IN THE MATTER of the Resource Management Act 1991

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IN THE MATTER of submissions and further submissions by Rangitata Diversion Race Management Limited (**RDRML**) on proposed Variation 2 to the proposed Canterbury Land & Water Regional Plan

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STATEMENT OF EVIDENCE OF PETER FRANCIS CALLANDER

Introduction

1. My name is Peter Francis Callander and I have been a Director of Pattle Delamore Partners Limited (PDP) since 1997. I hold the qualifications of BSc (Geology) from the University of Auckland and MSc (Earth Sciences) from the University of Waterloo (Canada). I am a member of the New Zealand Hydrological Society and the USA based National Ground Water Association. I have over 25 years of experience as an environmental scientist specialising in groundwater and surface water resources. Prior to my employment at PDP, I had been employed for seven years by the Canterbury Regional Council (CRC) and its predecessor the North Canterbury Catchment Board.

2. I have particular experience in the management of water resources. This has included work on numerous projects where I have modelled and advised on the management of water quality impacts associated with irrigation including work for the Waimakariri Irrigation Scheme, Rangitata South Irrigation, Barhill-Chertsey Irrigation, the Southern Valleys Irrigation Scheme (Marlborough), Wairau Valley Water Enhancement Scheme and assessments in the Hurunui catchment for proposed irrigation developments for the Hurunui Water Project and Ngai Tahu Property Ltd. I have also reviewed work completed by other parties for the proposed Central Plains irrigation scheme (on behalf of the Christchurch City Council and others) and applications for irrigated land use change in the MacKenzie basin (on behalf of Meridian Energy).

3. I provide the following statement of evidence regarding the submission lodged by Rangitata Diversion Race Management Limited (RDRML) for Proposed Variation 2 of the Proposed Canterbury Land and Water Regional Plan. I

have read the Code of Conduct contained in the Environment Court's Practice Notes for Expert Witnesses and agree to comply with it.

Scope of evidence

4. My evidence provides commentary on the following topics:

   4.1 The hydrogeologic setting that is relevant to matters raised in the RDRML submission.

   4.2 The calculation of required nitrogen leaching loads undertaken by the CRC officers.

   4.3 The relative effectiveness of Managed Aquifer Recharge and Targeted Stream Augmentation to achieve the water quality targets stated in Variation 2.

   4.4 Some comments on the groundwater aspects of some of the changes to Variation 2 sought by RDRML.

5. In preparing this evidence I have read and am familiar with proposed Variation 2 ('**Variation 2**' or '**V2**'), the submission and further submissions of the Rangitata Diversion Race Management Limited ('**RDRML**') and the CRC officers' report.

Executive summary

6. The groundwater system beneath the Hinds/Hekeao Plains and the coastal drains are affected by agricultural land use practices, although the effects are variable and there is a consistent pattern of deeper groundwater having lower nitrate-nitrogen concentrations than shallower groundwater (less than 40 metres deep).

7. The assessment of the acceptable nitrate leaching loads is based on a simple assessment of soil drainage based on Overseer simulations. There is uncertainty in the quantities of nitrate load and drainage volume, which in turn creates uncertainty as to the target nitrate leaching load for the future, the percentage reductions that might be required from Good Management Practice and the volume of Managed Aquifer Recharge water that might be

required to achieve the water quality targets. Given this uncertainty, Targeted Stream Augmentation could provide a more reliable means of achieving surface water quality targets and thereby provide more flexibility for the definition of, and timing to implement, land use and groundwater quality improvements, including the implementation of Managed Aquifer Recharge.

8. Replacing currently operating surface water abstraction consents with deep groundwater abstractions that do not directly impact on any particular surface waterway can help to improve the management of water resources for over-allocated surface waterways. Therefore Variation 2 should allow this extra deep groundwater abstraction to occur when it is to be implemented for that purpose.

Hydrogeological setting

9. The current hydrogeologic setting has been described in the CRC documents for proposed Variation 2, particularly Durney and Ritson (2014) and Scott (2013). Certain aspects of the groundwater environment are described in the following paragraphs of my evidence that are relevant to points raised in the RDRML submission to Variation 2.

10. The Hinds/Hekeao Plains are underlain by a variable mixture of gravels, sands and silts that extend to depths of a few hundred metres. Groundwater moves through the pore spaces between these unconsolidated deposits in a generally down-plains direction, from north-west to south-east, towards and beyond the coast line. There is considerable variability in the permeability of the strata and zones of more permeable open gravels support high yielding abstraction bores, whereas other more silty zones represent areas where groundwater flow is restricted.

11. The groundwater is recharged by drainage of rainfall and irrigation water through the soil profile and by seepage losses from rivers and open water race networks that distribute irrigation water and stockwater throughout the area. There tends to be a downwards and lateral hydraulic gradient in the upper and mid-plains. In the lower plains the groundwater levels are close to the land surface and groundwater discharges into spring-fed drains. Durney and Ritson (2014) present the following estimations of the quantities of each of the groundwater recharge and discharge components.

Table 1: Analytical groundwater budget (from Durney & Ritson, 2014)

Average Inputs (m^3/s)		Average Outputs (m^3/s)	
Land surface recharge	15.5	Coastal drains	3.0-7.0
River recharge:		Groundwater abstraction	3.0 – 7.5
- Ashburton River/Hakatere	1		
- Hinds River/Hekeao	0.3	Discharge to the Rangitata River	0.3
- Rangitata River	0		
		Offshore groundwater flow	9.2 – 9.7
Water race losses	3.2		
Total inputs	**20**	**Total outputs**	**20**

12. Changes in groundwater levels reflect the variation between the recharge and discharge components to the groundwater system. Groundwater levels rise during times of increased recharge and decline during periods of lower recharge and/or increased abstraction. The CRC note that some recent declining trends in water levels may be due to conversions from border dyke to spray irrigation and increased bore abstraction.

13. There are two long term water level monitoring records in the area from bore K37/0215 (26.2 m deep) and K37/0245 (19.8 m deep), both situated in a mid-plains locality, as shown in Figure 1. The records are plotted in Figure 2 and indicate a period of higher groundwater levels during the 1970s – 1990s, which is likely, in my opinion, to be related to a modified groundwater system experiencing extra recharge from extensive border dyke irrigation. As noted by the CRC officers, levels have declined since 2000, which likely reflects, in my opinion, conversions from border dyke to spray irrigation and increased groundwater abstractions, but the range of water levels may simply be returning to the more natural range of water levels experienced during the 1950s. Given this, I am of the opinion that it could be premature to describe, as the CRC does, the current trend as an unnatural situation of over-abstraction.

14. Age determinations of groundwater are reported by Durney and Ritson (2014) to show the following patterns:

14.1 0-7 years for wells less than 20m deep;

14.2 Up to 38 years for wells between 25 and 60m deep;

14.3 Older than 60 years for wells more than 60m deep.

15. Therefore, there is a lag, typically of several years duration, between land use change and the groundwater quality patterns that it influences. Groundwater ages represent an indication of the average age since the water entered the groundwater system. However in reality there is a wide distribution of ages that make up the groundwater composition at any particular location comprising both younger and older water due to the variable movement of the water through zones of strata with differing permeability. Current groundwater quality patterns therefore reflect a spectrum of historical land use activities and not the total impact of the current farming operations.

16. Both groundwater quality and surface water quality in the coastal drains are affected by elevated nitrate concentrations as a result of agricultural practices on the plains. However the results are quite variable.

17. Figure 3 shows groundwater nitrate–nitrogen concentrations relative to bore depth. It shows that the highest concentrations are mainly limited to bores less than 40 m deep. Bores deeper than 40 m have not shown concentrations above the Maximum Acceptable Value in the New Zealand Drinking Water Standards. A wider range of bores show concentrations above the National Bottom Line value of 6.9 mg/L. Whilst that is a surface water criteria and is used in Variation 2 because the groundwater provides baseflow to the spring-fed coastal waterways, it is also a criteria that helps to achieve the Maximum Acceptable Value for nitrate-nitrogen in the New Zealand drinking water standards (11.3 mg/L).

18. Figure 4 shows a plan map of average annual nitrate–nitrogen concentrations in bores measured on four occasions in 2014. All the bores are relatively shallow and show elevated concentrations in the mid to lower plains.

19. Figure 5 shows a plan map of the annual median nitrate–nitrogen concentrations at surface water monitoring sites in the lowland plains sampled on three or more occasions in 2014. Most of the values are significantly elevated, relative to a national bottom line (NPSFM 2014) value of 6.9 mg/L, although some lower values are present. It is expected that these are influenced by low nitrate recharge from the Hinds River or water race distribution networks, thereby demonstrating the improved surface water quality that can be achieved by Targeted Stream Augmentation.

20. The nitrate-nitrogen concentrations that are measured in the groundwater and springfed streams are a mixture of land drainage inputs from recent to several years ago – perhaps up to 10 years ago for the shallow groundwater, with younger inputs for the shallowest groundwater and a reasonable influence from 10 year old water in wells at depths of around 20 metres deep. This is because the soil drainage water does not move evenly through the ground. Some moves relatively quickly through permeable pathways but other components of drainage will move quite slowly, hence the mixture of inputs from a range of years.

21. Because of that characteristic of sub-surface water movement it is difficult to predict the time period over which nitrate-nitrogen concentrations in groundwater will change. The current trend at most monitoring points is for increasing concentrations in the shallow groundwater and springfed streams. The factors that influence that increasing trend are:

    21.1 More intensive land use;

    21.2 Less drainage due to conversions from border dyke to spray irrigation;

    21.3 Less leakage from water races due to more piping of the distribution networks.

22. Whilst those factors will continue to be present in the catchment in the immediate future, the groundwater concentrations can't go higher than the soil drainage concentrations. Stuart Fords' evidence for RDRML indicates current annual average soil drainage nitrate-nitrogen concentrations across the Hinds Plains of 10.3 mg/L. Some monitoring points are already at those levels so if the Overseer leaching estimates are accurate then there should not be large increases over what is currently occurring, but the elevated concentrations could remain at these elevated levels for the next 5 – 10 years before the effect of any land improvement measures to reduce soil leaching concentrations actually show up in the groundwater and spring flows.

The CRC water quality modelling assessment to determine nitrogen loss limits

23. The CRC have, in Variation 2, set a nitrate-nitrogen target in the spring-fed drains of an annual median of 6.9 mg/L and an annual 95th percentile of 9.8 mg/L (Table 13(j)). They want this target to be met in 2035. These nitrate-nitrogen values are consistent with the National Bottom Line specified in the National Policy Statement for Freshwater Management 2014.

24. Because the baseflow to springfed coastal drains is sourced from groundwater, a groundwater quality target has also been set at a value of 6.9 mg/L, calculated as an average annual nitrate-nitrogen concentration (Table 13(k)).

25. The CRC's approach to modelling the nitrogen soil loss limits to achieve these water quality targets is described in their report R13/93 entitled, "Hinds Plains Water Quality Modelling for the limit setting process" (Scott, 2013) and subsequent memos on that topic.

26. The modelling assumes that the nitrogen leaching loss through the soil, estimated from Overseer, and its associated drainage water will correspond directly to the concentration of nitrate-nitrogen in the shallow groundwater, which in turn will match the median nitrate-nitrogen concentration in the coastal drains. Other sources of groundwater recharge, such as low nitrate seepage from water races have been ignored, even though they form a significant proportion of the water balance, as shown in Table 1 at the end of paragraph 11 of my evidence. Therefore, in my view the CRC assessment is a conservative and broad brush estimate of nitrate-nitrogen concentrations in the groundwater system.

27. These assessments show that under a "Development Scenario" with 30,000 ha of additional irrigation and all farms operating at Good Management Practices (GMP), catchment nitrogen leaching will amount to around 5,600 tonnes N/year. CRC's proposed approach is to reduce the nitrogen leaching to 3,400 tonnes N/year, which is around a 40% reduction. Variation 2 has chosen to increase this reduction by requiring a 45% reduction to account for existing farms not currently operating at GMP (Scott, 2015). This value of an overall 45% reduction has been adopted in policy 13.4.9(d) of Variation 2.

28. The nitrogen loss of 3,400 tonnes N/year corresponds to a nitrate-nitrogen concentration of around 9.7 mg/L in drainage water, shallow groundwater and coastal drains. In order to reach the target concentration of 6.9 mg/L specified in Table 13(j) and 13(k) the addition of around 4.5 m^3/s of Managed Aquifer Recharge (MAR) water must be utilised to dilute the shallow groundwater as a continuous steady infiltration flow all year (Scott, 2014).

29. By its very nature this approach to modelling is a broad brush simplification of the natural groundwater system. This is correctly acknowledged in Scott (2013) where she says,

"The scenarios I modelled are not intended to be quantitative predictions of future water quality in the Hinds Plains. They are intended to provide an indication of relative changes that might be expected under various conditions in the catchment to inform a community decision process."

Despite that wise qualification, the numbers from Ms Scott's modelling calculations have been incorporated into the plan in the nitrogen loss limit of 3,400 tonnes N/yr (Table 13(g)) and in the calculated reduction requirements for nitrogen leaching.

30. An example of the potential uncertainties in these estimates occurs in a consideration of the volume of water draining through the soil. My understanding is that the Overseer estimates of soil drainage volumes are less then drainage volume estimates from other soil moisture balance models. The CRC officers calculations assume an annual land surface recharge volume of 349 million m^3 per year, which I understand is derived from Overseer output and corresponds to an annual soil drainage of 275 mm. However, the water balance estimate in the Table 1, at the end of paragraph 11 of my evidence, indicates an annual land surface recharge flow of 15.5 m^3/s, which corresponds to a volume of 489 million m^3 per year (385 mm per year). That higher value of soil drainage would correspond to an allowable nitrogen leaching loss of around 4,200 tonnes N/year to achieve the water quality targets (in combination with 4 m^3/s of MAR water), rather than the 3,400 tonnes N/year as currently proposed.

31. Because of these uncertainties it would seem unwise to specify 3,400 tonnes N/year as a target to be met in 2035, as currently stated in Table 13(g) of

Variation 2. If that target of 3,400 is to be used then it would seem more appropriate to extend the time frame for its achievement to a longer time period such as 2055, as proposed in the evidence of Mr Ford and Mr Bryce. That longer time period allows for refinement of the soil drainage volumes and nitrogen leaching loads that are actually achievable, the implementation of MAR and TSA trials to demonstrate their effectiveness and an allowance for the residual effects of historical land use to work their way through the groundwater system.

Managed aquifer recharge (MAR) and targeted stream augmentation (TSA)

32. Variation 2 places a strong emphasis on MAR and TSA to achieve the water quality targets and in the CRC modelling exercise a continuous MAR input of around $4m^3/s$ is the suggested requirement. Based on the numbers in Table 1 of this evidence that level of input represents a significant component of the groundwater balance for the area (around 20%). The water is introduced by infiltration basins in the upper to mid – plains area. It is difficult to control what happens to that water following its discharge via a MAR system. Whilst MAR definitely has the potential to help address water quality and quantity issues, the exact extent and magnitude of those benefits is uncertain until field trials are conducted. It also comes with a risk of exacerbating high groundwater level situations and land drainage problems in the lowland parts of the catchment.

33. In contrast, TSA provides a more refined tool to address surface water flow and quality issues in the coastal drains. It involves the provision of a supplementary flow of good quality water at, or close to, the stream headwaters at those times of year when it is required. Whilst TSA is mentioned in Variation 2 (i.e. Policy 13.4.14) it has not been quantified to the same extent as MAR in the CRC officers reports. However because it is targeted to specific streams at particular times of year it is likely to require a much smaller annual volume of water compared to MAR and should have a greater likelihood of achieving the surface water targets than MAR over a shorter time frame, whilst avoiding the potentially problematic land drainage issues.

34. Figure 6 indicates the variability that occurs at different times of year for the nitrate-nitrogen concentrations in the coastal spring-fed waterways, indicating

that the required input of TSA water can be varied throughout the year in order to achieve the proposed water quality standard. Furthermore, the minimum flow requirements for the coastal surface waterways total around 2 m^3/s (Table 10.12 from Durney and Ritson, 2014), indicating a smaller and variable augmentation requirement to achieve the water quality targets compared to the MAR proposition.

35. The use of TSA to address water quantity and quality issues in the coastal drains also means that their improvement is not totally dependent on waiting for an improvement in groundwater quality issues in the spring discharge areas by the use of MAR at locations further inland. Therefore, with consideration to the evidence of Mr Stuart Ford, a more realistic approach to achieving the groundwater quality targets could be taken, in terms of time frames and percentage reductions.

Groundwater comments related to changes sought by RDRML

36. Much of the RDRML Submission relates to the following inter-related limits and targets:

36.1 The nitrogen load target of 3,400 tonnes N/year in 2035 for the Lower Hinds/Hekeao Plains and a leaching limit of 27 kg N/ha/yr (Policy 13.4.8)

36.2 The reduction requirements to achieve that load of 45% below GMP (Policy 13.4.9);

36.3 Groundwater and surface water nitrate-nitrogen targets of 6.9 mg/L.

37. Issues related to nitrogen leaching values and percentage reductions are covered in the evidence of Mr Stuart Ford. My only issue with those numbers is to reiterate the qualification that Ms Scott placed upon her work, which was that the numbers (such as 3400 tonnes N/year) are not intended to provide quantitative predictions of future water quality. Therefore, there is considerable uncertainty as to whether a load limit of 3400 tonnes/year and around 4 m^3/s of MAR is the correct load that corresponds to the groundwater target of 6.9 mg/L in Table 13 (k).

38. Whilst Ms Scott says her calculations provide an indication of the relative changes that are required there is uncertainty about the need for a 45% reduction in nitrogen load due to the uncertainties in the Overseer calculations of leaching loads (discussed in Mr Stuart Ford's evidence) and their relationship to groundwater quality data. Given these uncertainties and the potential for TSA to address coastal drain issues it could be feasible for Variation 2 to adopt more readily achievable nitrogen load values and timeframes, as discussed in Mr Ford's evidence.

39. The nitrate-nitrogen target for groundwater is specified in Table 13(k). Scott (2013) notes that an average nitrate-nitrogen concentration of 5.7 mg/L in shallow groundwater is considered an appropriate target to ensure that not more than 10% of samples exceed the Maximum Acceptable Value for drinking water (i.e. 11.3 mg/L) in a given year. However the Hinds community indicated that was not a fair target to use because the drinking water issue can be addressed by treatment or alternative sources, including deeper water supply bores as indicated by Figure 3. Therefore a decision was made to set the groundwater target based on achieving the coastal spring fed drains water quality target, given that groundwater provides the baseflow to those drains.

40. I consider that to be an aspirational target, which is an appropriate approach to take, but the time frame for it to be achieved could be relaxed, particularly if TSA is implemented to help address the coastal drain water quality issues and given that the local community is accepting of the use of alternative supplies as an acceptable approach for the groundwater quality situation. A more relaxed approach to the timing for implementation of the groundwater target helps to address the concerns about realistic implementation measures and time frames described in the evidence of Mr Stuart Ford. Therefore Mr Bryce's proposal to achieve the groundwater nitrate-nitrogen target of 6.9 mg/L (Table 13(k) by 2055 seems an appropriate approach, although the other targets in Table 13(k) related to *E.coli* and other contaminants of health significance should be reached over a shorter time period, as proposed by CRC.

41. The final groundwater related point regarding the RDRML submission is the encouragement to replace consented abstractions from over-allocated surface waterways with abstractions from deep groundwater (policy 13.4.5). That is a reasonable approach to address the surface water allocation issue

although to be effective, there must be an allowance in the plan for additional groundwater allocation to occur when that allocation is replacing an operative surface water take from an over-allocated catchment, i.e. Rule 13.5.31 must prevail over the region-wide rule 5.130.

42. At the present time the Valetta groundwater allocation zone (GAZ) is over-allocated and the Mayfield-Hinds GAZ is around 83% allocated. Most coastal surface waterways are over-allocated. Variation 2 proposes to reduce the allocation limit of the Mayfield-Hinds GAZ to the currently allocated volume so that it becomes fully allocated (Table 13(f)), thereby not allowing any increase in allocation. However, if a currently used surface water take is replaced by a deep groundwater take that does not directly impact on the flow in a surface waterway that will be a better overall outcome for the allocation of the water resource and should be encouraged. Figure 7 attached to my evidence presents a comparison between consented surface water abstraction rates and groundwater yields from deeper bores in the lower plains. This indicates there is a reasonable expectation that bore yields up to 80 L/s can be achieved, thereby providing an effective alternative to many surface water takes.

Conclusion

43. The general approach in Variation 2 to seek improved management practices that reduce nutrient loss and avoid over-allocation of waterways seems appropriate, including the use of MAR and TSA.

44. Some of the numeric limits/targets in the plan (such as the 3,400 t/yr nitrogen load limit and a requirement to reduce nitrogen leaching by 45% below GMP) are not, in my opinion, well justified in terms of achieving particular water quality outcomes. So some flexibility and allowance for future refinement of those requirements would seem appropriate.

45. The requirement to link groundwater quality targets to coastal surface waterway limits is not essential if TSA is used as a water management tool.

46. Replacement of surface water takes with deep groundwater takes is a helpful approach to address the overall over-allocation approach to water resources

in this area, particularly given that the Mayfield-Hinds groundwater allocation zone is not currently over-allocated.

47. Having considered the recommended changes highlighted in Mr Bryce's statement that relate to the issues described in my evidence, I am satisfied from a water quality perspective, that they represent an appropriate approach for incorporation into Variation 2.

References

Durney, P & Ritson, J. (2014); Water resources of the Hinds/Hekeao catchment: Modelling Scenarios for load setting planning process, Environment Canterbury Report No. R14/51.

Scott, Lisa (2013); Hinds Plains water quality modelling for the limit setting process, Environment Canterbury Report No. R13/93.

Scott, Lisa (2014); Hinds Plains Water Quality Modelling – Adjustments To The Model And Final Catchment Load Calculations. Memo dated 3 April 2014.

Scott, Lisa (2015); Variation 2 Submissions Recommending Alternative Load Allocation Approaches, Environment Canterbury Technical Memoranda 31 March 2015.

Name: Peter Francis Callander

Date: 15 May 2015

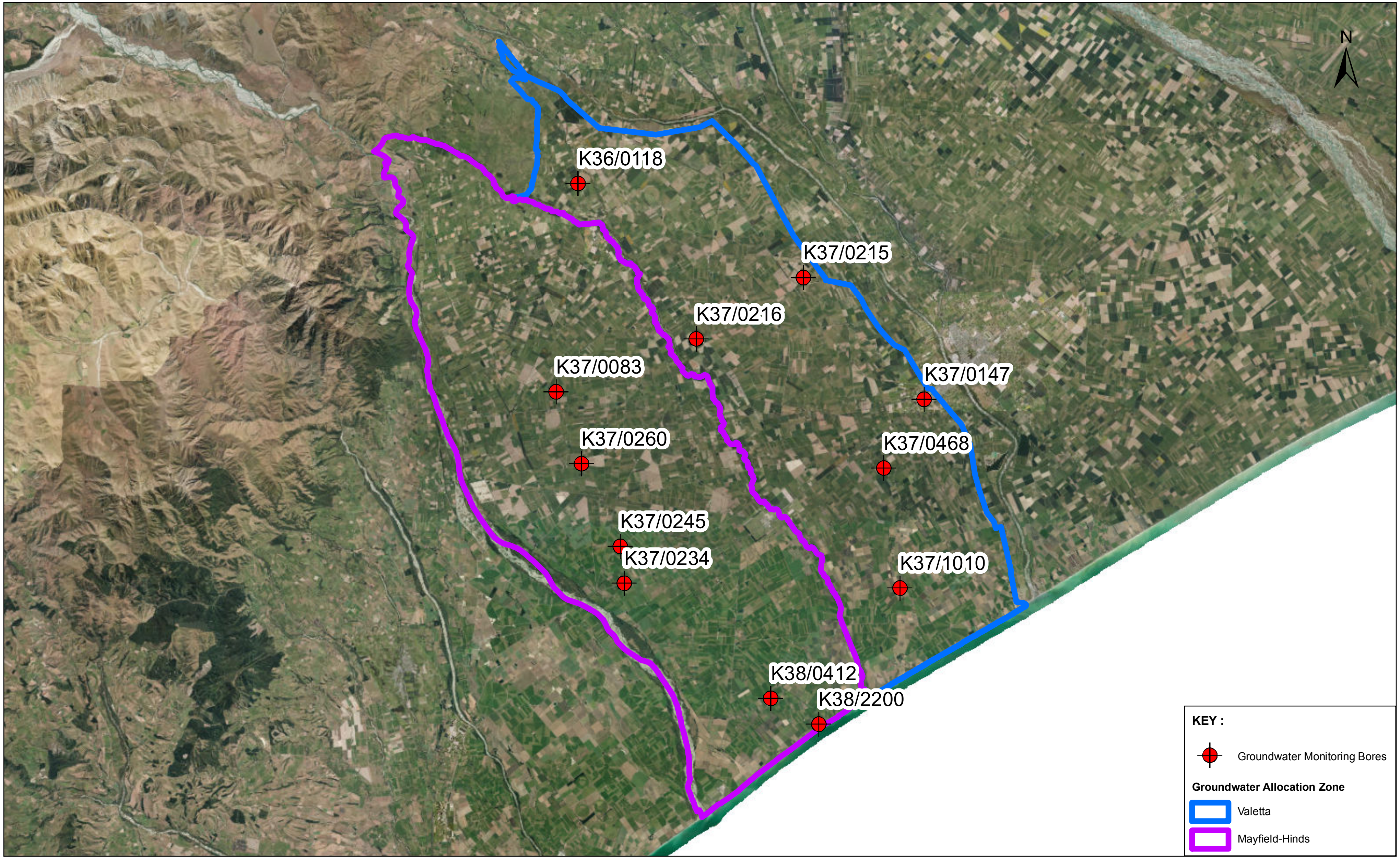

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Figure 1: Groundwater Monitoring Bores

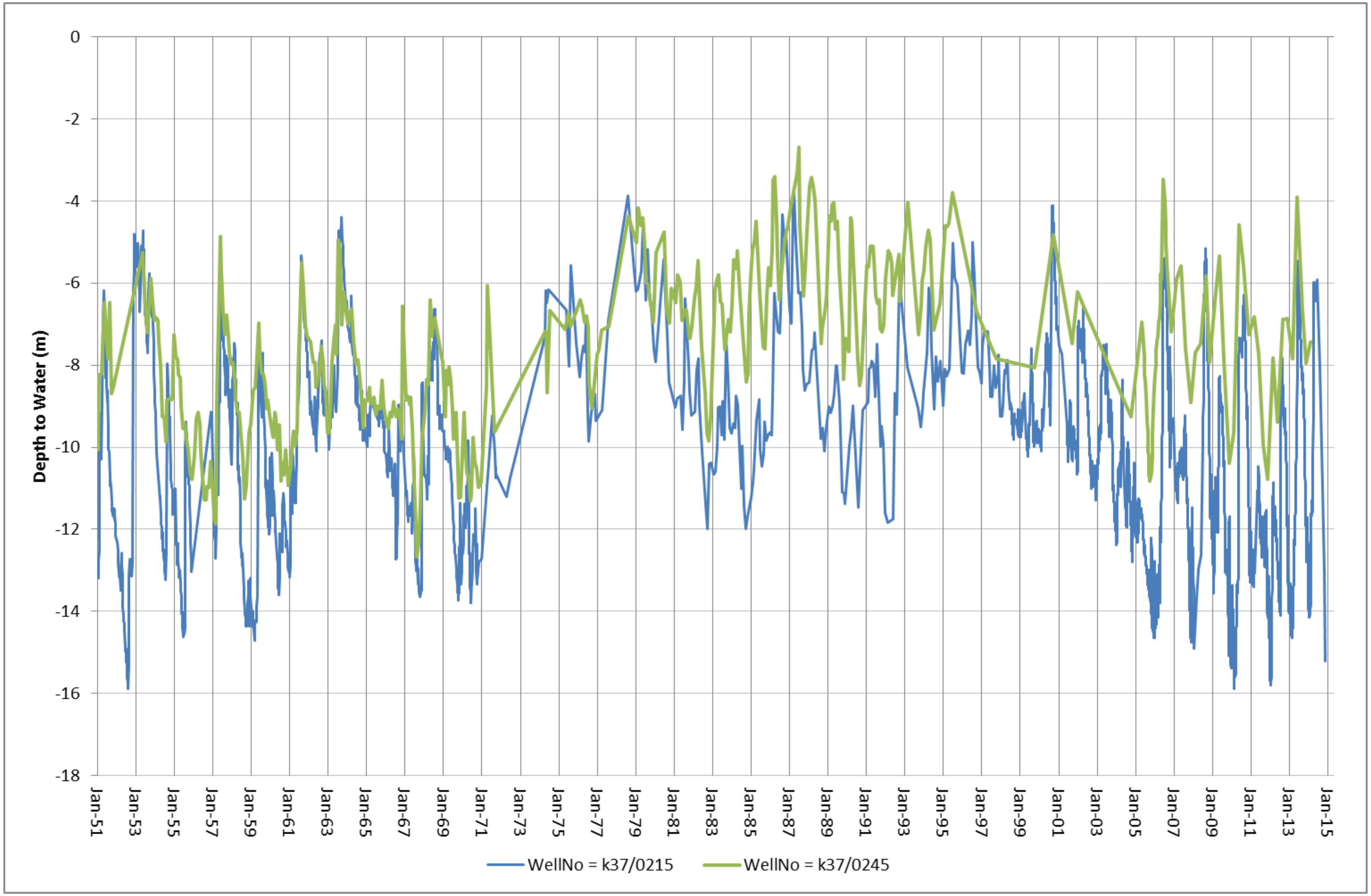

Figure 2: Long Term Groundwater Level Monitoring Records

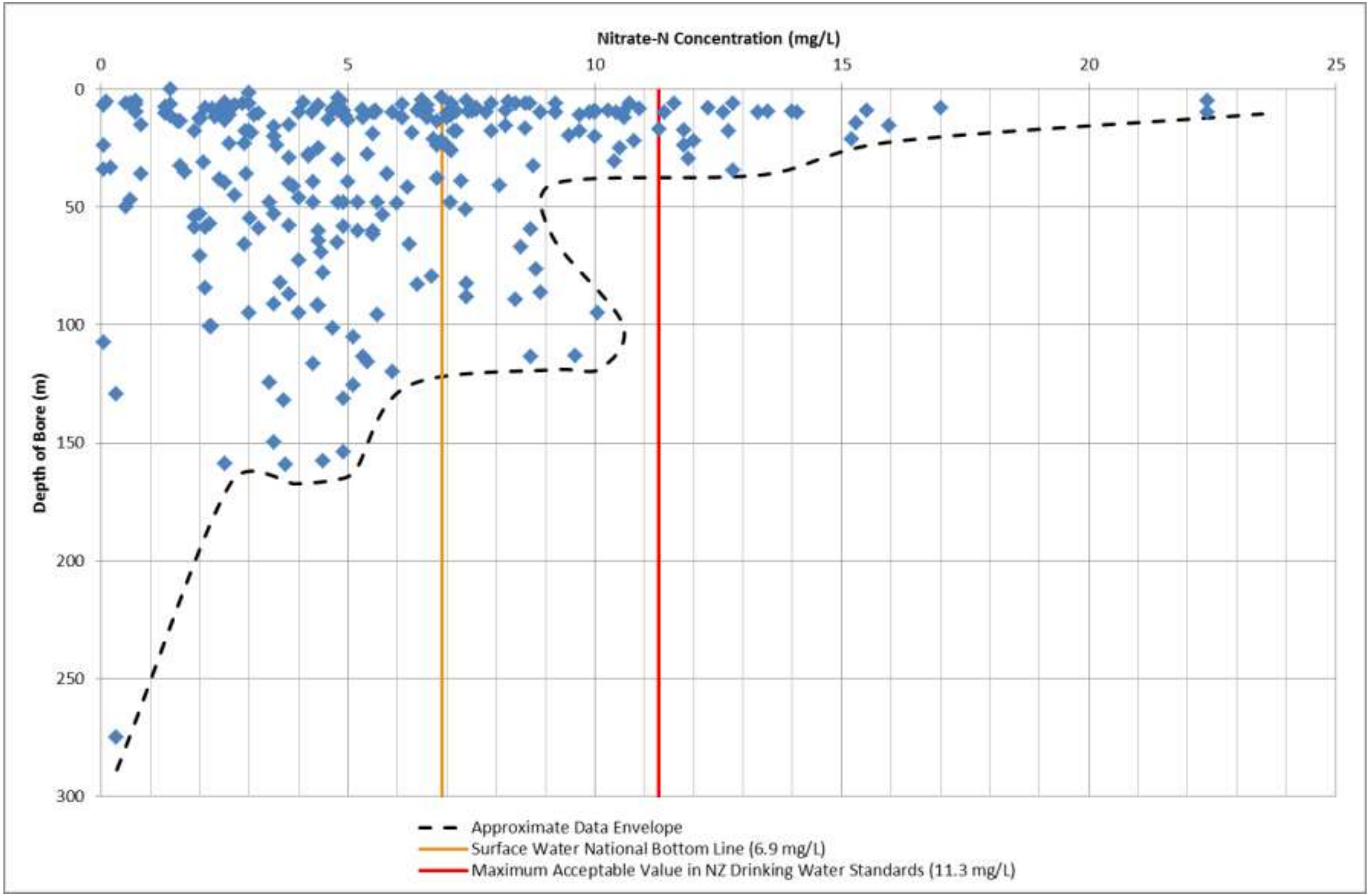

Figure 3: Nitrate-N Values versus Depth of Bore

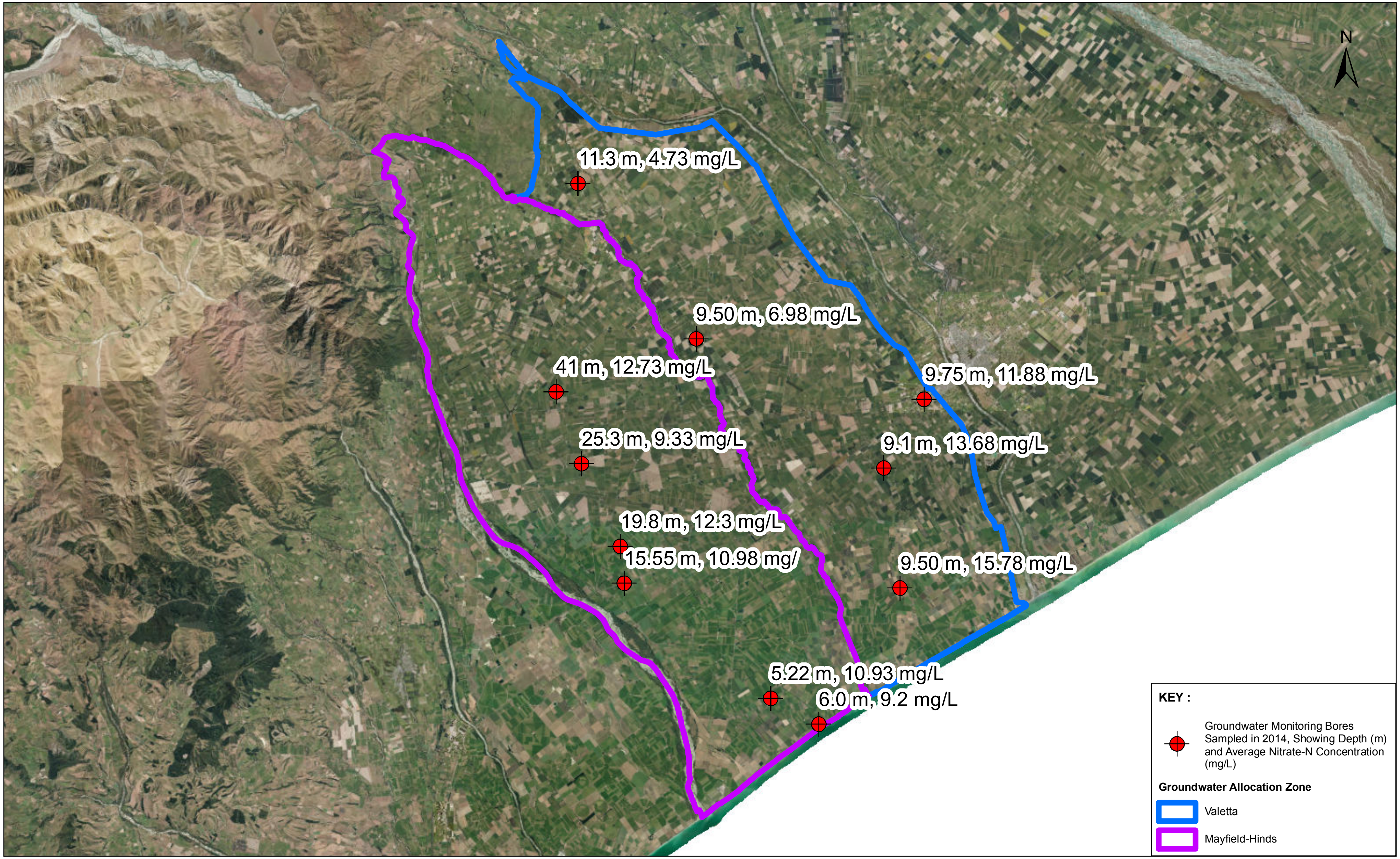

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Figure 4: Depth and Average Nitrate-N Concentration for Bores Monitored in 2014

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Figure 5: Median Nitrate-N Concentrations at Surface Water Monitoring Sites in 2014

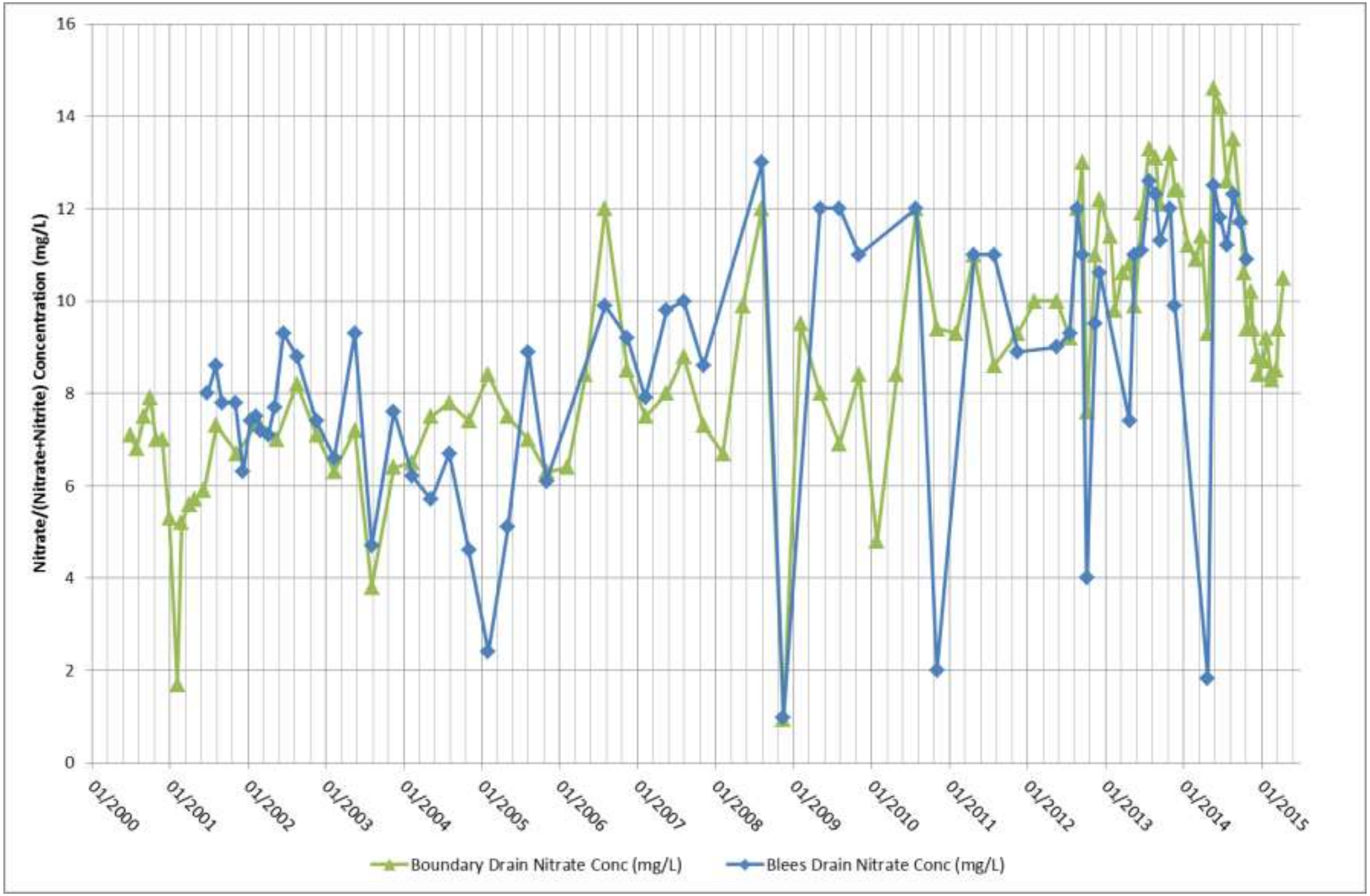

Figure 6: Nitrate-N Concentrations in Boundary Drain and Blees Drain

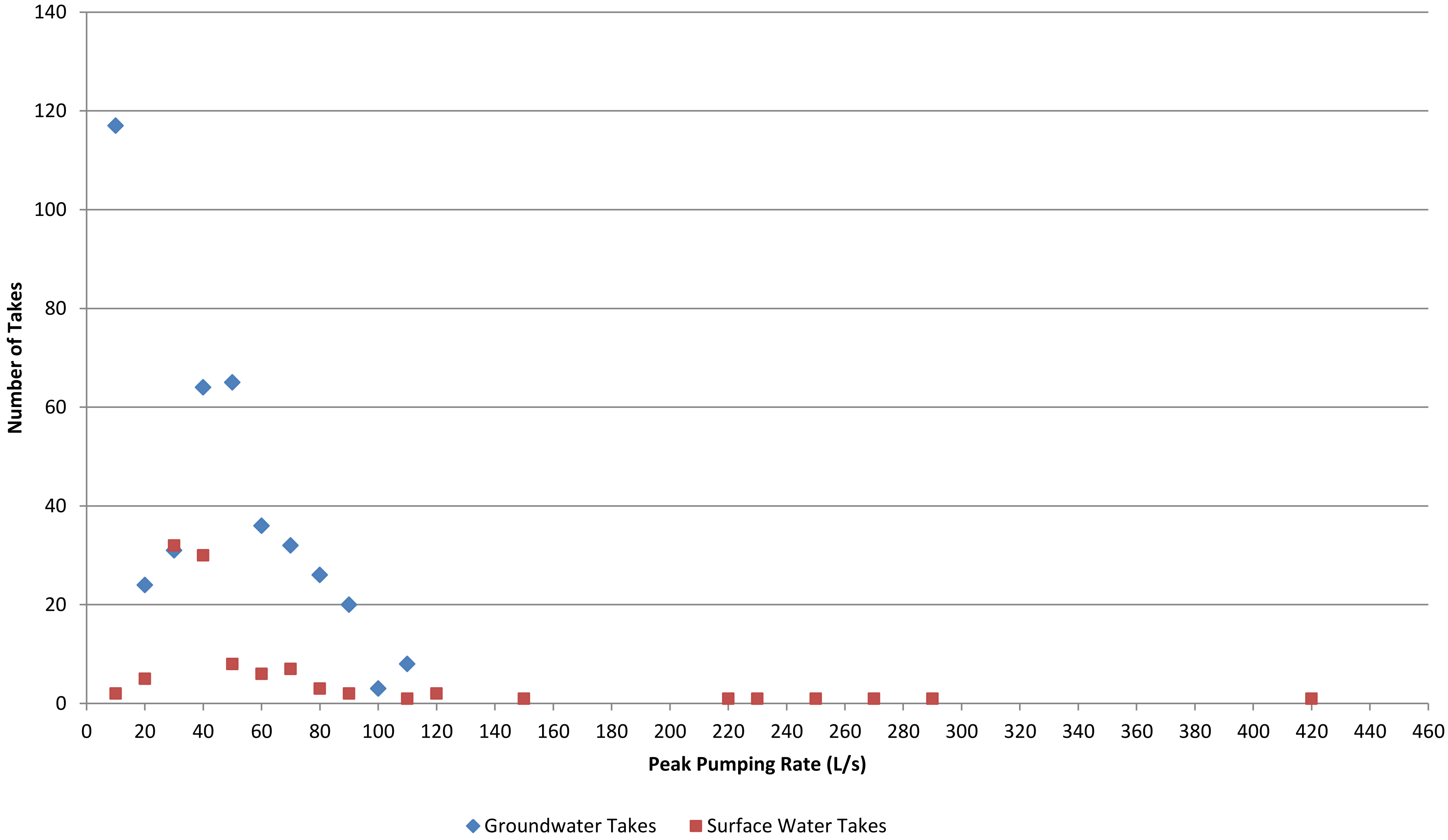

Figure 7: Comparison between consented surface water abstraction rates and individual yields in bores greater than 30 metres deep in the Lower Hinds Plains.