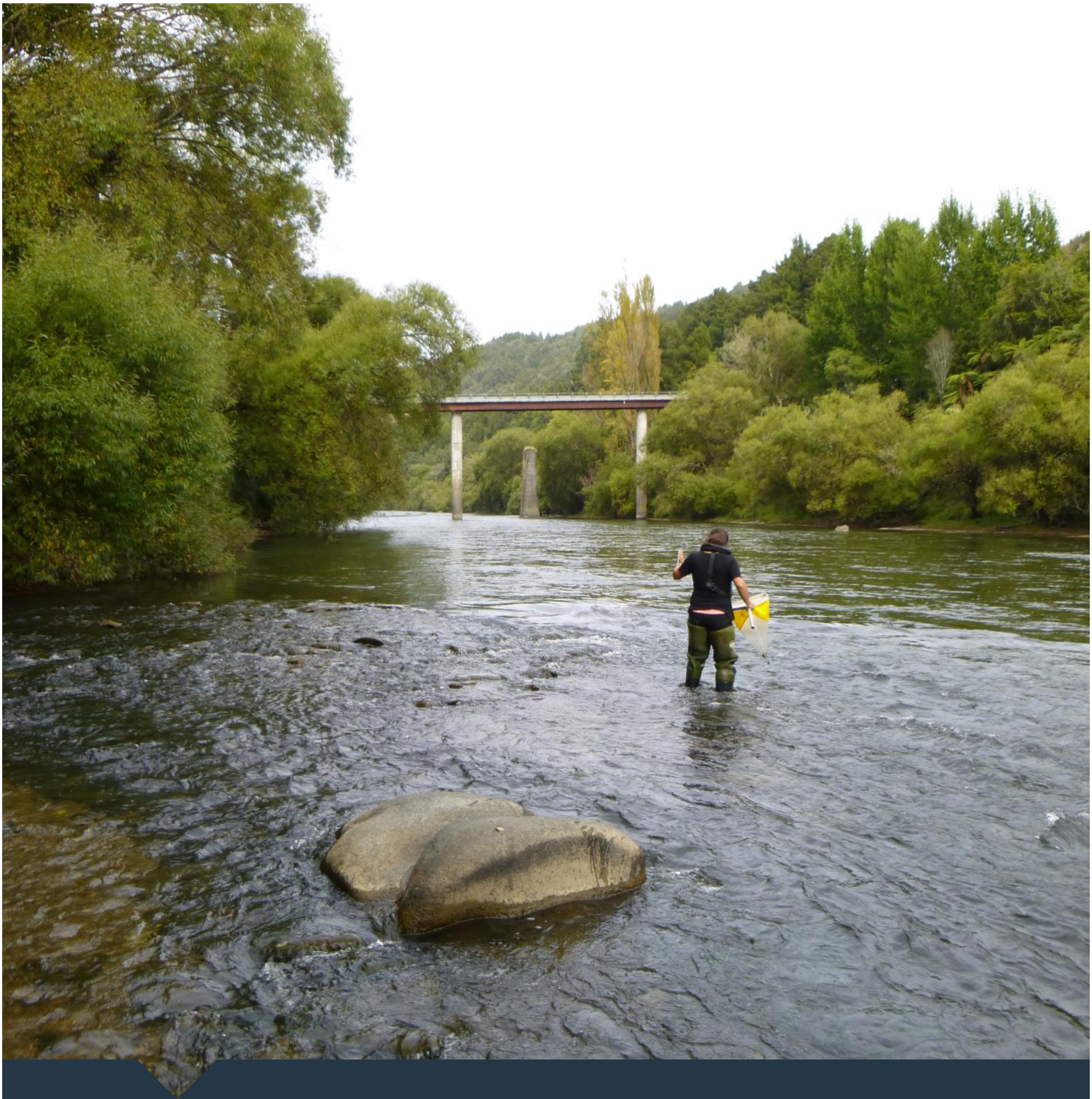

Rangitīkei Groundwater Management Zone Allocation Limit

September 2023

horizons
REGIONAL COUNCIL

Prepared for:

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September 2023
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Rangitīkei Groundwater Management Zone Allocation Limit

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Horizons Regional Council

September 2023

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Limitations:

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Executive Summary

This report was prepared to assist with setting an updated groundwater allocation limit for the Rangitīkei groundwater management zone. A computer model was developed and updated to represent the groundwater system in the area which generally represents the patterns of groundwater levels observed in bores within the zone.

Some observed groundwater levels in the Rangitīkei zone show a long term declining trend in recent years, which appears to correlate with an increase in actual groundwater abstraction in the area. The model also suggests that the decline is a result of increased abstraction. The current scale of decline does not appear to have resulted in substantial effects on surface water, or the risk of saline intrusion. Three scenarios were run using the model to simulate how groundwater levels may change under different groundwater use options.

Under two of the scenarios, where groundwater use continued at current levels, or increased by around 33%, the model indicates that groundwater levels will continue to decline. Particularly under the increased abstraction scenario, the scale of the decline implied potentially adverse effects on surface water bodies and an increased risk of saline intrusion within a 10 year timeframe. These declines imply that current groundwater use, and therefore groundwater allocation, is not at sustainable levels and that actual groundwater use may need to reduce.

A scenario simulating the effect of reducing actual groundwater use by 30% indicated that groundwater would likely stabilise at a similar level to current levels. Therefore, an interim allocation limit is recommended that is no more than the current level of allocation, which is around 75% of the allocation limit set within the One Plan.

To reduce actual groundwater use to a point where groundwater levels stabilise, a staged approach is recommended, which initially seeks voluntary reductions in water use from current consent holders and then looks to implement greater water efficiency requirements over a timeframe of around 5 years before finally implementing a consent review based on further monitoring.

A revised groundwater management zone boundary is also proposed which better accounts for groundwater flow directions and aligns the allocation zone with groundwater recharge zones.

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1.0 Introduction

This report has been prepared by Pattle Delamore Partners on behalf of Horizons Regional Council to assist with groundwater allocation in the Rangitīkei Groundwater Management Zone. Groundwater allocation limits in the Horizons region are set out in Schedule D of the One Plan, which specifies a numeric annual allocation limit for each of the groundwater management zones that are defined across the region. These limits were originally defined in 2010 as 5 % of total annual rainfall across each zone on the basis that such a limit was thought to be a conservative proportion of the estimated groundwater recharge occurring within the zone.

Since that time, the total volume of groundwater take consents within the Rangitīkei groundwater management zone has increased, although it remains within the One Plan allocation limit. However, in some areas of the Rangitīkei zone this increase correlates with a persistent, long term declining pattern in groundwater levels since around 2005.

Patterns in long term groundwater levels provide a representation of the long term balance between recharge to, and discharge from, a groundwater system. Where groundwater levels show a long term declining pattern, recharge to a groundwater system is less than discharge whereas a long term rising pattern indicates that recharge to a groundwater system is greater than discharge. Discharge from a groundwater system includes groundwater abstractions and naturally occurring discharges into surface water bodies (streams, rivers and the ocean).

Groundwater modelling was undertaken by PDP on behalf of Horizons (PDP, 2015) to help identify the cause of the declining trend observed in several bores in the Santoft area of the Rangitīkei groundwater management zone. The results of the modelling indicated that the decline was likely to be the result of increases in groundwater abstraction rather than changes in recharge to the groundwater system.

In addition, scenario runs using the groundwater model suggested that groundwater levels would continue to decline if abstraction continued at the rates observed between 2010 and 2014, if recharge patterns also remained similar. That model prediction has been largely borne out through continued observation of groundwater levels since 2014, which have continued to decline. The model also predicted declines in shallow groundwater levels which will affect surface water bodies such as the coastal lakes. Long term model predictions, assuming a continued pattern of recharge, suggested that the groundwater system may eventually reach equilibrium in 30 to 40 years, at much lower groundwater levels than currently exist.

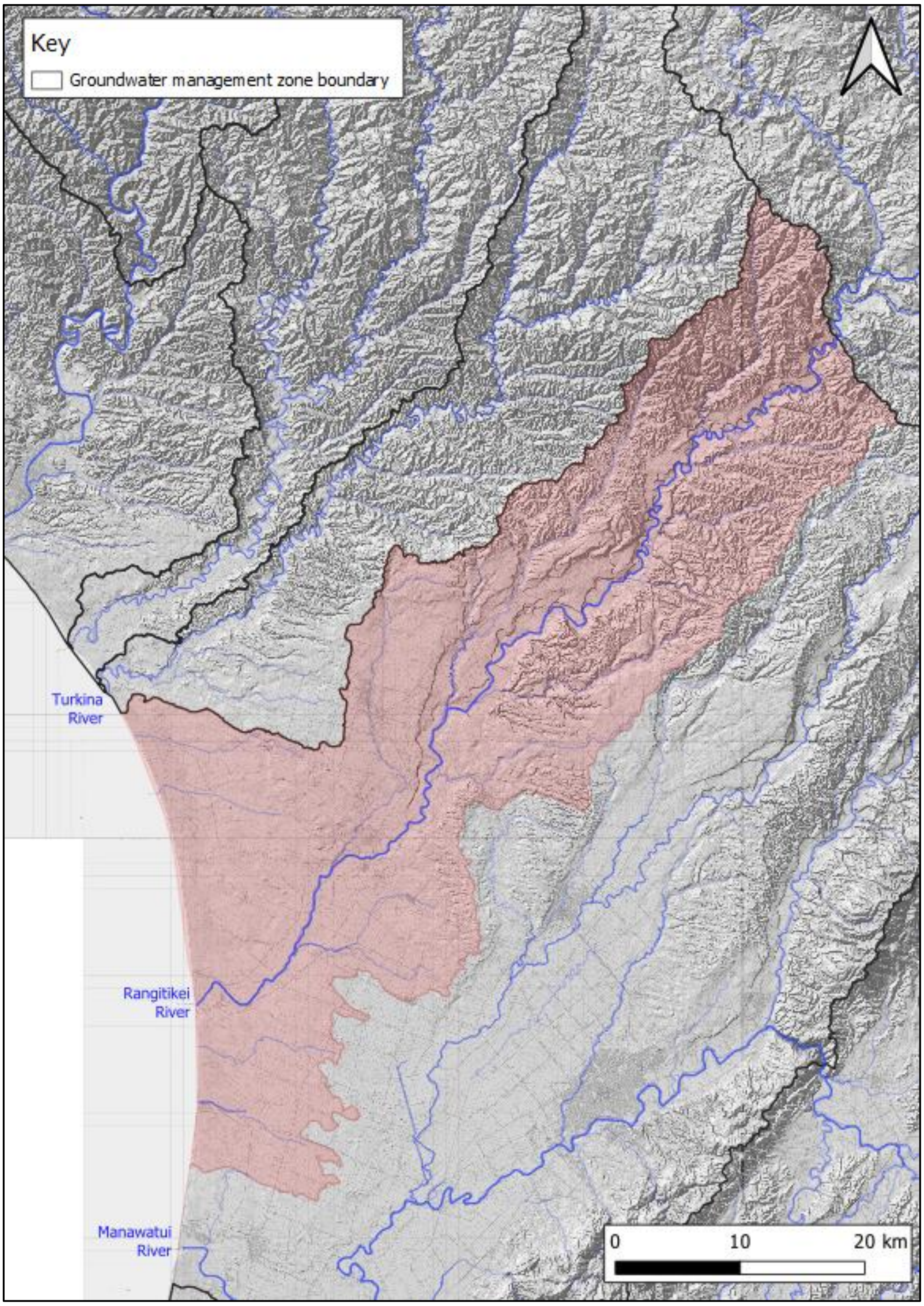


Figure 1: Map of the Rangitīkei groundwater management zone (highlighted in pink)

Many groundwater consents in the Rangitīkei groundwater management zone are in the process of being renewed, or will be renewed in the next 2 to 3 years. Applications to increase the consented groundwater abstraction volume have also been submitted. Against a backdrop of declining groundwater levels and legislative direction to manage freshwater in a sustainable manner, any increase in the allocation of groundwater, or even renewal of existing consents may be unwise , despite the available groundwater allocation within the One Plan limit. As a result, Horizons is investigating updating the groundwater allocation limit so that it is consistent with national, statutory instruments (e.g. the National Policy Statement for Freshwater Management (NPS-FM), 2020).

This report has been prepared to assist with setting an updated groundwater allocation limit for the Rangitīkei groundwater management zone. A computer model has been developed to represent the groundwater system in the area and a number of scenarios have been run to simulate how changes in groundwater use may affect patterns of groundwater levels. The results of the scenarios have been assessed to determine a potential sustainable long term groundwater allocation limit.

A map showing the Rangitīkei groundwater management zone is provided in Figure 1.

2.0 Model description

2.1 Conceptual model

The conceptual model of groundwater movement in the Rangitīkei groundwater management zone, and more specifically the Santoft area, is described in PDP (2015). A brief summary of the conceptual model is presented below.

The majority of recharge into groundwater in the area is likely to be a result of rainfall infiltration. Data from gauging surveys along the Rangitīkei River do not obviously imply that there are large losses from the major rivers (i.e. the Rangitīkei and the Turakina Rivers) that would have large effects on groundwater levels.

Spatial plots of groundwater level contours (Appendix A) show that the general flow direction is towards the coast, although around Bulls the pattern of groundwater levels suggests that there is some discharge of groundwater into the Rangitīkei River. The effect is pronounced in data from shallow bores, but more muted in data from deeper bores.

Groundwater level time series indicate that seasonal groundwater level fluctuations are typically small although some seasonal variation occurs. Longer term rising trends in some bores are most likely be related to long term variations in rainfall. Long term rainfall patterns (from 1970 to 2022) show that rainfall was greater than average in the period from 1990 to 2011, which largely coincides with the rising pattern in some groundwater levels. Indeed, the rising pattern of groundwater levels can only be explained as a result of greater than average recharge to the groundwater system. However, the effect is spatially variable as some groundwater levels are generally stable or show a much smaller rise.

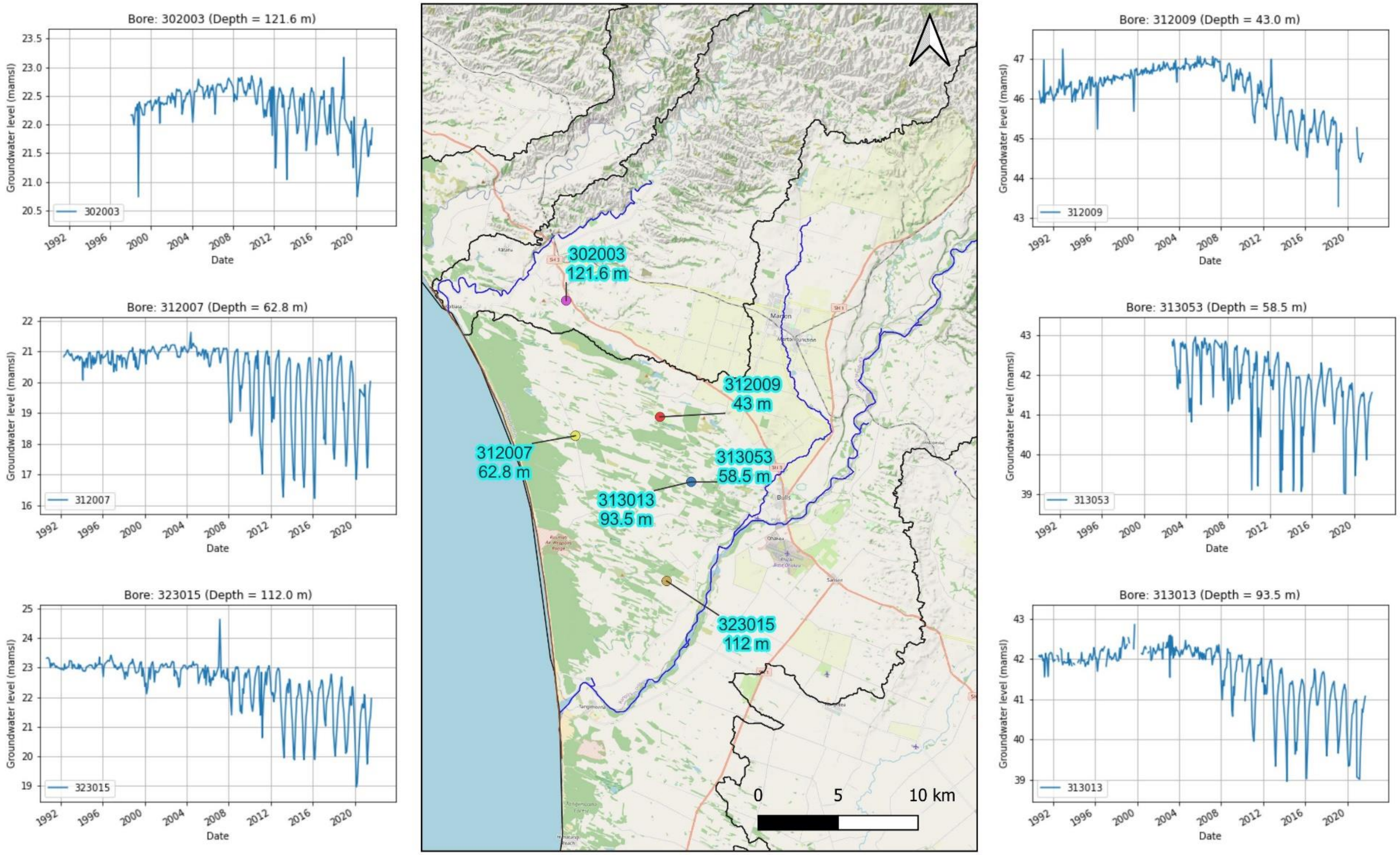


Figure 2: Locations of selected groundwater level observations and associated groundwater level timeseries

A plot showing the location of selected long term monitoring bores, as well as the timeseries associated with each bore is shown in Figure 2.

In some bores located towards the coast, declining trends now occur, most likely as a result of increased groundwater abstraction. Note that the declines observed started around 2005 and may not be directly related to trends in climate, as evidenced by plots of the cumulative deviation in long term average annual rainfall.

Pumping tests in bores indicate an apparent pattern of higher permeability in bores located in strata closer to the sea outfall of the Rangitīkei River, compared to bores in strata located to the north and inland. That overall pattern may suggest that the strata that occurs between the Rangitīkei River and the Turakina River to the north has a generally lower permeability, which may be consistent with a low rate of recharge and apparent abstraction effects on groundwater levels. The large vertically downwards gradients that occur inland may also imply a low vertical permeability in that area.

Pumping tests also generally indicate a low value of groundwater storage within the strata. In combination with a small seasonal variation in groundwater levels, that also implies that rainfall recharge slowly infiltrates to deeper strata. If rainfall recharge infiltrated rapidly to deeper strata, then larger seasonal variation may be expected.

In the area between the Turakina and Rangitīkei Rivers, most groundwater is likely to discharge offshore. However some of that groundwater is likely to migrate into shallow strata, which may then subsequently discharge into spring fed streams in the area. Closer to the main Turakina and Rangitīkei Rivers, some groundwater discharge to those surface water ways is likely to occur, although contours of observed groundwater movement do not imply that is a large effect.

Groundwater abstractions within 5 km of the coast are required to monitor electrical conductivity in bores, either on a continuous basis or based on manual readings. Recent analysis of the data from some takes close to the coast (around 100 m deep) indicates that as groundwater levels drawdown when a bore is pumped, electrical conductivity increases. As pumping ceases, electrical conductivity reduces (as shown in Figure 3). In the data available from the Hyde Park Farms bore (AUTH-2006011251.03, bore 312012), no long term pattern was evident and the electrical conductivity does not exceed threshold values set within the consent conditions.

This information does however indicate a potential connection between deeper strata and a coastal outflow, with the increase in electrical conductivity caused by movement of saline water towards the pumping bore. Although this effect is currently small, in the long term, there is a risk that continuation of such a trend could contaminate the parts of the aquifer to such an extent that it becomes unusable as a source of abstraction.

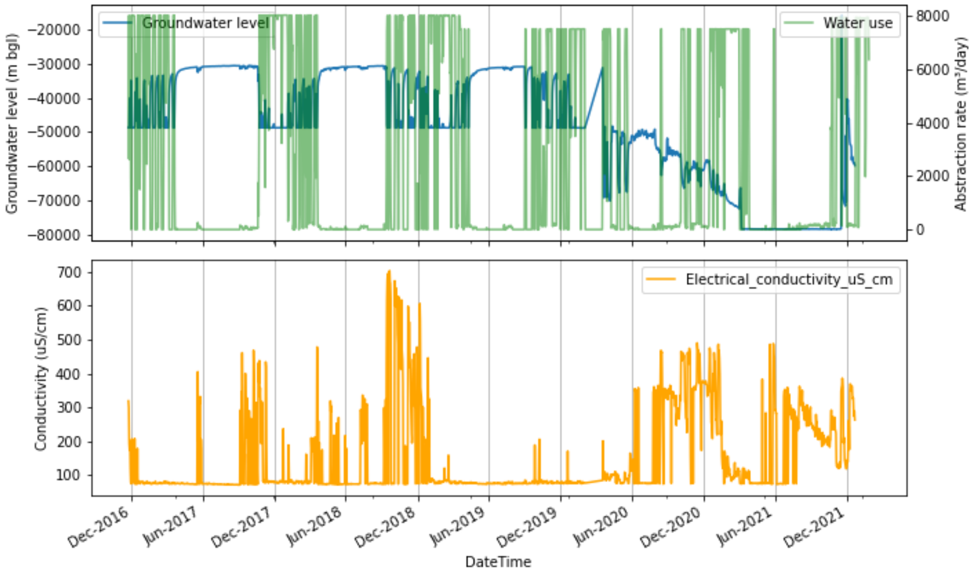


Figure 3: Groundwater levels, electrical conductivity, and water use data for the Hyde Park Farms consent (ATH-2006011251)

2.2 Model design

The original groundwater model (PDP, 2015) was developed using MODFLOW-NWT and was calibrated to groundwater levels between 1990 and 2015. The original model has been updated as part of this work but the overall model design has not been changed, and the same geometry and layering has been used, together with the same model boundaries. A map showing the model area and the location of the key model boundaries is provided in Figure 4.

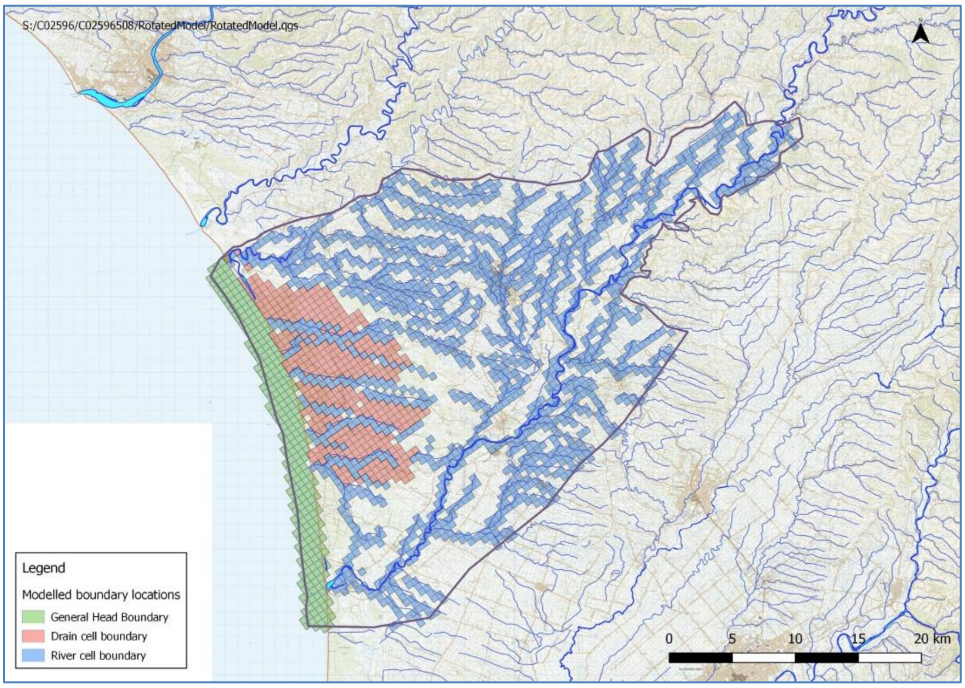


Figure 4: Locations of key model boundaries

Updates to the model included extending the model simulation time to July 2022 and updating the model to use the USGS MODFLOW 6 computer code. The model was also recalibrated to account for the extended and updated datasets. Updated datasets included:

- Updated recharge data
- Updated groundwater abstraction data
- Updated observation bore data (used to calibrate the model).

Recharge data

The original model recharge was calculated using rainfall and potential evapotranspiration data from the NIWA Virtual Climate Station Network. However, updated data to cover the 2015 – 2022 period was not available from the VCSN. Therefore, the recharge model was rerun using rainfall and PET data collected from the Horizons climate station network, as well as publicly available data from the NIWA Cliflo database. These daily data were interpolated onto the model grid using Theissen polygons to create a series of gridded daily rainfall and PET data.

Daily rainfall and PET data were then used within the daily soil moisture balance/recharge model (based on the Rushton method). Note that the recharge model was also updated to allow for a lagged recharge effect in some areas of the model where groundwater levels were more than 20 m deep, as indicated by observed groundwater level data. Broadly, this area is inland of SH3. The lagged effect was achieved by applying a limit to the drainage rate from the soil store to the groundwater recharge store which simulated the smoothing effect of seasonal recharge through a substantial unsaturated zone.

Groundwater abstraction data

Groundwater abstraction data was also updated as part of the updates to the groundwater model. Some groundwater use data is available from data provided to Horizons by consent holders but this data does appear to include gaps, for example where a consent is active (i.e. between the consent start and end dates) but no water use data is available. A summary of where water use data is available compared to consent start and end dates is provided in Figure 4.

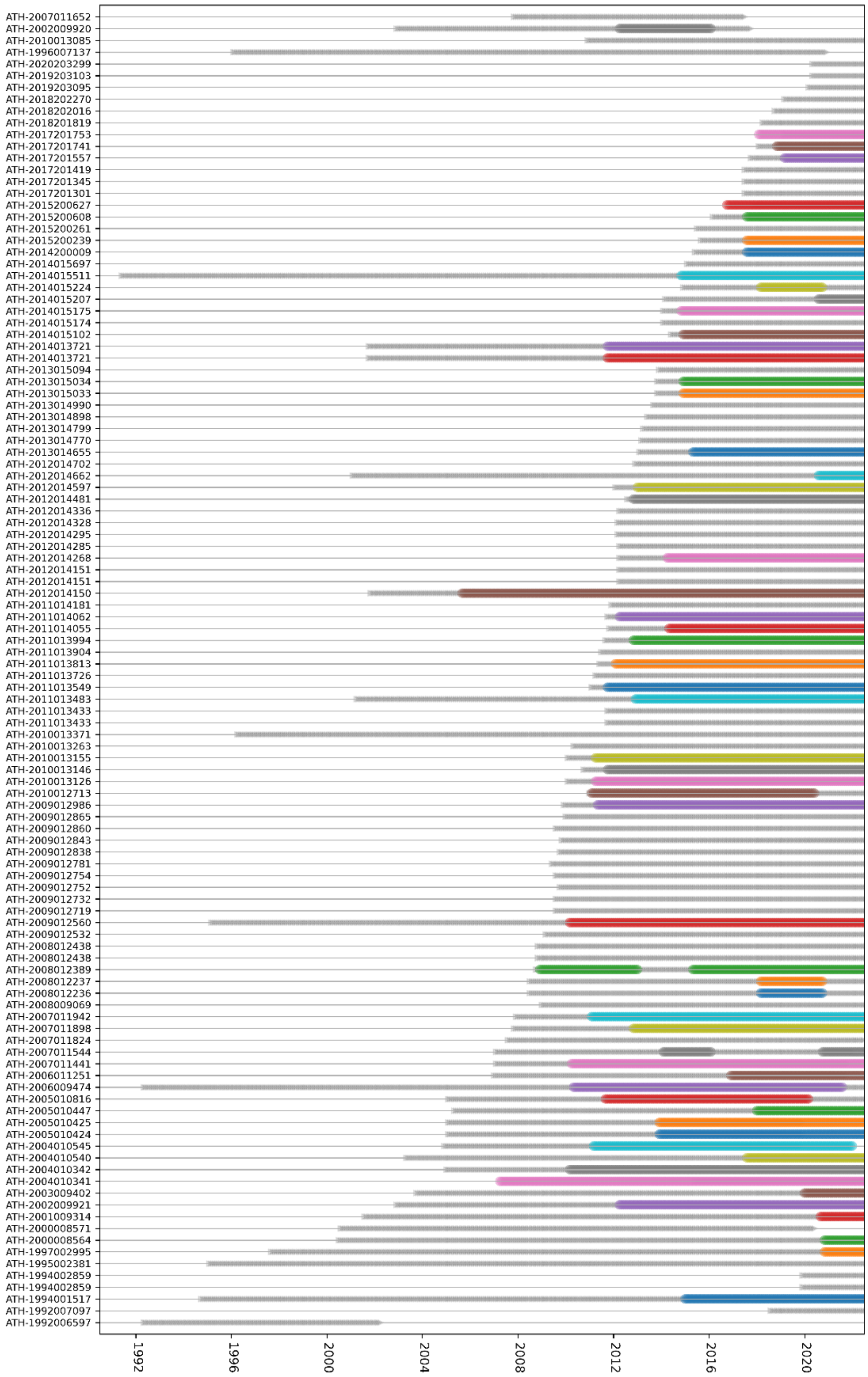


Figure 5: Consent start and end times (grey bars) and water use data availability (coloured bars)

As is evident from Figure 5, there are some gaps in the water use record. Given the decline in groundwater levels in the Santoft area is correlated to an increase in abstraction, groundwater use data is a critical input to model. Therefore, gaps in the datasets were infilled based on typical use patterns from nearby bores using water for the same purpose (i.e. irrigation, stockwater etc.) calculated as a proportion of the daily consented volume.

This is not a perfect means by which to infill gaps and, as will become apparent in section 2.3 of this report, this approach certainly results in potential errors in the abstraction timeseries used in the groundwater model. Figure 6 shows the proportion of actual use data to infilled data used in the model.

Overall, Figure 6 indicates that the consented rate of abstraction has remained relatively stable over the last five years (i.e since around 2018), although there have been variations in actual use. This stable consented rate is helpful for informing subsequent scenarios of groundwater use patterns.

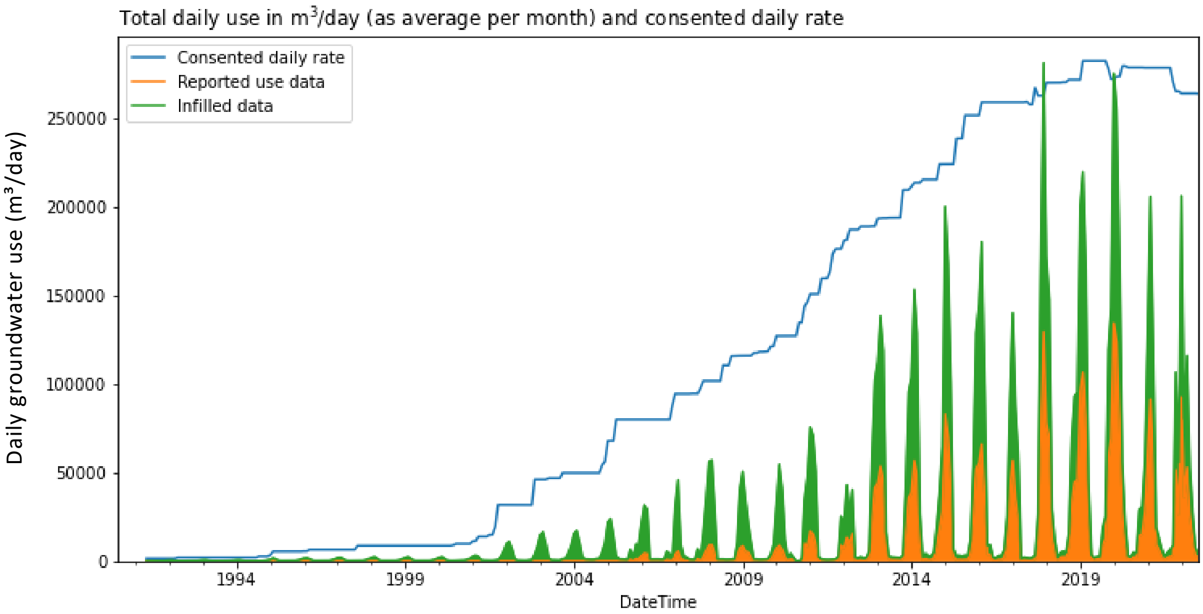


Figure 6: Actual use data and infilled data (as a stacked graph).

2.3 Model results

The model was calibrated to groundwater level timeseries for bores within the model area. Figure 7 shows the location of the bores and Figure 8 shows a comparison between the modelled and observed timeseries. Note that the model was calibrated both to annual maxima as well as monthly measured groundwater level data as the annual maxima allowed the long term trends to be better matched during the calibration process. The aim of the model is to predict the effect of abstraction on long term groundwater level trends and therefore greater weight was given to matching the annual maximum water levels because this ensured that the long term trends were better matched by the model, rather than short term seasonal changes.

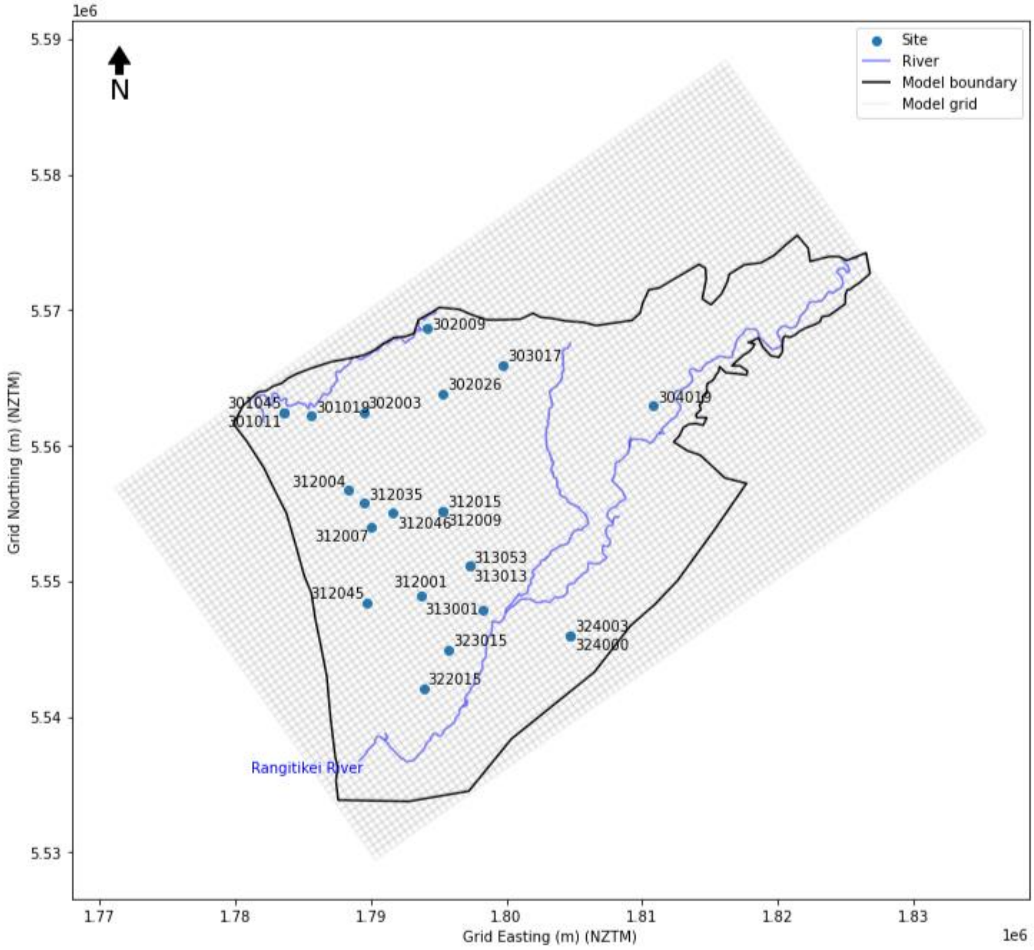


Figure 7: Monitoring bore locations

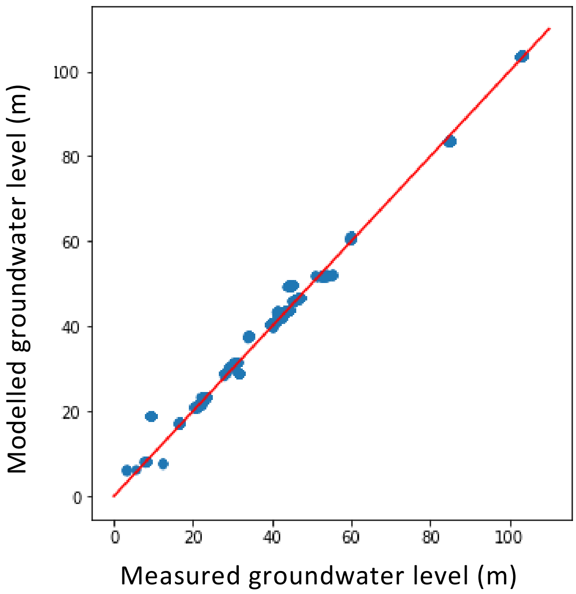


Figure 8: One to one plot comparing measured and modelled maximum annual groundwater levels (m above mean sea level)

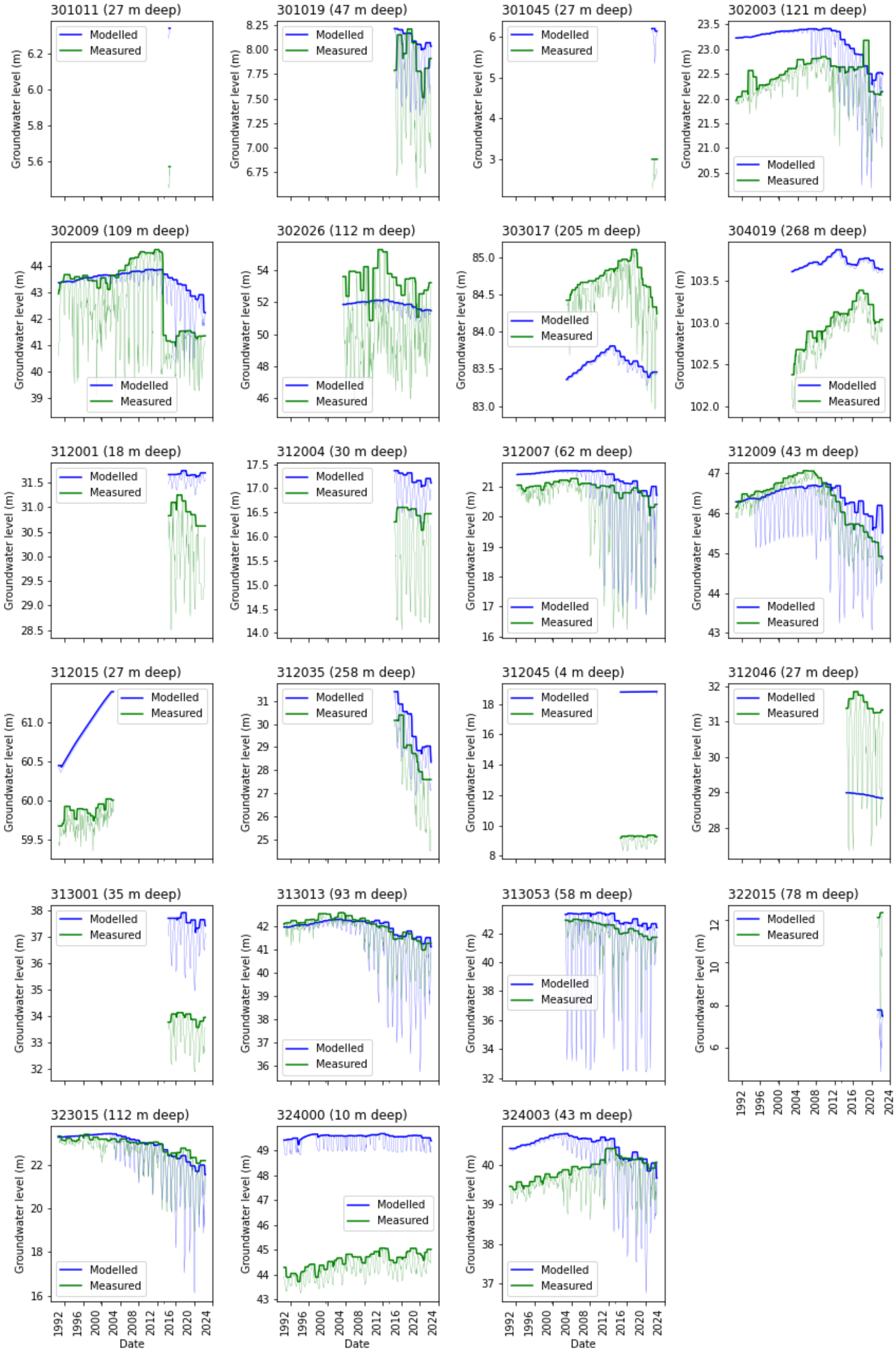


Figure 9: Observed and modelled groundwater levels. The dark blue and dark green lines represent the modelled and measured annual maximum groundwater levels.

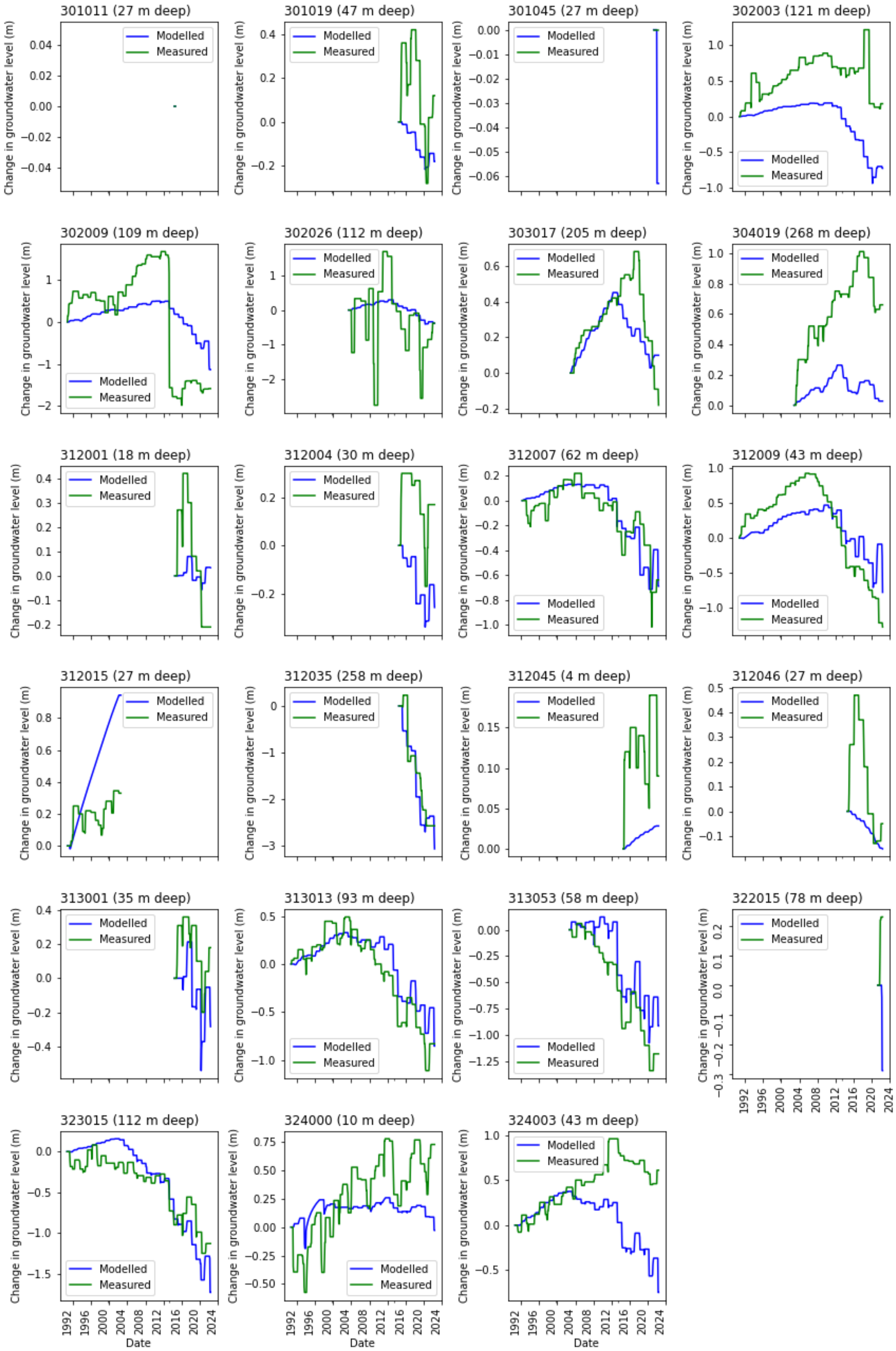


Figure 10: Modelled and observed groundwater levels plotted as the change in annual maximum groundwater levels since the start of the record.

In general, the model calibration is reasonable and the long term trends in the data are matched both in terms of the rising trend prior to 2005 and the declining trend after 2005. In some cases it is evident that the timing of abstraction effects close to a bore is incorrect (for example bore 303017) and the model predicts a drawdown effect prior to that observed in reality. Although further work could be undertaken to improve the abstraction dataset used in the model, it is equally clear that in many cases it does accurately reflect actual use, and the general trends in groundwater levels are accurately simulated.

The model is calibrated to groundwater leves (Figure 9 and 10) but the model is not calibrated to flows in smaller scale surface waterways or lakes in the area, or to flows in the larger rivers such as the Rangitīkei or the Turakina Rivers. This is partly due to the absence of data for flows in small streams and also the difficulties in defining the baseflow input to very large rivers such as the Rangitīkei (which is simulated by the model). Therefore, predictions of the effects of abstraction on these surface waterways is likely to be subject to a wider range of uncertainty compared to the predictions of groundwater levels in the area. However, general indications of the relative effect of abstraction on surface waterways as a result of changes in shallow groundwater levels are within the predictive capacity of the model.

Model water balance

A plot showing a timeseries of the overall model water balance is presented in Figure 11 and an average ('steady state') water balance is shown in Figure 12. In Figures 11 and 12 (an in subsequent figures in this report), the key refers to the following abbreviations:

Table 1: Key to water balance plot abbreviations

Figure abbreviation	Description
'RCHA_IN' and 'RCHA_OUT'	Recharge into or out of the model
'GHB_IN' and 'GHB_OUT'	Inflow to or outflow from the model via the coastal boundary
'RIV_IN' and "RIV_OUT'	Inflow to or outflow from the model via the modelled river boundaries
'DRN_IN' and 'DRN_OUT'	Inflow to or outflow from the model via the drain boundaries
'WEL_IN' and 'WEL_OUT'	Inflow to or outflow from the model via the modelled groundwater takes
'STO-SY_IN', STO-SY_OUT, STO-SS_IN and STO-SS_OUT	Inflow to or outflow from the model via groundwater storage

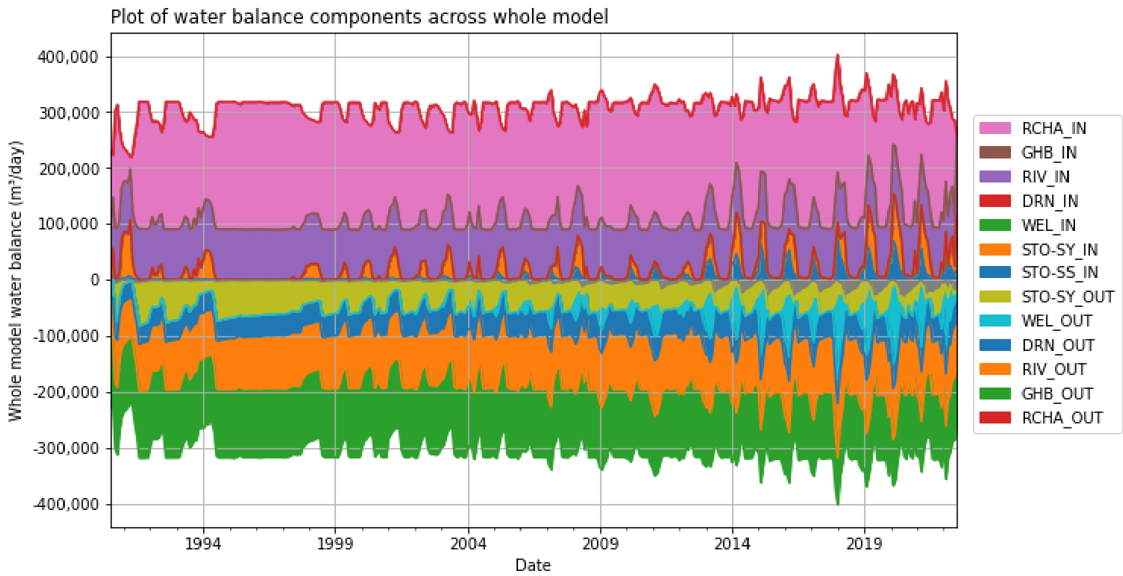


Figure 11: Modelled water balance through time

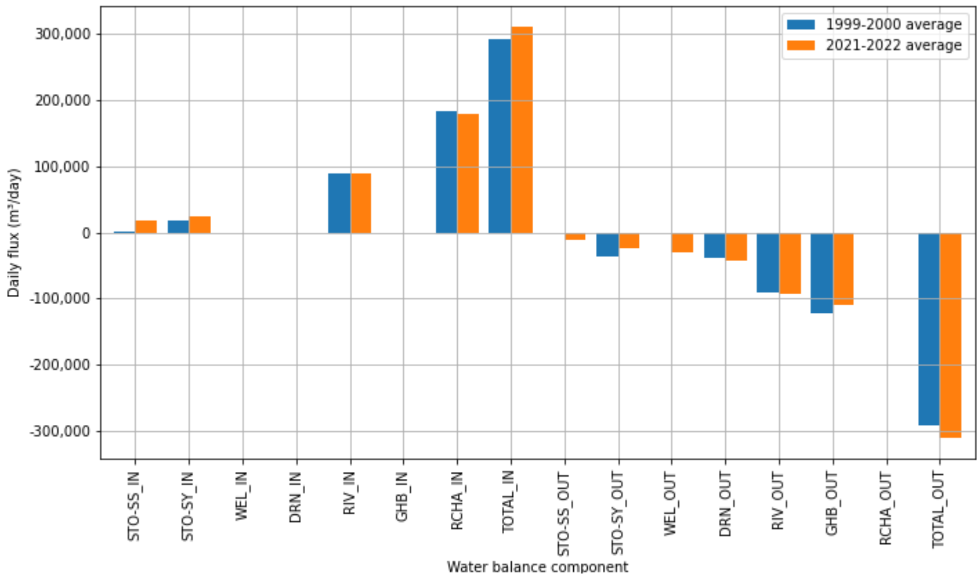


Figure 12: Average annual modelled water balance prior to widespread groundwater abstraction (1999-2000, blue bars) and recently (2021-2022, orange bars)

Figures 11 and 12 illustrate that the majority of water in the model is sourced from rainfall infiltration to groundwater (RCHA_IN), together with seepage losses from rivers that cross the model area. Groundwater discharges from the model generally via the coastal general head boundary ("GHB_OUT'), together with a smaller proportion of discharge to rivers and drains.

Figure 12 compares the average annual water balance for a year prior to when significant groundwater abstraction occurred (1999-2000) to the most recent year, when groundwater abstraction is well developed. The model water balance changes as a result of abstraction, with an increase in water drawn from storage and a reduction in discharge across the coastal general head boundary.

These changes reflect the decline in groundwater levels observed in bores across the model area (as an increase in water drawn from storage) and the limited change in observed baseflows to surface waterways across the model area. However, through time, the reduction in groundwater levels will result in some eventual decline in baseflow to surface waterways.

Shallow groundwater level drawdown

Figure 13 shows the simulated drawdown effect of abstraction between 2005 and 2022 in groundwater levels in model layers 1 and 2. In general the effect indicates that drawdown in the shallowest model layers is around 0.5 to 2 m, with the greatest effects centred around areas of abstraction close to the coast on the true right bank of the Rangitīkei River. These relatively small changes in shallow groundwater are consistent with the observed data. A drawdown effect of around 0.5 m extends along the coast in model layer 2, although such an effect does not appear to be simulated in layer 1.

The model predicts a rise in shallow groundwater levels between 2000 and 2022 in inland areas. This effect cannot be verified because there is little monitoring data in these areas, however, these areas not likely to be affected by the large scale groundwater abstraction that occurs closer to the coast and a rise would be consistent with the long term rising trend in other bores in the region, prior to the onset of increased abstraction.

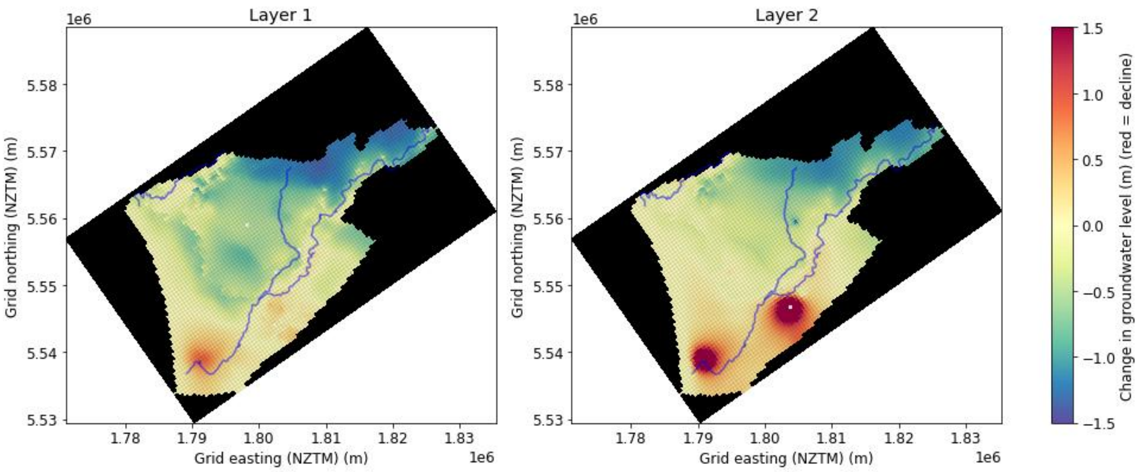


Figure 13: Change in average groundwater levels between 2005 and 2022 in model layer 1 and 2. Red colours represent a decline and blue colours represent a rise.

These modelled effects in shallower strata help to illustrate the very low vertical permeability of the strata (also shown via many pumping tests in the area) in the area and the slow response at the water table to abstraction from deep strata.

Overall, the model suggests that the main change in the groundwater system as a result of abstraction between 2000 and 2022 appears to be a lowering of deeper groundwater levels and a reduction in groundwater discharge from deeper strata to the coast.

3.0 Model scenarios

3.1 Introduction to scenarios

The computer model described above represents the groundwater system in the Rangitīkei groundwater management zone. It reasonably represents the long term groundwater level trends observed in bores in the area and therefore it can be used to assess a variety of 'what if' scenarios regarding future groundwater management in the area. The 'what if' scenarios aim to provide information on what may happen to groundwater levels in the area based on different management options for groundwater allocation.

The model is calibrated to groundwater levels at different depths within the area. Therefore, the scenarios are expected to represent the effect of different scenarios accurately at those groundwater level observation points, but the accuracy of the predictions will be less away from those points. The model is not calibrated to river flows or surface water fluxes in the area and therefore direct predictions of the effects of abstraction on those receptors are expected to be less certain. However, effects can be inferred based on the change in shallow groundwater levels.

The following scenarios have been developed to assist with the development of an updated groundwater allocation limit.

- Scenario 1: A scenario where groundwater allocation is reduced to a point where the long term decline in groundwater levels ceases over the next 10 years. Abstraction rates are reduced for 10 years into the future.
- Scenario 2: A scenario simulating a cap on allocation at existing levels of abstraction (i.e. no new consents are granted but existing consents are renewed). Abstraction continues at the same rate as the current year for 10 years into the future
- Scenario 3: A scenario considering a proportional increase in existing levels of abstraction up to the existing allocation limit. Abstractions are increased to the limit for 10 years into the future

These scenarios have been compared to a scenario where no abstraction is simulated to indicate the effect of groundwater takes compared to a 'natural' setting. In the following discussion, the scale of groundwater level decline refers to the difference between the modelled groundwater levels allowing for abstraction, and the naturalised groundwater levels.

Scenarios 1 to 3 represent a prediction 10 years into the future and are based on the last 10 years of recharge. This assumes that recharge in the next 10 years

(2022 to 2032) is similar to recharge between 2012 and 2022. Abstraction rates are then varied for each scenario.

With respect to the different scenarios and allocation limits, it is helpful to consider the existing status of consents within the model area, and when existing consents will expire. Figure 14 shows a timeseries of consented annual volumes within the model area.

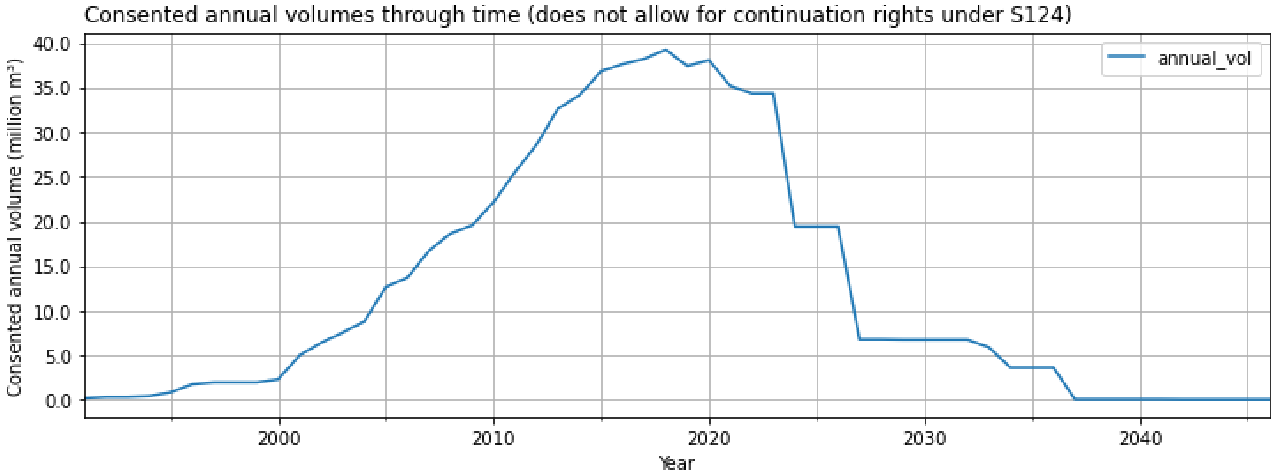


Figure 14: Consented annual volumes through time

Many consents are currently due to expire in 2024, with a further block of consents expiring in 2026.

3.2 Groundwater abstraction scenarios

3.2.1 Scenario 1 – reduced abstraction

Plots of simulated groundwater levels in the observation bores used to calibrate the model are presented in Figure 15. Figure 15 shows:

- the simulated groundwater levels from the calibrated model (from 1990 to 2022),
- the model predicted groundwater levels if abstraction reduced by 30% for the next 10 years (from 2022 to 2032) and
- naturalised groundwater levels, which are the groundwater levels that are simulated if no abstraction occurred from 1990 to 2032.

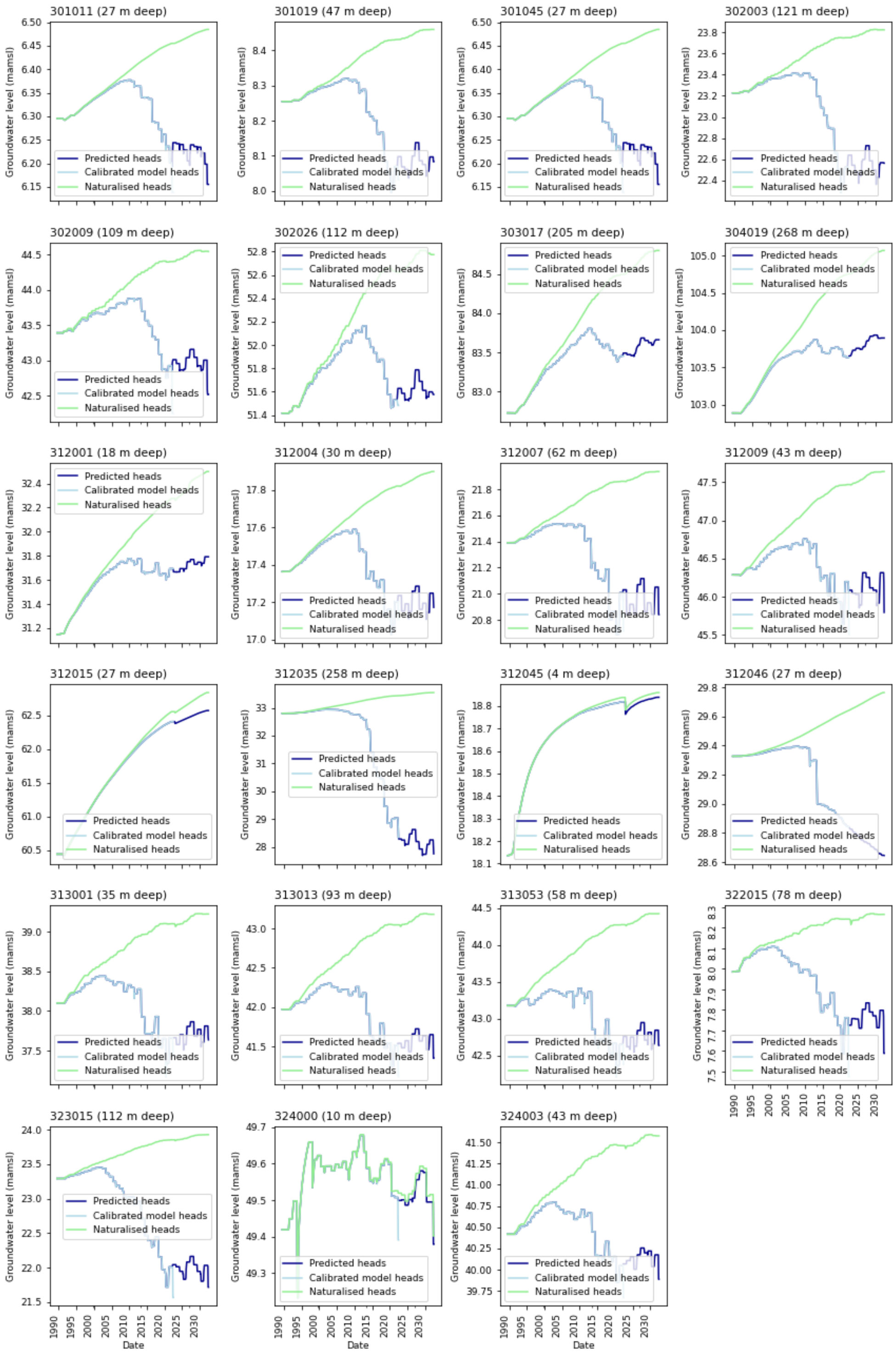


Figure 15: Modelled heads for Scenario 1 (reduced abstraction)

These results indicate that if groundwater abstraction rates reduced by around 30% compared to the most 5 years of abstraction (i.e. from 2018 to 2022), the currently declining trend in groundwater levels is likely to stabilise in most bores, although the stable pattern is dependent on the natural recharge to groundwater remaining at the same level as what has occurred in the last 10 years.

Figure 16 shows the modelled difference in shallow groundwater levels, which indicates that the decline in shallow groundwater levels is likely to be restricted to around 0.5 m (compared to a situation where no abstraction took place) across most of the modelled area, albeit with some 'hotspot's where greater declines are predicted by the model.

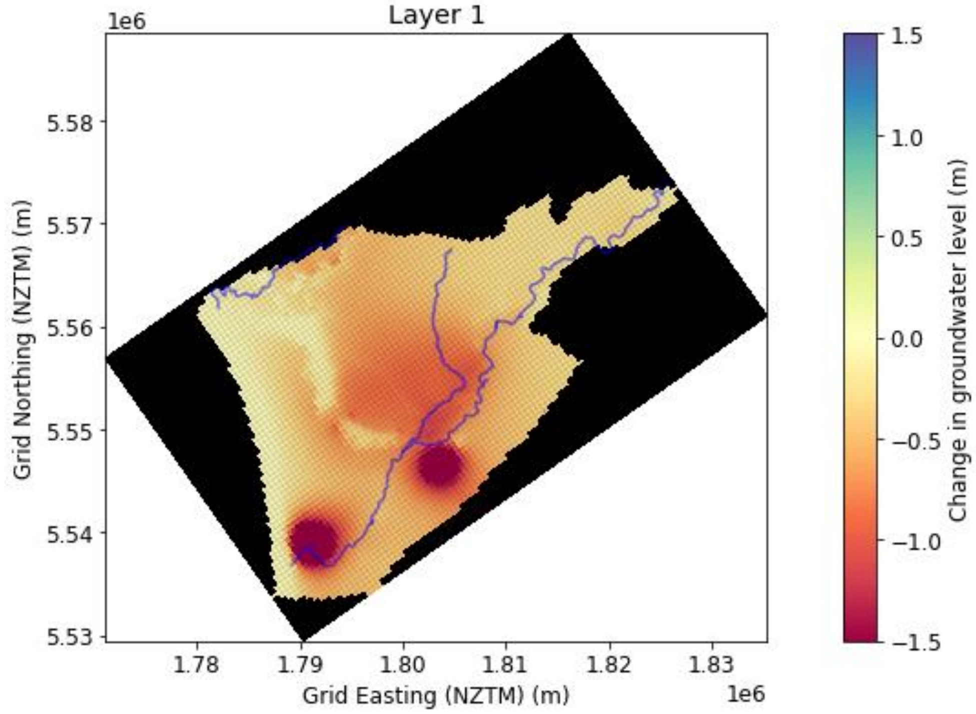


Figure 16: Modelled change in shallow groundwater levels (Scenario 1)

Figure 17 shows the change in the modelled water balance compared to a naturalised situation where no abstraction is simulated. Some reduction in discharge across the general head boundary is still expected to occur which is in keeping with the overall reduction in groundwater levels. However this change is similar to the change modelled under the existing situation (because groundwater levels are stabilised).

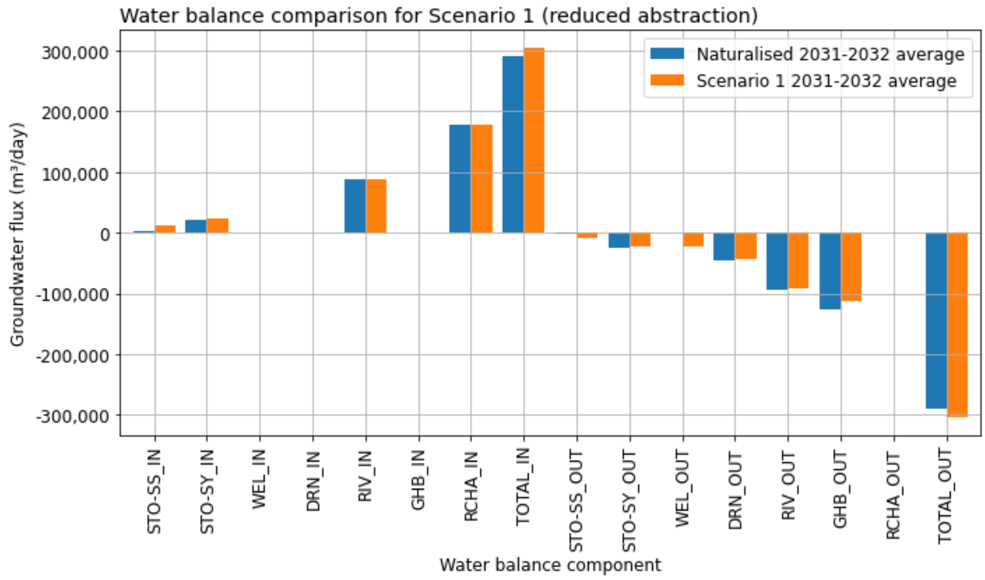


Figure 17: Modelled change in water balance (Scenario 1)

3.2.2 Scenario 2 – continued abstraction

Scenario 2 simulates a situation where groundwater abstraction continues at current rates for the next 10 years, for example where existing consents are renewed but no further consents are issued. Figure 18 shows the change in groundwater levels in observation bores used to calibrate the model.

Under scenario 2, groundwater levels are expected to continue to decline for at least the next 10 years, reaching a maximum decline of around 7 m (in bore 312035, 258 m deep) although a more typical decline is around 2 to 3 m compared to a situation where no abstraction had occurred.

Figure 19 and 20 present the modelled change in shallow groundwater levels and the model water balance respectively. These indicate that drawdown in shallow groundwater levels is expected to approach 1 m across much of the model area, with the same 'hotspots' in two areas along the Rangitīkei River. Figure 19 appears to show that drawdowns along the coastal margin are modelled as less than 1 m but it should be noted that these are cells simulated as general head boundaries with fixed heads in the simulation; therefore no drawdown occurs in these cells.

The water balance for Scenario 2 indicates that the main change is in a reduction in outflow to the general head boundary representing the coast as well as a reduction in modelled discharge to the rivers. Both these effects are greater than in Scenario 1 reflecting the greater volume of abstraction.

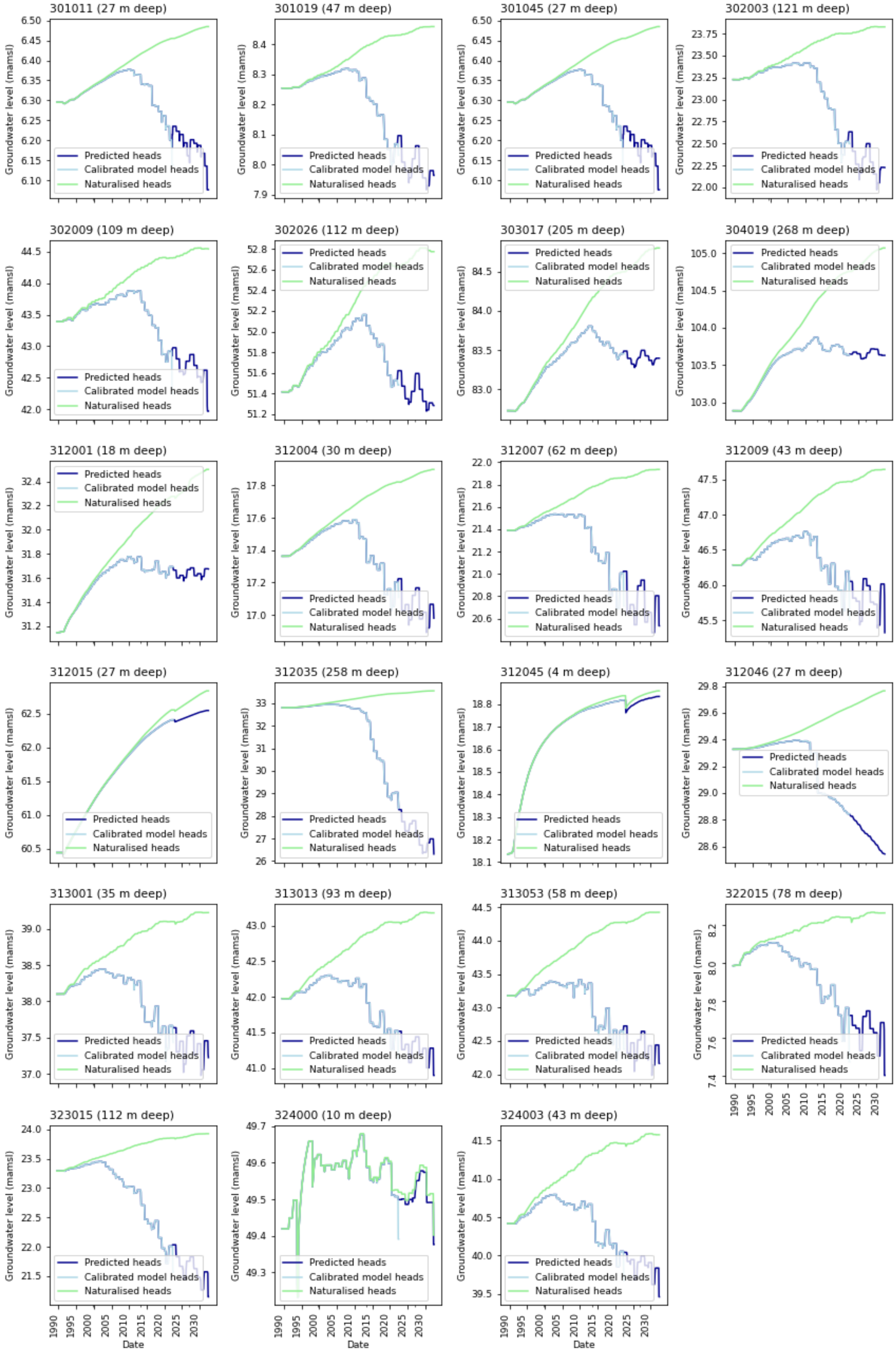


Figure 18: Modelled heads for Scenario 2

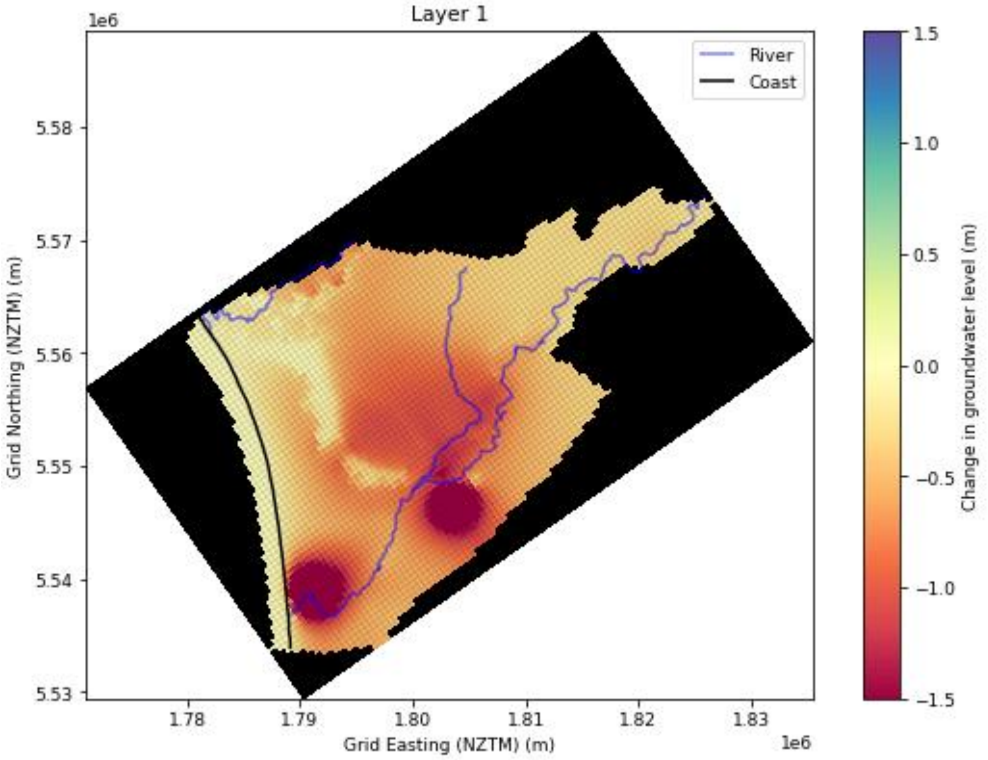


Figure 19: Modelled drawdown in shallow strata for Scenario 2

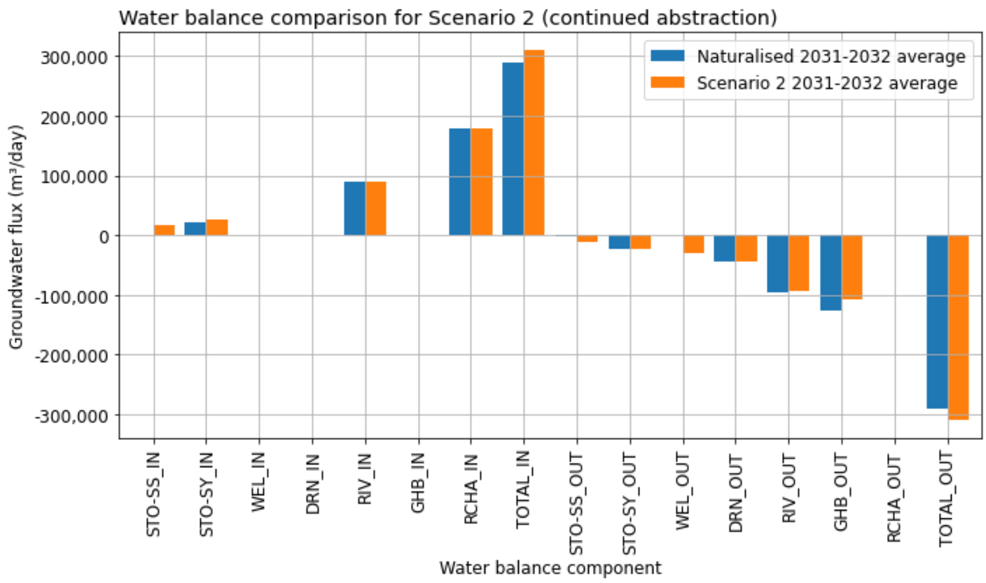


Figure 20: Modelled water balance for Scenario 2

3.2.3 Scenario 3 – increased abstraction

Scenario simulates a situation where further groundwater is allocated, as would be permitted under the existing allocation limit for the Rangitīkei groundwater management zone. The Rangitīkei groundwater management is currently around

75 % allocated and therefore there is around 25 % allocation available. This available increase has been applied to all abstractions within the model area to provide some indication of what could happen if further groundwater were to be allocated. This scenario is only indicative however because the precise location of any new abstraction is not known, and the locations will have some impact on the pattern of effects on the groundwater system.

Figure 21 shows the effect on groundwater levels which, in keeping with Scenario 2, indicates further declines in groundwater levels. Under this scenario, the greatest groundwater level decline is around 8 m (in bore 312035, 285 m deep), with other declines of around 2 to 3 m (compared to around 1 to 2 m under Scenario 2). In some cases, this scale of decline would be significant and could conceivably restrict the use of some bores as there would be an insufficient depth of water above the pump to achieve the bore yield.

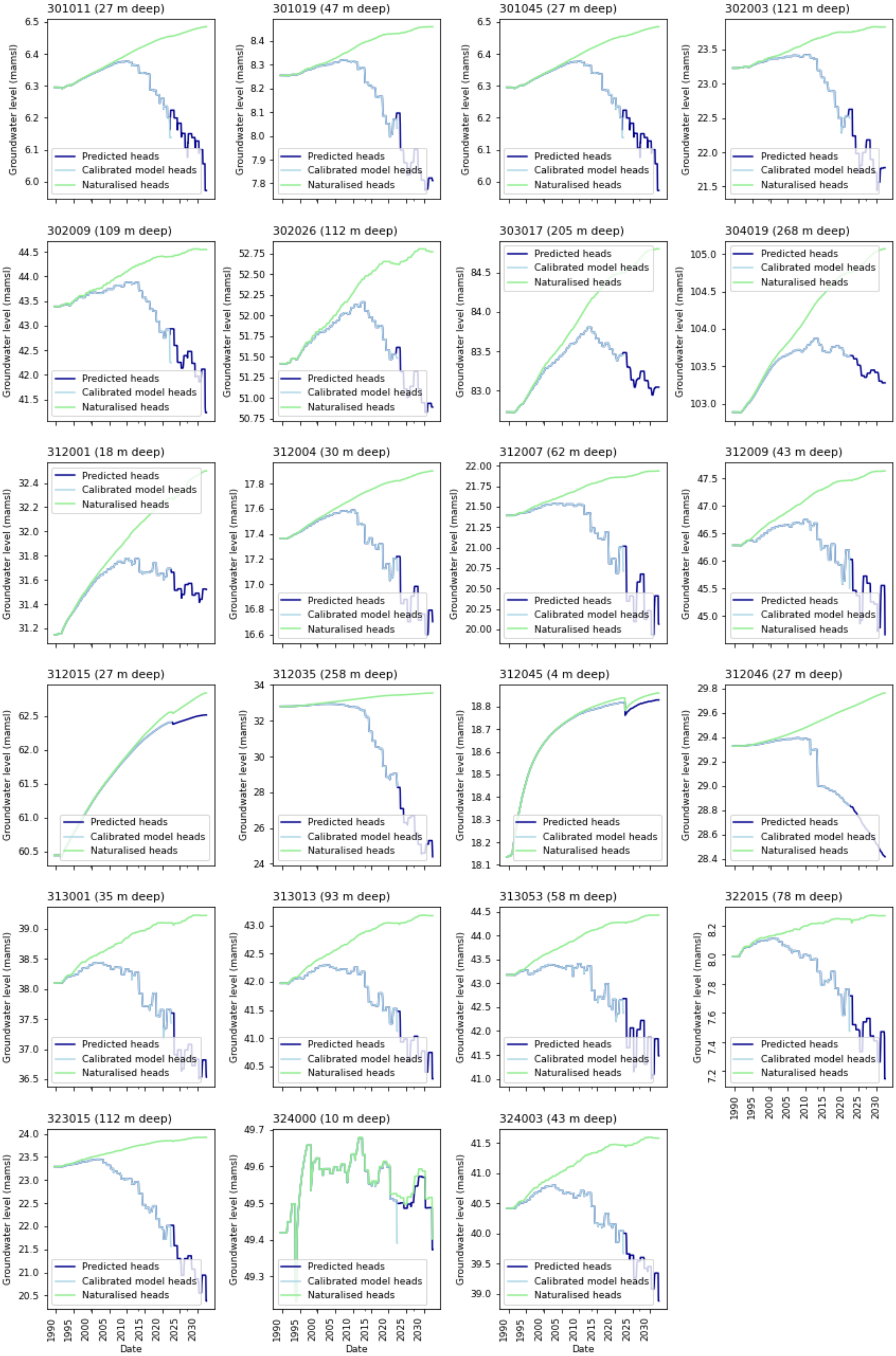


Figure 21: Modelled groundwater levels for Scenario 3

Figure 22 shows the modelled effect of increased abstraction on shallow groundwater, where effects could be more than 1 m in some areas of the model. Figure 23 shows a similar plot for model layer 7, which represents a depth of around 70 to 80 m.

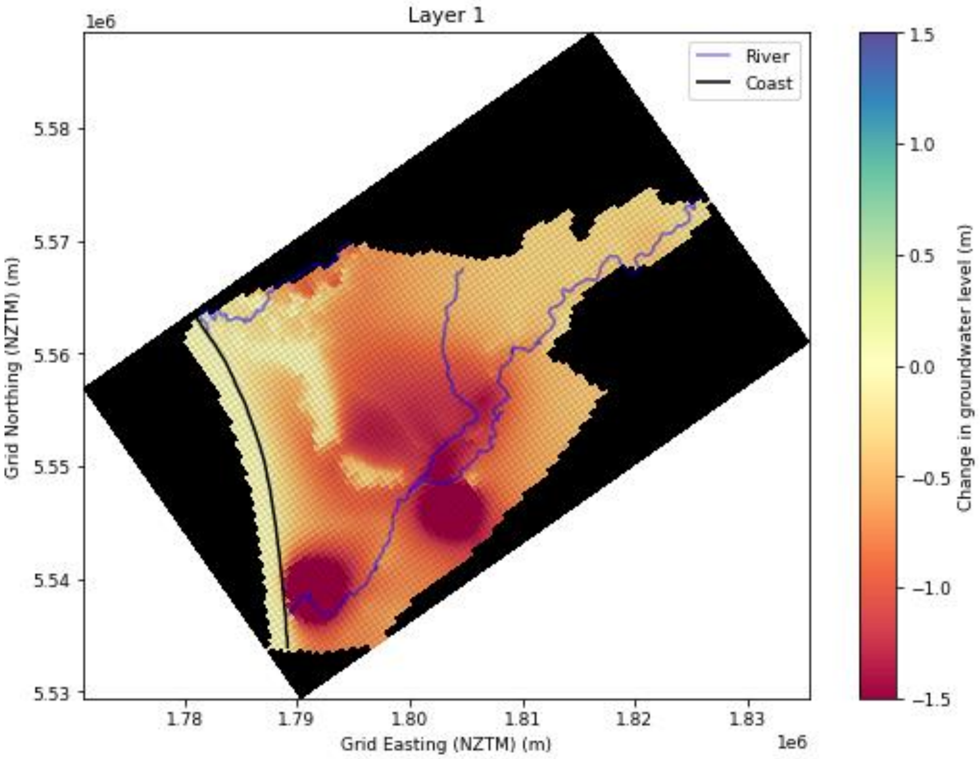


Figure 22: Modelled drawdown in shallow strata for Scenario 3

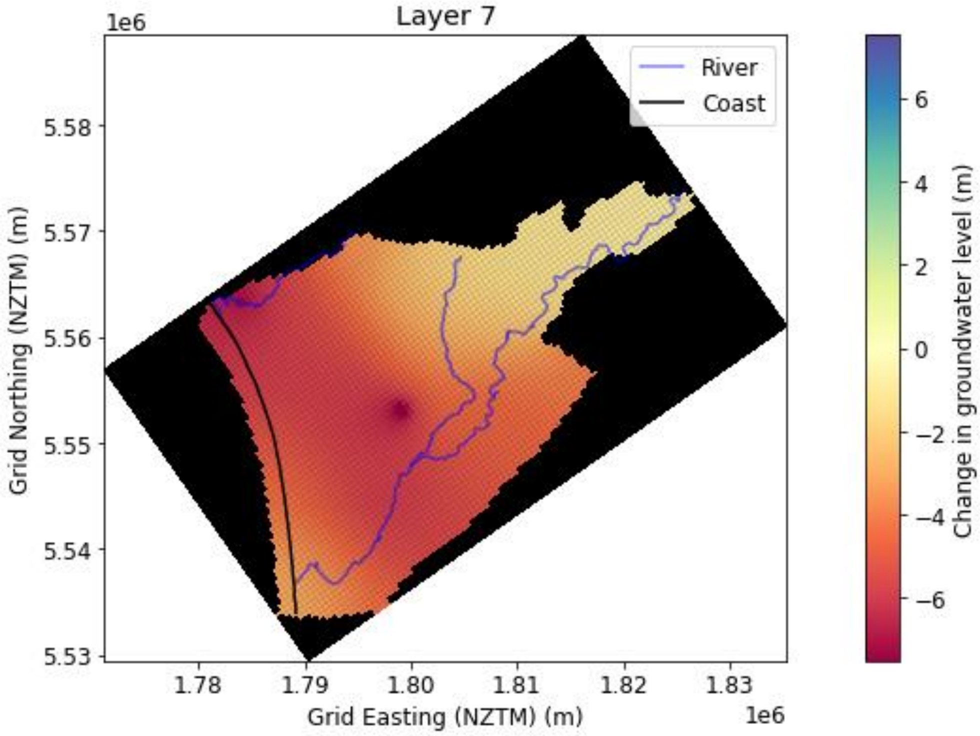


Figure 23: Modelled drawdown in deeper strata for Scenario 3

In model layer 7, drawdown effects are around 6 to 7 m compared to where groundwater levels would be under a naturalised scenario. This represents a decline of around 4 to 5 m compared to present groundwater levels (because the naturalised scenario with no abstraction predicts a continued increase in groundwater levels). A decline of around 4 to 5 m at the coast has the potential to start to reverse groundwater gradients and potentially start to induce the intrusion of saline water inland. Smaller effects are seen in Scenario 2.

Figure 24 shows the change to the model water balance, which helps to illustrate the decline in the modelled outflow over the coastal general head boundary.

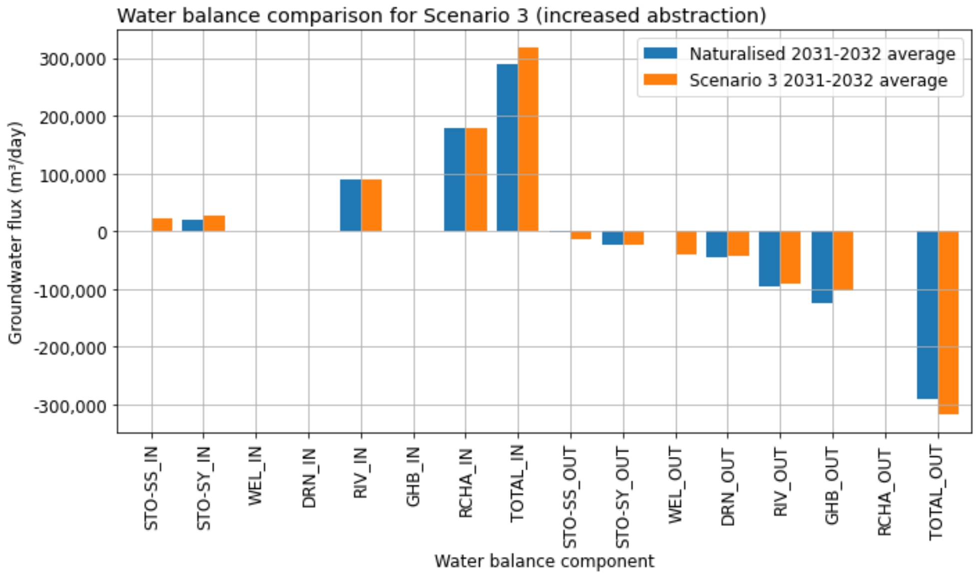


Figure 24: Modelled water balances for Scenario 3

3.2.4 Summary of Scenarios 1, 2 and 3

To further demonstrate the model outcomes of scenarios 1, 2 and 3, a selection of three time series plots of some representative bores are presented in Figure 25.

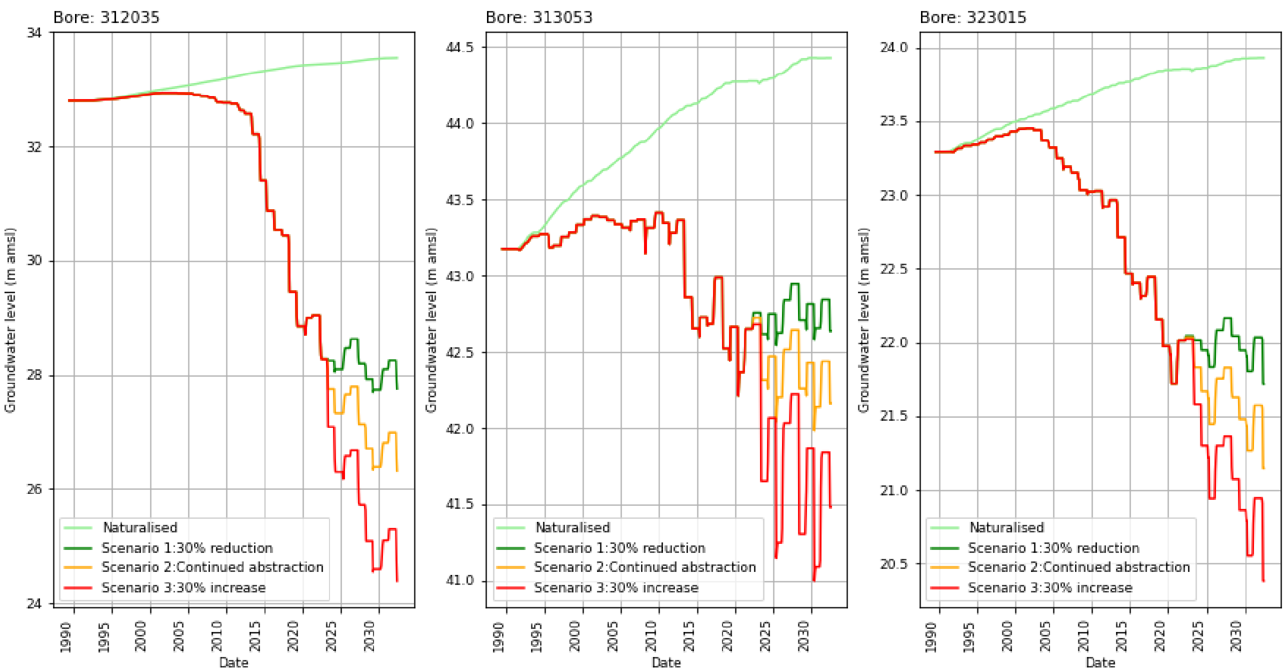


Figure 25: Results of scenarios on maximum annual groundwater levels in three representative bores

4.0 Groundwater allocation

4.1 Proposed boundaries

The existing Rangitīkei groundwater management zone boundaries are likely to cut across groundwater flow paths, particularly towards the south, as shown in Figure 25. Therefore, it would be reasonable to adjust the zone boundaries so that the areas of groundwater recharge and outflow are better matched.

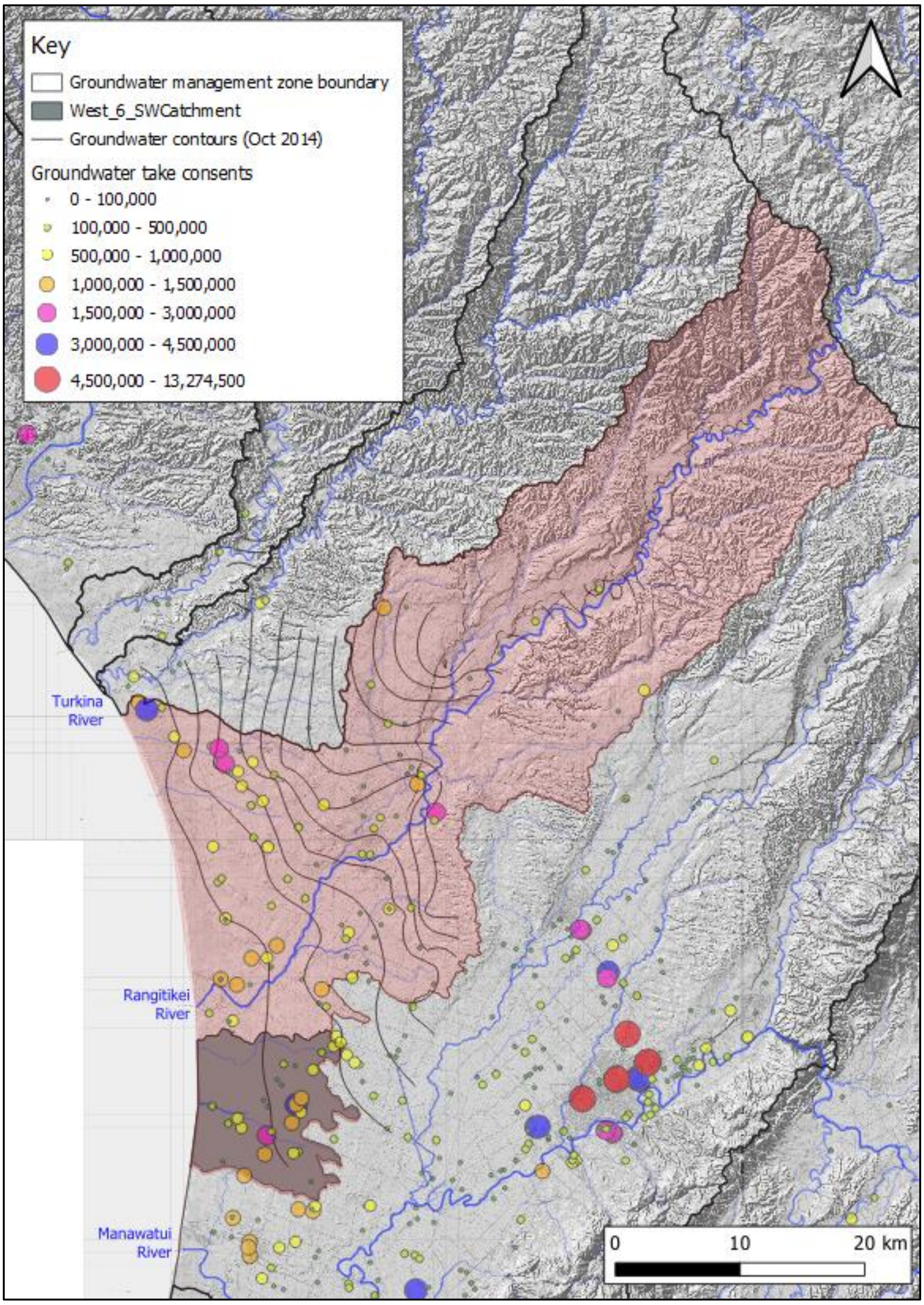


Figure 26: Proposed updated groundwater zone boundary

The Rangitīkei management zone currently encompasses the West_6 surface water catchment. Groundwater take consents within this catchment are unlikely to affect groundwater levels in the rest of the Rangitīkei management and therefore it would be more appropriate if the West_6 catchment were part of the Manawatu groundwater management zone, which is where the groundwater takes within that catchment are likely to receive most of their recharge. This change is also unlikely to affect the abstraction scenarios discussed above and ensures that groundwater takes that do not contribute to the current declining trend are not restricted by changes in the Rangitīkei management zone allocation limit.

4.2 Proposed allocation limit

All groundwater takes will result in some reduction in groundwater levels and some reduction in discharges to surface water from the groundwater system. Therefore, any groundwater allocation framework must include some implicit acknowledgement of these effects. However, it is important that these effects result in a sustainable balance between recharge to, and discharge from, the groundwater system. A sustainable balance implies long term groundwater levels that fluctuate within a stable range.

Observed long term groundwater levels are currently declining and the model scenarios discussed above indicate that under both a scenario of increased abstraction, and under a scenario of continuing abstraction at current rates, groundwater levels are expected to continue to decline for at least the next 10 years. The declining pattern is a response to additional discharge (i.e. groundwater takes) from the groundwater system. Eventually, groundwater levels will stabilise (because the groundwater system will reach a balance between lower groundwater levels resulting in increased induced leakage from shallow strata, reduced offshore discharge and groundwater abstraction rates), but that point is likely to be more than 10 years into the future and would involve further groundwater decline than what is shown in the modelled scenarios presented in this report.

The model was not designed to directly assess the impact of continued declining groundwater levels on surface water receptors (including offshore groundwater discharge) however effects can be inferred from the modelled changes in groundwater levels at the coast and in shallow groundwater. These indicate that shallow groundwater levels could reduce by up to 1 m generally and groundwater levels in deeper strata close to the coast could reduce by 4 to 5 m compared to current levels. These effects could have widespread impacts on surface water flows and raise the risk of saline intrusion into the deeper strata that is targeted by irrigation abstractions.

The model scenarios described above indicate that groundwater levels could be managed to stabilise in the very near future if actual water use reduces by around 30% compared to the existing water use (Scenario 1). Groundwater levels would stabilise at a lower level than would naturally occur, but this level would be similar to current groundwater levels and therefore no further impact on surface water discharges would occur.

Although there is limited data available to describe the effect of deep abstractions on surface water discharges or shallow groundwater because of limited long term monitoring, the data that is available does not immediately suggest that effects to date have significantly changed the shallow groundwater or surface water environment, for example bore 312045 (4m deep) which shows an apparently stable groundwater level trend based on the data from around 2016 to 2023. Other data include some monitoring data from around Lake Koitiata, which includes shallow and deep bores monitored as part of a consent condition. The shallow groundwater levels, or levels monitored in Lake Koititata, did not show clear declining trends over the period of monitoring which extended from around 2005 to 2015. It should also be recognised that there are many other factors that have impacted surface water and shallow groundwater, including landuse change and land drainage. Given this situation, reducing actual groundwater use to a point where the existing observed decline stabilises should be a medium or long-term goal for groundwater management in the area.

Consented annual volumes are set to enable abstraction up to a 1 in 10 dry year event. Therefore, the allocation limit must also reflect a volume of water that would be used in a 1 in 10 dry year event. At times outside a 1 in 10 dry year, less water would be used. However, the declining groundwater level pattern reflects the effect of average groundwater use during a range of recharge patterns. Therefore, a reduction in actual groundwater use is required on average and not just at times of higher demand. Simply reducing the consented volumes and or the allocation limit is not likely to be sufficient to stabilise groundwater levels.

Reducing actual use will be complex and it is likely to be best achieved if a staged process takes place, likely over a number of years. It would be sensible if each stage of the process follows a set timeframe and that the goals for each stage are clearly defined. A proposed approach is outlined below.

Stage 1

The goal for Stage 1 should be to not authorise any further increase in groundwater abstraction and to identify any voluntary reductions that can be made within the existing user group. An indicative timeframe for Stage 1 would be 1 year.

- No increase in groundwater allocation should be consented, which effectively redefines the allocation limit to the current level of consented takes.
- The Santoft Water Users Group should be convened so that this issue is raised with them. This group should be canvassed to identify any possible voluntary reductions in actual use.
- Consent holders should be provided with copies of their actual use records to confirm that the information held by Horizons is correct.

- All consent holders must ensure that they are providing accurate records of water use to Horizons.
- Any application to renew existing consents should be scrutinised in detail to confirm that water is being used efficiently and applied only when required. The application should ideally include proposed measures to reduce water use.
- Additional monitoring for electrical conductivity in bores located close to the coast should be initiated.

Stage 2

The goal for Stage 2 should be to reduce groundwater use to a point where groundwater levels are expected to stabilise – i.e. around a 30% reduction. A realistic timeframe for Stage 2 is around 5 years and should dovetail with the times when many of the existing consents in the area will need to be renewed. During stage 2, the following should take place:

- Continued monitoring of groundwater levels should take place during this stage together with monitoring of electrical conductivity in all bores close to the coast.
- A set of criteria should be developed to strongly encourage efficient water use, for example the use of soil moisture meters as part of irrigation infrastructure as well as mapping of soils.
- A review of all consents within the area should be initiated to identify potentially inefficient takes and measures put in place to improve efficiency and reduce water use.

At the end of stage 2, a review should be undertaken to consider the impact of reductions in actual use, current water level patterns and information collected on electrical conductivity. This information should be used to inform Stage 3.

Stage 3

The final goal of stage 3 should be to reduce actual use. The groundwater model should be updated and rerun to assess the impacts of actual use on long term groundwater levels and consider how this compares to predicted changes in groundwater levels. The final reductions that are required to stabilise groundwater levels should be determined and if required, changes to consents should be implemented.

5.0 Summary and conclusion

This report was prepared to assist with setting an updated groundwater allocation limit for the Rangitīkei groundwater management zone. A computer model was developed and updated to represent the groundwater system in the area which generally represents the patterns of groundwater levels observed in bores within the zone.

Observed groundwater levels show a long term declining trend in recent years, which appears to correlate with an increase in actual groundwater abstraction in the area. The model also suggests that the decline is a result of increased abstraction. The current scale of decline does not appear to have resulted in substantial effects on surface water, or the risk of saline intrusion. Three scenarios were run using the model to simulate how groundwater levels may change under different groundwater use options.

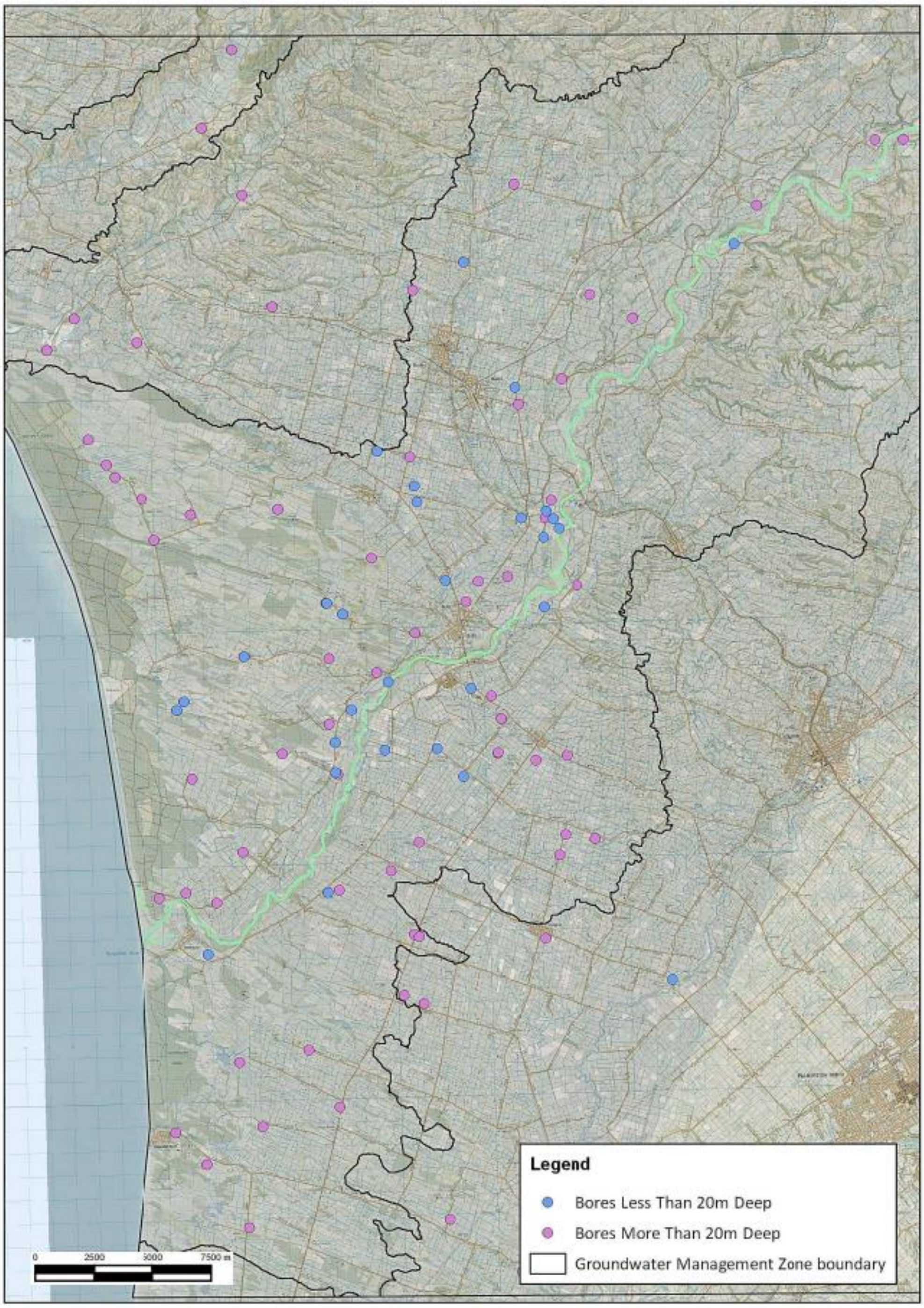
Under two of the scenarios, where groundwater use continued at current levels, or increased up to around the existing One Plan allocation limit, the model indicates that groundwater levels will continue to decline. Particularly under the increased abstraction scenario, the scale of the decline implied potentially adverse effects on surface water bodies and an increased risk of saline intrusion within a 10 year timeframe. These declines imply that current groundwater use, and therefore groundwater allocation, is not at sustainable levels and that actual groundwater use may need to reduce.

A scenario simulating the effect of reducing actual groundwater use by 30% indicated that groundwater would likely stabilise at a similar level to current levels. Therefore, an interim allocation limit is recommended so that no more than the current level of allocation, which is around 75% of the allocation limit set within the One Plan.

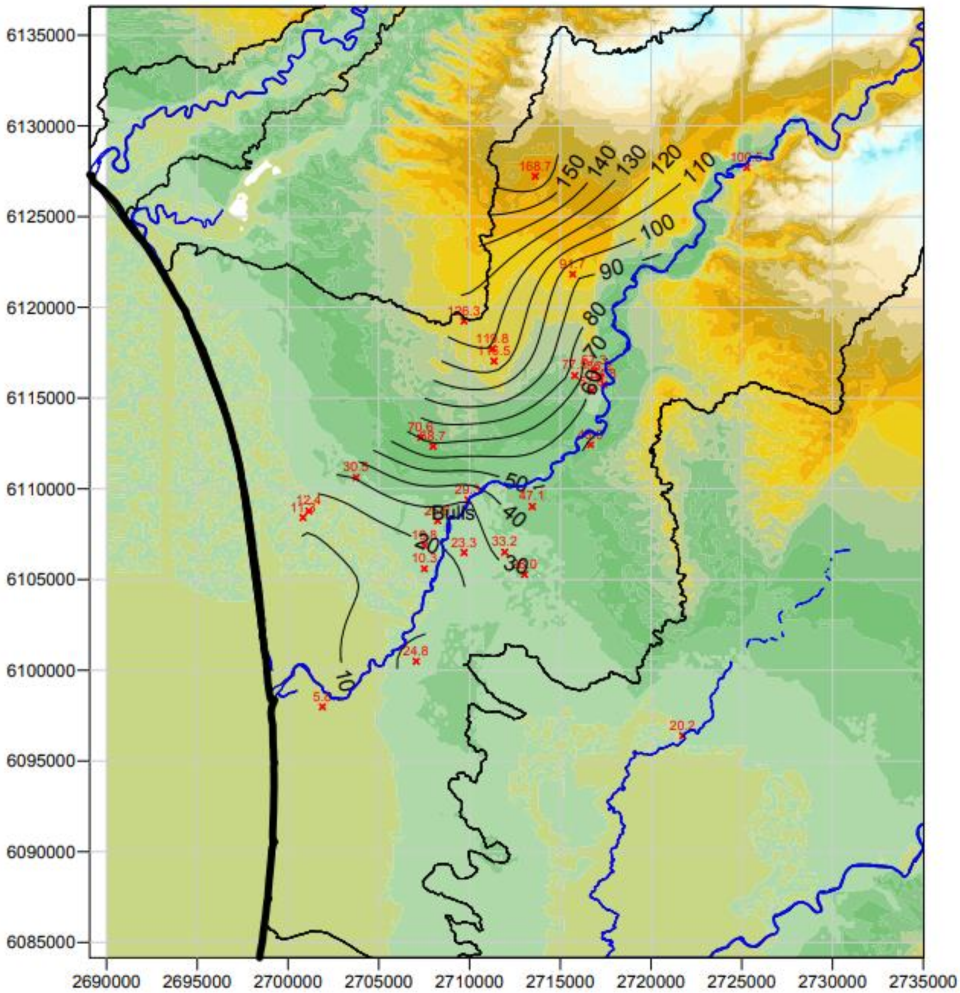
To reduce actual groundwater use to a point where groundwater levels stabilise, a staged approach is recommended, which initially seeks voluntary reductions in water use from current consent holders and then looks to implement greater water efficiency requirements over a timeframe of around 5 years before finally implementing a consent review based on further monitoring.

A revised groundwater management zone boundary is also proposed which better account for groundwater flow directions and aligns the allocation zone with groundwater recharge zones.

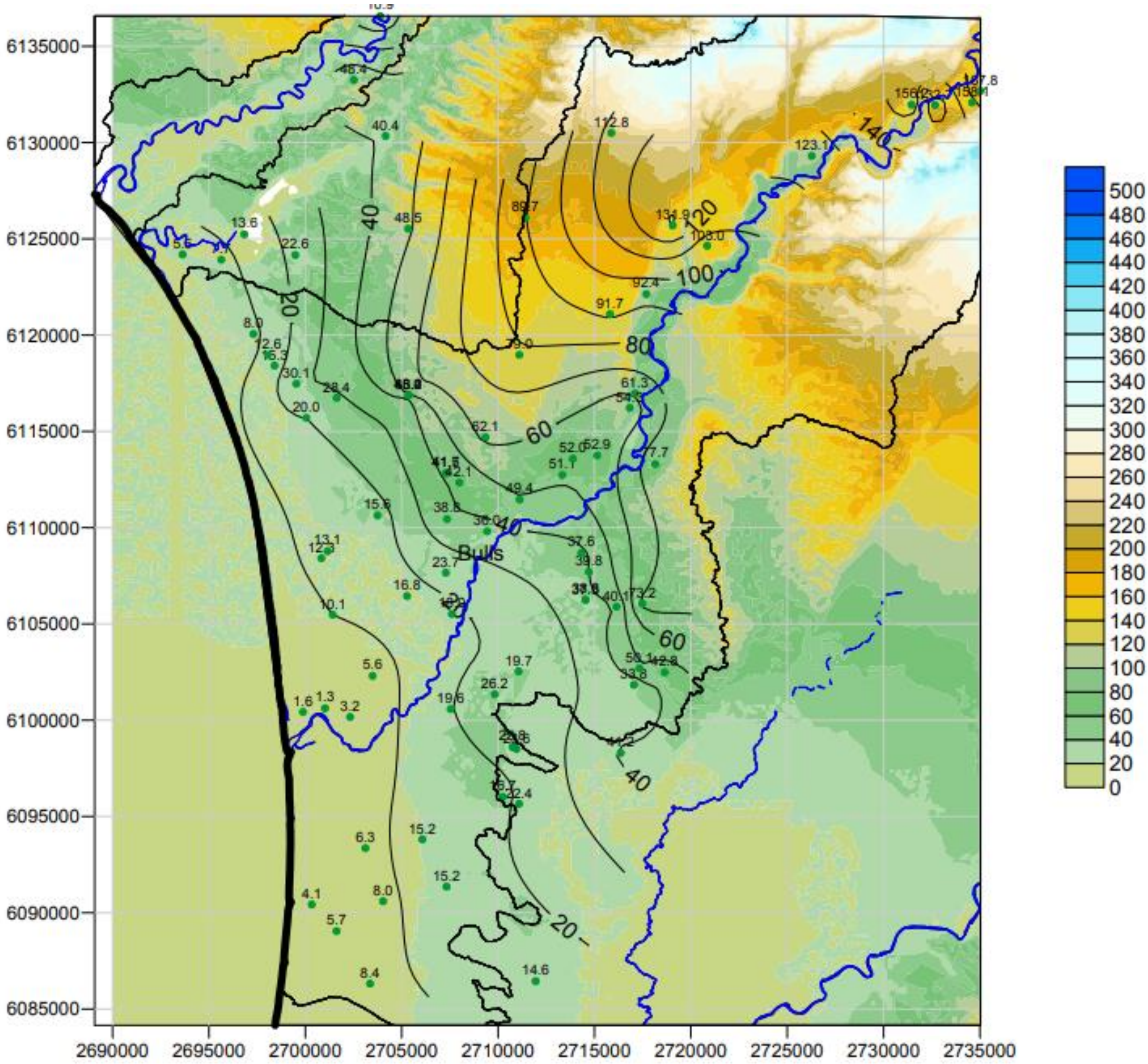
Appendix A: Plots of groundwater contours



Location of bores used to generate piezometric contours

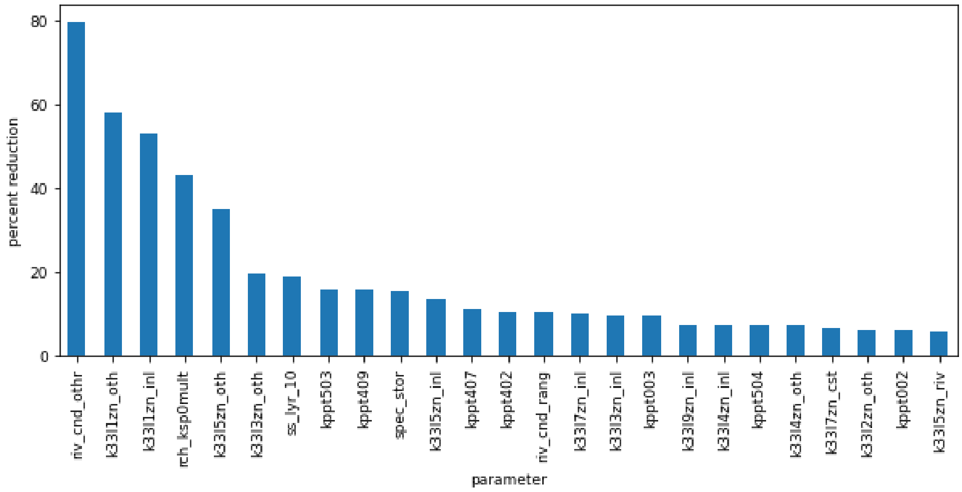


Shallow groundwater level contours (bores <20 m deep)



Groundwater level contours for bores >20 m deep. Background colours represent ground surface elevation in m above mean sea level.

Appendix B: PEST model sensitivity analysis



Percentage reduction in parameter variance for 1st 25 parameters

Where the percentage uncertainty reduction is small, the model calibration is generally insensitive to variations in that parameter. The model is most sensitive to variations in the river bed conductance for small stream away from the Rangitikei River because these influence the volume of recharge to the model. Other parameters that are important are generally hydraulic conductivity values at pilot points across the model area and particularly within model layer 5, where many of the observation bores are located. The PEST results suggest that the hydraulic conductivity at pilot points within the near surface strata is less well constrained by the observation data as there are few observation points in the shallow strata.

horizons

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