current pumping scenario is shallower than the long_natural scenario (i.e. no irrigation). This is due to high use of river-depleting water that is transferred from outside the Hillside zone and used there instead of groundwater takes from within the zone. This water from outside the Hillside zone recharges and increases groundwater levels in the zone- if an equivalent amount of water was abstracted from interior of the Terrace Aquifer it would lead to lower levels. This indicates that in the absence of irrigation groundwater levels will be lower than their current levels, as illustrated by the penetration depths.

The modelling suggested that even a relatively small increase in the current abstraction (long_current scenario) will reduce reliability in bores. The MAPC scenario suggests that under the long_current scenario groundwater levels in several indicator wells will be below the adequate penetration depth for extended portion of the time e.g., the s_terrace well (60%), mid_terrace (15%), and ne_terrace (100%) wells. This suggests that the current allocation should be kept if the shallower long_current depth is used for assessing reliability. In contrast to that, if groundwater reliability is assessed against the long_natural depth, an additional 2,019m^3/day may be available before reliability is reduced. This addition will give an annual allocation limit of 454,275m^3/year, which is similar to the existing allocation of 410,000m^3/year (LAL, 2023).

It is recommended to take a conservative approach by maintaining the current allocation (410,000m^3/year) and using the long_current penetration depth for assessing reliability. In addition to the lower allocation limit, this approach is more conservative because the long_natural depth represents an unrealistic scenario (i.e. no irrigation). Furthermore, the Terrace Hillside is already over-allocated by around 945,000m^3/year, hence, increasing the allocation will be challenging.

c) *Terrace – River zone*

This zone has a small number of consented takes, with a large one situated on the sub-terrace on the southwestern portion of the zone. Increasing the abstraction to the MAPC scenario has minimal impact on groundwater levels in the zone apart from near the sub-terrace monitoring point, where the effects are likely local. However, the results suggest some impacts (e.g. the sub_terrace indicator well) where the long_current depth is shallower than the long_nat depth (similar to the Terrace Hillside zone). The scenarios suggest that 100% increase in pumping will not significantly reduce reliability relative to the deepest adequate penetration depth (which is the long_current for some indicator wells and long_nat for others). However, the division between the two Terrace zones is not a groundwater flow boundary, hence abstraction in one zone can impact levels in the other, especially near the boundary. The division aims to ensure that takes are appropriately distributed across the Terrace and avoid local over-allocation near the base of the Grandview Range. Therefore, any changes will need to consider the impact on both zones (LAL, 2023). Modelling suggests that pumping the full allocation in the Hillside zone alongside increased allocation in the Riverside zone can substantially lower groundwater levels in the centre of the Terrace, with levels even falling below the (deeper) long_natural adequate penetration depth.

One option is to maintain the current allocation, where usage is substantially below the maximum allocation limit (Table 1) and there is currently around 84,000m^3/year remaining to allocate. The model suggests that some increase is possible, but, if selected, it is suggested an increase of no more than 25% to the annual allocation volume, to an allocation of 1,710,500 m^3/year and a maximum daily take of 12,700m^3/day (a modest 10% increase from the current daily volume) [LAL, 2023].

d) *Sandy Point Zone*

The current groundwater use in the zone is minor (apart from river-depleting groundwater takes), currently at 56m^3/day and 13,233m^3/year, which is much lower than the annual allocation of 860,000m^3/year (Table 1). This allocation was based on Land Surface Recharge (LSR) estimation by Wilson (2012). The current study suggests that 50% of the mean LSR (using the current RPW approach) is 660,570m^3/year, hence, a mean LSR of 1,321,140m^3/year. It is recommended to allocate 35% of LSR, equivalent to 462,399m^3/year, consistent with the pLWRP. However, the zone is currently over-allocated by around 460,000m^3/year (Table 1), which will need to be addressed. In addition to that, there is currently very little monitoring data from this zone. Hence, further monitoring will be needed before any increases in future allocation.

e) *Maungawera Flat & Te Awa zone*

The Maungawera Flat and Te Awa zones are located on the western side of the Hāwea River yet they form part of the basin's groundwater system, alongside the Maungawera Valley and Camphill Moraine zones. These zones fringe the Hāwea River and are also currently served by the westside branch of the Hāwea Irrigation Scheme, sourced from Lake Hāwea at the Hāwea Dam. These zones currently have no consented groundwater takes and there is minimal groundwater information about them (Table 1). The results show that both zones can have significantly higher use before impacting reliability, suggesting that a high proportion of the additional water is sourced from depleting the Hāwea River. It is therefore important to determine what is the acceptable river depletion. A proposed conservative approach is to maintain the existing allocation limits of 297,000m^3 for the Te Awa and 570,000m^3 for the Maungawera Flat zones. As there is very little groundwater data and information from these zones, further monitoring will be required before any increases in future allocation.

f) *Camphill Moraine*

The Camphill Moraine is underlain by fine-grained glacial till deposits, considered to be largely non-productive. Although small capacity domestic or stock water bores may be feasible in this area, it is unlikely that consented groundwater takes for irrigation or industrial purposes will be viable due to its heterogeneity, low permeability, and low storage. Therefore, no allocation from the moraine was modelled. A proposed conservative approach is to not allocate any groundwater from the zone whilst retaining any PA takes (LAL, 2023).

g) Maungawera Valley

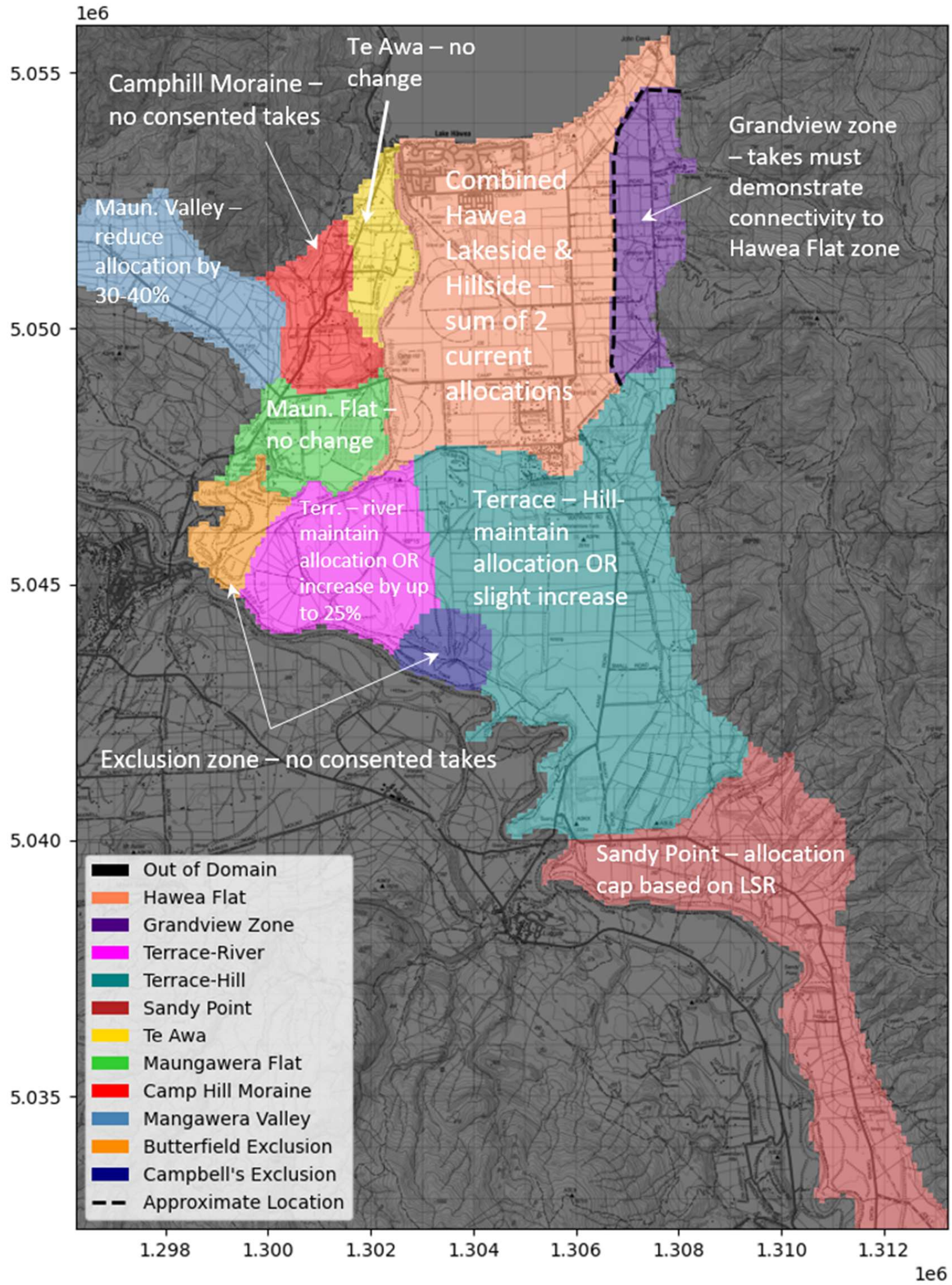
Groundwater recharge sources in the Maungawera Valley include LSR and hillside creek inflows. The transition from the Maungawera Valley and Maungawera Flat zones to the main basin is found at a distinct narrowing by the combined pinching of the Camphill Moraine and the basement schist near State Highway 6 (LAL, 2023). The Maungawera Valley is considered over allocated, with a limit of around 1.2 million m^3/year, and accordingly the report suggested a lower allocation. Nevertheless, the current usage is much lower than the allocation (Table 1). This current usage is consistent with maintaining bore reliability. However, increasing the abstraction to the MAPC will substantially reduce reliability, with water levels below the adequate penetration depth between 30-45% of the time. Due to that, scenarios of reducing allocation were modelled. The results show that a 30% reduction of the allocation (i.e. allocation of 847,000m^3/year) will result in groundwater levels below the adequate penetration depth for around 5% of the time while a 40% reduction (726,000m^3/year) will substantially reduce the time when water levels are below the depth. These reduced allocation volumes are substantially higher than the current water use, hence there is likely capacity for these reductions. It is therefore proposed to reduce the allocation by at least 30%. Similar to other areas, there is also paucity of information regarding groundwater levels in the Maungawera Valley, hence further monitoring will be needed if groundwater use increases in this zone.

h) Summary of modelling results & proposed allocation

- Several zones are over allocated – this means that if users took their full consented amount of groundwater, levels would lower to an unacceptable level impacting on bore reliability. However, the estimated actual use is only between 25-40% of the consented or 'paper' allocation (Table 1).
- It is recommended to combine the current Hāwea Flat Lakeside & Hillside zones into a single Hāwea Flat zone. The eastern part of the basin should be delineated as a separate zone (Grandview).
- Under the current allocation & usage scenario (long_current) groundwater levels in Hāwea Flat, Terrace Hill & River, Maungawera Flat & Valley, and Te Awa zones are likely to be consistent with maintaining bore reliability, i.e. above the adequate penetration depth. The only exception is one indicator well in the Terrace Hill zone (s_terrace).
- Under the maximum allocation (MAPC) scenario groundwater levels in indicator wells in Hāwea Flat (3%), Terrace-Hill (5-8%), Terrace River (45%) and Maungawera Valley (30-45%) will be below the adequate penetration depth for the respective portion of the time, hence reduced reliability for accessing groundwater, where bores may go dry
- Modelling suggests that higher allocation will lower reliability and increase the frequency of bores drying in most zones. Under increased allocation groundwater levels in indicator wells are projected to fall below the adequate penetration depth for higher proportion of the time, notably in the Hāwea Flat (12-26%), Terrace Hill (11-60%), and Terrace River (15-20%) zones
- The modelling suggests that the current usage in the Maungawera Valley zone is consistent with maintaining groundwater levels. However, increasing the actual abstraction to the maximum allocation will substantially reduce reliability. It is therefore suggested to reduce allocation by at least 30%.

- The main effects from the model and recommended changes are noted below. These are shown illustrated in Table 2 and Figure 4:
    - Reduce the allocation in the Maungawera Valley and Sandy Point zones.
    - Keep the same allocation for the Hāwea Flat, Te Awa, Maungawera Flat, and both Terrace zones
    - The model added the Maungawera Valley, Grandview, & Camphill Moraine zones and the wetlands exclusion zones (section 3.4).

Figure 4: Zone-specific recommendations for the Hāwea basin



Aquifer	current allocation (m^3/a)	current consented (m^3/yr)	Difference (m^3/yr)	Estimated aver. use (m^3/yr) & % of current allocation	proposed allocation (m^3/yr)	comments	Science recommendation?
Hāwea Flat Lakeside	4,600,000	2,337,015	2,262,985			•The model suggests that under the current allocation groundwater levels are not expected to fall below the adequate penetration depth. Conversely, the MAPC scenario suggests that bores in Hāwea Flat will be below the adequate depth around 5% of the time. •Increasing the allocation above the current volumes will increase the duration when bores are below the adequate depth by up to around 50% of the time.	
Hāwea Flat Hillside	4,080,000	4,585,896	-505,896				
Hāwea Flat (new zone)		6,922,911	1,757,089	2,499,733 (36% of allocated)	8,680,000		Maintain current annual allocation by combining the volumes of the two current zones.
Grandview Zone			Due to the high uncertainty about the zone's boundary & hydrogeology there are three potential options: a) No groundwater allocated apart from PA takes. b) Allocating up to 50% of the zone's LSR of 787,000m^3/year. Due to the uncertainties, it is worth considering a more conservative approach (i.e. less than 35% LSR) c) Takes from the zone that wish to be included in the Hāwea Flat allocation will need to demonstrate they are hydraulically-connected to recharge from the Hawea Flat zone & Lake Hāwea. Any water allocated in the Grandview zone will then needed to be deducted from the Hāwea Flat allocation limit.				Option C, although the exact details will still need finalising
Terrace – Hillside	410,000	1,355,263	-945,263	23,500 (6%)	a. 410,000 (current) **OR** b. 454,275 (equiv. to +2,019m^3/day)	•Despite light groundwater use, the model suggests that even a small increase in current pumping will reduce reliability, with levels falling below the long_current depth for around 5% of the time •If the long_natural depth is used as a reliability indicator (rather than the shallower long_current), the model suggests that the allocation can slightly rise by a maximum of 2,019m^3/day (i.e. allocation of 454,275m^3/yr), before impacting reliability	Maintain current annual allocation volumes
Terrace – Riverside	1,560,000	1,475,111	84,889	322,376 (21%)	a. 1,560,000 (current) b. **OR** 1,710,500 (up to 25% increase)	•Increasing the allocation to the MAPC or above it will have minimal impacts on groundwater levels in this zone, apart from near the sub-terrace indicator well. However, as the division between the two Terrace zones is not a groundwater flow boundary, takes in one zone can impact the other. •Full allocation of the Hillside zone & increased allocation in the Riverside can lower groundwater levels in the centre of the Terrace, even below the long_nat depth •If an increased allocation is considered, a conservative increase of <25% (1,710,500m^3/year) is suggested.	Maintain current allocation volumes
Sandy Point	860,000	1,321,560	-461,560	7,563 (0.88%)	462,399m^3/year (35% of LSR)	•The modelling suggests capping the allocation based on a portion of the LSR for the zone (total of 1,321,140m^3/year).	Reduce annual allocation to 35% LSR (462,399m^3/year)
Te Awa Aquifer	297,000			0	297,000 (current)	•The model suggests that the allocation for the zone can be increased, but may deplete the Hāwea river. •Conservative approach is to maintain the current allocation	Maintain current annual allocation volumes
Maungawera Flat	570,000	183,204	386,796	0	570,000 (current)	•The model suggests that the allocation for the zone can be increased, but may deplete the Hāwea river. •Conservative approach is to maintain the current allocation	Maintain current annual allocation volumes
Maungawera Valley	1,210,000	1,228,355	-22,747	162,066 (13%)	a. 847,000 (-30%) **OR** b.726,000 (-40%)	•Current abstraction is consistent with maintaining reliability for bore users •Increasing takes to the MAPC will substantially reduce reliability. The modelling suggests reducing the allocation by 30-40% in order to maintain reliability	Reduce annual allocation by 40% (to 726,000m^3)

Table 2: summary of zone-specific modelling results and recommendations. Zones where the difference is denoted in green currently have available water. Over-allocated zones are shown in red. The average use is based on the existing times 135 days (obtained from the LAL [2023] pump curve). The recommendations are coloured coded by keeping current annual volumes (blue), reduce annual volumes (pink), and zone-specific recommendations (yellow).

3.2 Groundwater abstraction near wetlands

The Hāwea basin contains the Campbell and Butterfield significant wetlands. The impact of groundwater pumping on the wetlands was modelled and an exclusion zone for each wetland, where no groundwater abstraction is to take place, was mapped (Figure 1). It is suggested to prohibit/restrict any groundwater takes apart from PA. The latter can be located as far away from the wetlands as possible through ORC's discretion over bore locations.

3.3 Clearer classification of groundwater/surface water take

The distinction between river proximal galleries (i.e. stream-depleting groundwater takes) and true groundwater abstraction should be better constrained. The model suggests that transferring all the river proximal (i.e. stream-depleting) takes in the Hāwea domain into the centre of the aquifer is likely to significantly lower groundwater levels (LAL, 2023). It is planned to address this matter by the proposed changes to stream depletion management in the pLWRP.

3.4 Management of Lake Hāwea Levels to protect the aquifer

The report identified strong connection between groundwater in Lake Hāwea, where the lake provides substantial recharge and affects groundwater levels in the aquifer. It also identified the likely existence of a band of low conductivity sediments that cause a sharp gradient between the lake and groundwater levels (analogous to an underground waterfall). The precise nature and elevation of this band is unknown, but the report estimates it to be between 327 – 337mASL, which is below the current lower range of operation. A fall in lake levels below this elevation will therefore cause a sharp decline in groundwater levels in the basin (substantially affecting reliability), particularly if lake levels remain below this level for an extended time period (LAL, 2023). Although this does not affect the current planning and management provisions, this impact should be noted and assessed as part of any future considerations for lake management when the Hāwea hydroelectric power generation consent is reviewed or due for renewal.

4. Other matters for consideration

Despite its limitations, this study substantially improves groundwater knowledge in the Hāwea basin and the impact of different pumping scenarios. However, there are several matters that are not directly science-related, where the decision is likely to need input from Policy and the community:

- The report suggested that it may be possible to increase the allocation in some zones, including ones that are currently overallocated. What is the community's view?
- Managing over-allocation and actual usage substantially below the allocation limits
- The modelled impacts on groundwater levels assume that bores are adequately penetrating. However, many domestic bores are likely to not be adequately penetrating, hence their water levels are likely to be affected by the current and potentially increased allocation. These lower levels may be further exacerbated by future climate change, lower rainfall, and lower lake levels. What is the acceptable portion of time when bores can have low water levels?
- The model suggests that groundwater abstraction in some zones is connected to and is depleting the Hāwea River. What is the acceptable level of river depletion?
- The model did not consider the impacts of current and future abstraction on groundwater quality. As further increase in allocation will lead to irrigation and landuse intensification, which may adversely impact groundwater quality. What are the community views regarding that?

- It is proposed to install new groundwater SoE monitoring bores in the Maungawera Valley and Sandy Point zones, where there is currently very little information. This data will increase the understanding of groundwater flow in these zones and help to improve their management.

5. References

Kitteridge, M. 2022. *Hāwea Water Usage Processing*. Hāwea Groundwater modelling project, Report 1052-08-01 R1.

Lincoln Agritech Limited (2022). Hawea Basin Current State Review. Report 1052-08-01R1.

Lincoln Agritech Limited (2023). *Hāwea Basin groundwater model & allocation review*. Prepared by Matt Dumont, Jens Rekker, and Zeb Etheridge. 161 pages.

Wilson, S (2012). Hāwea Basin Groundwater Review. Prepared by Resource Science Unit of Otago Regional Council, June 2012, Dunedin. 69 pages.