PATTLE DELAMORE PARTNERS LTD
295 Blenheim Road
Upper Riccarton, Christchurch 8041
PO Box 389, Christchurch 8140, New Zealand

Tel +64 3 **345 7100** Fax +64 3 **345 7101**
Web **www.pdp.co.nz**
Auckland Tauranga Wellington **Christchurch**

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28 June 2019

Alison Johnstone
Silver Fern Farms Ltd
RD2 Fairton
PO Box 30
ASHBURTON 7740

Dear Alison

SILVER FERN FARMS TAKAPAU CONSENT RENEWALS SECTION 92 REQUEST

1.0 Introduction

This letter outlines the work we have undertaken to assist with the response to the Section 92 request received from Hawke's Bay Regional Council (HBRC) on 6 December 2018. The request is for additional information for the consents to discharge partially treated meat processing wastewater onto land and to discharge domestic wastewater from an oxidation pond to land via a border dyke system.

As requested, we have provided responses to questions 6, 7, 8, 9, 10, 11, 12, 14, 15, 16, 22, 23 and 24 and 25.

The key concern raised by HBRC is that there appears to be significant room to reduce the actual and potential effects of the discharge through a shift over time to more efficient irrigation of the wastewater. This is based on the review from Council's technical advisors and a 2018 Aqualinc report "*Wastewater Discharge Review – Takapau Plant*" that details a review of the irrigation system, which we have reviewed since receiving the Section 92 request for further information and the Aqualinc report.

To address the concerns raised in the Aqualinc report, the Section 92 request and the review provided by Williamson Water & Land Advisory, we have undertaken the requested analysis of the available soil moisture data. In addition to the requested soil moisture modelling for the domestic wastewater discharge via border dyke, we have also undertaken soil moisture modelling to compare the current expected drainage with that expected for an improved irrigation system, for the process wastewater discharge. This work provides useful information on how the effects of the current system (using travelling irrigators) would compare to an upgraded or new system (improved irrigation methods or centre pivot) and can be used to inform further optimisation of the current system to minimise drainage to groundwater.

We have noted that there appears to be some misunderstanding in the reviews on the difference between irrigation as a method for wastewater disposal and irrigation for agricultural production. A comparison has been made between wastewater irrigation and irrigation for the purpose of pasture production, with irrigation only when there is irrigation demand. Wastewater irrigation in most situations has the least environmental effects of disposal methods, compared to direct surface water discharge, or discharge to ground via methods that bypass the surface soils (trenches/rapid infiltration beds). Unlike the use of irrigation water for plant production, the discharge of processing wastewater via irrigation at the site is required throughout the year with no alternative disposal method available. This means there is a need to irrigate wastewater during periods when plant uptake is lower and when soil moisture is already sufficient for plant growth. It would be difficult to store wastewater during periods when irrigation is not required for plant growth and only irrigate when required for plant growth, both due to storage size requirements and wastewater management.

Following on from this, we are aware that condition 42 of the consent, which relates to field capacity, is interpreted to apply to the entire operation. Our view is that this should apply only to some of the soils on Block E and condition should be amended for the future consent to allow non-deficit irrigation in all blocks, except parts of Block E. It is not feasible for wastewater irrigation to occur on other areas only when soil moisture is below field capacity, unless there is a very large amount of storage, which is impractical for this operation, or an alternate method of discharge, which would be expected to have greater environmental effects. However, it is good to minimise the frequency with which exceedances of field capacity occur, via irrigation management optimisation. The soil moisture modelling has helped inform how often field capacity (and saturation) are exceeded across the operation and the results have been compared to the soil moisture data to check the model in the locations of those sensors.

2.0 Section 92 questions and responses

Excerpts and questions from the section 92 response are shown in bold italics, with the responses provided beneath each question/comment.

The introduction to the Section 92 request describes how the Porangahau sub-catchment has significant increases in instream nitrogen between Takapau and the downstream end of the Porangahau Stream. The stream's instream DIN concentration exceeds the target set out in the Tukituki Catchment Plan (TCP), and as such, all production land use activities in this sub-catchment will require consent from 1 June 2020. Through this consent process, improvements will be required to reduce nitrogen losses over time. The Section 92 request notes that it is important that the effects of Silver Fern Farms' discharges are well understood, and that Silver Fern Farms should also seek to improve management practices and reduce their nitrogen contribution over time. While significant improvements have occurred over time at this site, the work presented in this letter should help inform additional changes in management that may further reduce nitrogen leaching. These are likely to involve improving application rates, reducing return periods and greater use of the monitoring data, together with modelling as necessary. Phased implementation of system upgrades is expected.

The Section 92 request introduces the process wastewater questions with the following comments.

<u>Process Wastewater discharge effects</u>

An irrigation simulation model was developed and run for wet and dry years to investigate the response of the soils over a 10-year period under three different scenarios (base case (without irrigation), optimal irrigation (4 mm/day, and 'best management practice'), and the proposed irrigation regime (up to 65 mm every 14 day).

This model demonstrates that the proposed application rates will result in significantly elevated soil moisture content, and will lead to significantly greater leaching, primarily during winter, and that percolation to groundwater doubles under the proposed irrigation from that expected under best practice.

As outlined in the introduction to this letter, there appears to be some misunderstanding on the difference between irrigation as a method for wastewater disposal and irrigation for agricultural production. This comparison has been made between wastewater irrigation and irrigation for the purpose of pasture production, with irrigation only when there is irrigation demand. Unlike the use of irrigation water for plant production, the discharge of processing wastewater via irrigation at the site is required throughout the year and is not constrained by weather. This means there is a need to irrigate wastewater during periods when plant uptake is lower and when soil moisture is already sufficient for plant growth. It would be difficult to store wastewater during periods when irrigation is not required for plant growth and only irrigate when required for plant growth, both due to storage size requirements and wastewater management. Site specific soil moisture modelling is presented in subsequent sections of this letter.

The Section 92 request also includes the following comment. Further information is provided in this letter related to this comment.

At this stage, we consider that it is not certain that the current upstream and downstream surface water sites truly reflect the upstream and downstream conditions, and a better understanding of groundwater flow paths is required before attributing weight to the results of the water quality and MCI results to date.

2.1 Question 6

6. A map showing all monitoring bores (shallow and deep) and interpolated depth to groundwater contours in metres below ground level (mBGL) across the site and immediate surrounds (0.5 km buffer).

Figure 1, appended, shows the Silver Fern Farms monitoring bore locations together with groundwater surface elevation contours obtained from LiDAR data, in metres above sea level (m amsl). The LiDAR data used was HBRC's 250 mm contours from the Central Hawke's Bay (2006 May) ID#11 Survey. The data was first translated from the vertical datum used for all HBRC Engineering data (MSL = 10 m) to metres above sea level. Also shown on Figure 1 is the LiDAR elevation along the length of the Porangahau Stream. This will reflect either the elevation of the stream surface or the land directly adjacent to the stream.

In order to generate depth to groundwater contours, the depth to water readings provided to us for the shallow bores have been converted from depth below top of the casing to depth to water below ground level. This has been done based on the information on the well completion reports and other files provided. We have first generated groundwater elevation contours (in metres above mean sea level) using the kriging method of interpolation. In the absence of surveyed elevations for all data, we have used the detailed 250 mm LiDAR contours, which have enabled the ground elevations around the monitoring bores to be determined with a reasonable degree of accuracy. We have then calculated the difference between this and the LiDAR data, to generate the depth to groundwater contours.

The resulting depth to groundwater contours are shown in Figure 2a and Figure 2b, appended. These are based on the assumption that the levels measured in the shallow monitoring bores reflect the water table, which is considered reasonable based on the bore depths. The interpreted contours beyond the site and further away from the monitoring bores should be viewed as indicative only, given the absence of information in those areas.

Figure 2a shows the interpreted depth to groundwater during January 2017 while Figure 2b shows the interpreted depth to groundwater in August 2017. These two figures have been prepared to illustrate seasonal differences in groundwater levels, with typically low levels in summer/autumn and higher levels in winter/spring. Figures 2c and 2d, appended show the corresponding interpolated groundwater elevation plots for January 2017 and August 2017.

Figures 2a and 2b also show the interpreted depth to groundwater along the length of the Porangahau Stream. There is reasonable confidence in the interpreted depth in the vicinity of the shallow monitoring bore 15957 (Silver Fern Farms # 7B) (6.6 m deep) and bore 15962 (5B) (7.35 m deep). There is less confidence in the middle of the site, where there are no bores.

As shown in Figure 2a, the interpreted depth to groundwater along the length of the Porangahau Stream through the site is between 4 and 7 m in January 2017. Even considering the uncertainty with no bores in the central part of the site and that the steam surface may be slightly lower than indicated by the LiDAR data, this indicates that the stream is very likely to be losing to groundwater across the site. As shown in Figure 2b, these losing conditions were expected to also occur in August 2017, but the interpreted depth to groundwater is reasonably shallow (less than 1 m) towards the western boundary, so it is possible some reaches may have been gaining flows.

Historically, shallow monitoring bores with longer term records dating back to 2000 (bore 15636 (W), 15638 (I), 4455 (Z) and 4456 (Y)) indicate groundwater levels have been higher than measured in August 2017. For example, data for bore 4456 suggests levels have been almost 3 m higher (September 2006). This suggests that the stream may gain groundwater during periods of higher groundwater levels in parts of the site, but overall, the information suggests that the Porangahau Stream typically loses water to groundwater beneath the site.

The implications of this are that nutrients leaching to groundwater as a result of the wastewater irrigation are unlikely to enter the Porangahau Stream through the site, except during periods of high groundwater levels.

It was noted in the Technical AEE report (Pattle Delamore Partners Ltd, 2018) that it was possible the Porangahau Stream is losing water to groundwater in this section, and that that could be confirmed by a period of surface water level and groundwater level monitoring in the vicinity of the plant. The detailed 250 mm LiDAR contours obtained from HBRC have been very useful for comparing to the groundwater information and together this information suggests that the Porangahau Stream does typically lose water to groundwater beneath the site.

Overall the surface water quality monitoring at the two sites, one near the upstream site boundary and one at the downstream site boundary, suggests that the operation is having limited impact on local surface water courses. This is expected to be in part due to the controls to prevent direct discharges/runoff to the stream, but it is useful to now have the understanding that groundwater is not expected to typically recharge the stream in this location.

As outlined in PDP (2018), all groundwater ultimately re-enters surface water at some point to exit the Ruataniwha Basin.

2.2 Question 7

7. A map showing interpolated groundwater elevation contours in metres above mean sea level (mASML) for the shallow and deep aquifers. Provide a piezometric surface plot during high and low river stage times for the shallow and deep aquifers to assess any changes in groundwater flow direction under different climatic conditions.

Previously, there were only reported measuring point levels (RL's) for some bores (Takapau name W, Y, X, I, Z, W9, Layers, R and S) to enable groundwater elevation contouring. Groundwater elevation contours were generated for the shallow bores and included in our 2010 report (Pattle Delamore Partners Ltd, 2010). There was insufficient information to generate contours for deep bores.

In the absence of accurate survey data for all monitoring bores, the detailed 250 mm LiDAR contours have enabled the ground elevations around the monitoring bores to be determined with a reasonable degree of accuracy.

Information on flows in the Porangahau Stream has been obtained from HBRC. This is a daily mean record which combines the measured (rated) and synthetic (vector transformed) flow for the period 1976-2014. HBRC have noted that the synthetic flow data provided and any statistics calculated from the synthetic data should be considered as estimates and used with caution. It is considered that, while the actual flows may be uncertain, it is useful for defining periods of higher and lower flows, as required to respond to this Section 92 question.

The interpolated groundwater elevation contours for both shallow and deep monitoring bores for different stage conditions are shown in Figures 3a to 3d, appended. As with the other elevation contours, there is uncertainty in these, particularly away from the bores. However, the contours suggest that there are no significant changes in the general inferred groundwater flow patterns with different stream flows/stage.

Overall, the figures indicate a similar groundwater contour pattern to that presented in Figure 7 in PDP (2010), with a slightly more north-easterly direction inferred for the groundwater flow direction in the southern parts of the site.

2.3 Question 8

8. A map showing interpolated contours of nitrate nitrogen concentration (mg/L) in the shallow and deep aquifers.

We do not consider that contours of nitrate-nitrogen concentrations can be reliably defined based on the monitoring data, even though there are multiple monitoring bores at and around the site. Nitrate transport varies depending on a number of variables, including dispersion characteristics and aquifer heterogeneity and input concentrations, which in this case have varied considerably over time and spatially. Instead, we have responded to this request with maps of measured concentrations in the different bores, with symbol size/colour based on the concentration to illustrate locations of higher and lower concentrations.

These maps are shown in Figure 4a and 4b, appended for the shallow and deep aquifers, respectively, and show the averages, maximum and minimum for sampling data we have been provided for the 2017 year. They clearly illustrate the hot spots that occur in the southern areas. As outlined in PDP (2018), historic border dyke irrigation of the process wastewater occurred on Blocks B, C and D. As outlined in PDP (2010), modelling undertaken suggested it could take up to 43 years for the plume of nitrates to fully pass through the groundwater in the locations of the down-gradient monitoring bores.

2.4 Question 9

9. A map showing the extent of the area where an exceedance of the drinking water standard is likely to occur (in both shallow and deep aquifers), and identify (using databases of known wells and surveys or other methods) all domestic water supply bores within this affected area.

It is not possible to reliably define an area where an exceedance of the drinking water standard is likely to occur with the current data, given the variable nature of the monitoring results, variability in the groundwater flow system and the changes over time that have occurred to the discharge of wastewater at the site. Additional sampling of downgradient bores known to be in use for domestic supply was considered to be more helpful, unless those bores were affected by other sources. This additional sampling was recommended to Silver Fern Farms by PDP.

In PDP (2010), bore 2900, to the east of the Layers Bores (2898) was identified as in use for domestic purposes. It was noted that historically, and even prior to the Silver Fern Farms operation occurring, that high nitrate levels had been recorded in bore 2900.

Silver Fern Farms have undertaken a sampling round in June 2019 of down-gradient supply bores on neighbouring properties, including bore 2900. This sampling has included a number of bores to the southeast of the site, even though they are considered less likely to be affected, to confirm no high nitrate-nitrogen levels are occurring.

The results of the sampling are shown in Figure 5, together with average readings for 2017 for the regular monitoring bores for comparison. This shows no exceedances of the Maximum Acceptable Value of 11.3 mg/L in the Drinking Water-Standards for New Zealand in the bores, with the exception of bore 15639. This is not unexpected given it is upgradient of the Layers Bore (2898), where high concentrations are still occurring. Silver Fern Farms have confirmed that, while bore 15639 was included in the sampling, it is not used for drinking water supply.

Two down-gradient bores in reasonably close proximity to the site that have been identified as potentially in use for domestic supply were unable to be sampled. This is because the landowners could not be contacted. These bores are bores 2901 and 16657. Silver Fern Farms will further attempt to contact these bore owners to ask permission to sample the bores, if still in use.

2.5 Question 10

10. Based on the interpolated groundwater contour elevations (question 7, above), comment on the adequacy of coverage of the current array of monitoring bores for nitrate plume detection and monitoring. Comment on location of upstream and downstream surface water monitoring sites.

Our view is that the previously interpolated groundwater contours (Pattle Delamore Partners Ltd, 2010) suggest the array of monitoring bores is appropriate, and this is supported by the more recently generated contours. If any additional bores were considered, an additional shallow bore midway at the eastern edge of Block A may help with interpretation of the increasing trend in nitrate in down-gradient bore 15638 and better isolate the effects of Silver Fern Farms' activities. An additional shallow bore midway along the eastern boundary of Block G could be considered to improve spatial coverage in the monitoring network in that area. Given the very low concentrations measured in the deep bores in those areas of the site, no additional deep bores would be considered necessary.

The information on the expected depth to groundwater described for Question 6 suggests that the Porangahau Stream typically loses water to groundwater through the site. Based on this, while the upstream monitoring site is considered reasonable, the downstream site is only likely to provide an indicator of any groundwater contributions from the site to the stream during periods of higher groundwater levels. While the downstream site is not expected to typically capture groundwater potentially impacted by the site activities, it is still considered useful to monitor to capture periods where groundwater may enter the stream and to demonstrate that the site is being managed in a way that no direct discharges/runoff occurs with adverse impacts on the stream. If water quality were measured in the Porangahau Stream further downstream where groundwater discharge typically occurs, which could be some distance from the site, influences from other properties would also be reflected in the data, so this would not be considered appropriate to isolate Silver Fern Farms' effects.

Overall, the groundwater monitoring data in most bores indicates minimal impact from the plant, with the exception of the southern monitoring bores, which are expected to reflect the historic border dyke irrigation. However, it is considered important that irrigation on the blocks up-gradient of those bores is well managed, given the high concentrations.

It is acknowledged in our 2018 report that all groundwater ultimately re-enters surface water to exit the Ruataniwha Basin so that, while the operation appears to be having limited impact on local surface water courses, continuing to manage the operations with a view to maximising nutrient uptake via harvest will limit the site’s contribution to cumulative nutrient effects on down-gradient waterways. Further improvements in irrigation management to reduce drainage and leaching are being considered by Silver Fern Farms, based on the soil moisture modelling information provided.

2.6 Question 11

11. Provide a hydrogeological description of the groundwater recharge, groundwater through-flow and groundwater mean residence time characteristics using measured or typical published values to support the description.

As outlined in PDP (2018), groundwater in the Ruataniwha basin is recharged through rainfall, together with river seepage from the main Tukituki and Waipawa Rivers, with a lesser component of seepage from other, smaller streams that occur across the basin and irrigation recharge. The groundwater flow direction is generally to the south-east but locally, PDP (2010) showed the general flow direction across the site to tend more towards the north-east (this is supported by the groundwater contour maps appended to this letter). The Ruataniwha Basin is effectively enclosed by lower permeability strata and, as a result, groundwater discharges from the basin principally via upwards seepage into the main rivers and also through groundwater abstraction.

Locally in addition to rainfall recharge, there is irrigation recharge from the wastewater irrigation and irrigation from other properties and runoff from hills to the south. It is thought that the Porangahau Stream is spring fed further to the west from relatively deep aquifers 30 to 70 m below ground level (Willoughby, 1992), and may be a recharge source for the shallow aquifer in and around the vicinity of the processing plant (CPG, 2009). As outlined in the response to Question 6 and supported by the maps appended to this letter, it is expected that the Porangahau Stream will lose some proportion of flow to groundwater across the site.

Groundwater characteristics were outlined in Table 10 of PDP (2010). This is reproduced below. As outlined beneath the table, the values in brackets are those used to calibrate the modelling undertaken to assess nitrate transport, and are therefore considered to be the most likely to be representative of site conditions.

For the shallow aquifer, the values in Table 10 and the groundwater gradient interpolated from the contours, gave an estimated throughflow/unit discharge of 2.3 m^3/day/m, with a calculated average linear velocity of 0.15 m/day, as reported in PDP (2010). The aquifer thickness of 40 m for the shallow aquifer in Table 10 is considered quite large, but use of this value gave the best estimate for the average linear velocity. In reality, the thickness may be smaller and the corresponding transmissivity lower, so this is not of significant relevance to the calculated velocity, although the through-flow could be lower than estimated.

Overall, the groundwater velocity for the shallow aquifer indicates a long mean residence time, with PDP (2010) estimating that it could take an average of 36 years for nitrate from the up-gradient edge of historic border dyke activities on Block D to travel 1.9 km to bore 4455, with faster travel times from Block C. As outlined in PDP (2010), border dyke irrigation was utilised over Block B until 1984 and then onto Blocks C and D until 1994. On average, during this period the nitrogen loading rate was very high at approximately 2,400 kg N/ha/yr for Block B and 1,300 kg N/ha/yr for Blocks C and D. Following the addition of Block A in 1994, the irrigation methods were changed to spray irrigation. As outlined in PDP (2018), concentrations in bore 4455 have now reduced significantly.

For the intermediate aquifer, the values in Table 10 and the groundwater gradient interpolated from the contours gave an estimated through-flow/unit discharge of 0.96 m^3/day/m, with a calculated average linear velocity of 0.13 m/day, as reported in PDP (2010). This also indicates a long mean residence time. It was estimated that it could take 43 years for nitrate from the up-gradient edge of historic border dyke activities on Block D to travel 2 km to bore 2898. As outlined in PDP (2018), concentrations in this bore have stabilised at around 20 g/m^3, but have not yet declined.

In the absence of targeted on site testing, such as tracer tests, these values are considered to provide a general indication of groundwater movement. Overall, based on these values and the measured concentrations, particularly in the deeper bore 2898, groundwater flow at the site is expected to be reasonably slow, but there will likely be variations across the site.

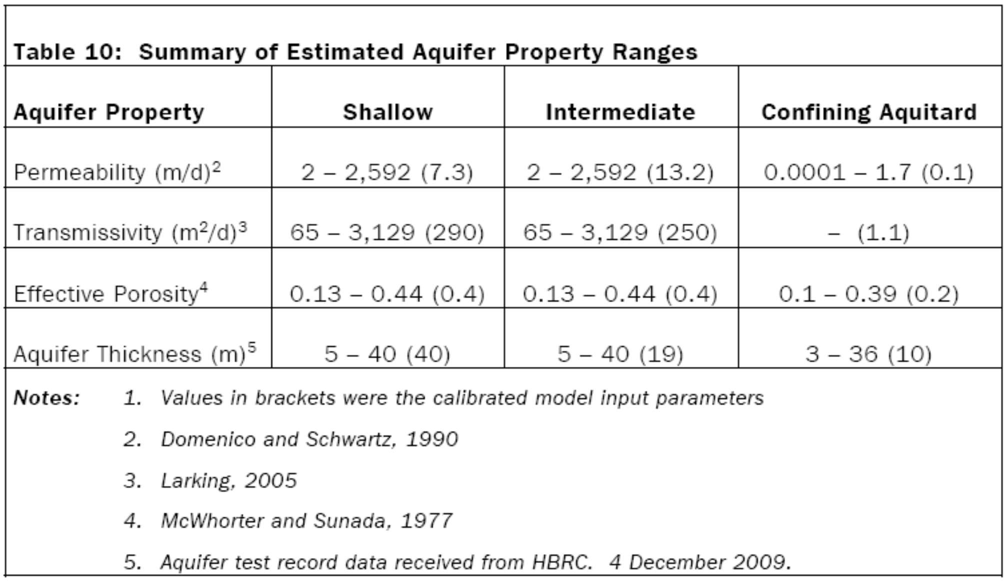


Table 10: Summary of Estimated Aquifer Property Ranges

Aquifer Property	Shallow	Intermediate	Confining Aquitard
Permeability (m/d)[2]	2 – 2,592 (7.3)	2 – 2,592 (13.2)	0.0001 – 1.7 (0.1)
Transmissivity (m^2/d)[3]	65 – 3,129 (290)	65 – 3,129 (250)	– (1.1)
Effective Porosity[4]	0.13 – 0.44 (0.4)	0.13 – 0.44 (0.4)	0.1 – 0.39 (0.2)
Aquifer Thickness (m)[5]	5 – 40 (40)	5 – 40 (19)	3 – 36 (10)

Notes:

1. *Values in brackets were the calibrated model input parameters*
2. *Domenico and Schwartz, 1990*
3. *Larking, 2005*
4. *McWhorter and Sunada, 1977*
5. *Aquifer test record data received from HBRC. 4 December 2009.*

2.7 Question 12

The Section 92 request makes the following comments related to Question 12 and subsequent questions.

The Aqualinc report raises similar issues with regard to irrigation efficiency, and indicates that the current irrigation system does not meet many of the performance criteria for effective and efficient irrigation. It also notes that the wastewater storage pond only provides a 1 day of holding capacity, which means that soils will be irrigated when they are already saturated.

The Aqualinc report notes that the maximum application depth of 65 mm was exceeded 5% of the time, and that on a number of occasions, the application depth exceeded 100 mm. The latest compliance report also indicates non-compliance with the 65 mm application depth limit.

Question 12 is as follows:

12. Outline the steps that have or will be taken to ensure that application depth limits will be met consistently, and provide a timeframe for implementing these actions.

Application depths can be managed with the existing technology, by having a minimum run speed. We understand from the Silver Fern Farms 2015/2016 monitoring report, that the majority of the exceedances resulted from various mechanical issues on the travelling irrigators (worn drive arms, cable / boom breaks, broken wheel prox's and A frame). However, on two occasions telemetry errors were the root cause.

It is outlined in that report that to manage each incident, repairs were made to the equipment and the corresponding return period was increased to 21 days, greater than the consented 14-day maximum. Furthermore, routine inspection of the irrigation runs following application did not identify any adverse effects, with no evidence of run off or surface ponding.

Silver Fern Farms are planning to undertake further improvements, such as further reducing irrigation depths, and managing the system as best as practicable to ensure compliance with consent conditions. The proposed soil moisture model that has been set-up will help inform potential improvements.

2.8 Question 13

13. The Aqualinc report identifies a range of opportunities for improvement (page 57). Confirm which of these improvements have already been implemented, and /or investigated, and the outcomes of those investigations.

We understand from Silver Fern Farms that none of the recommended improvements have been implemented to date. The further soil moisture modelling work presented in this letter will be used to further investigate improvements.

2.9 Question 14

14. Provide an analysis of the available soil moisture data for the irrigation blocks (collated using daily medians) to demonstrate how condition 42 of the existing consent has been complied with (i.e. irrigation not causing an exceedance of field capacity). Identify all key parameters including field capacity, wilting point, and irrigation decision points, and explain how the soil moisture system is used in scheduling and irrigation decision making.

Soil moisture data collected at the site is not used for scheduling irrigation at present. Scheduling is based on the standard return periods.

Soil moisture telemetry at the site is available from September 2014; however, there are gaps in the data and not all sensors are still recording data. Instead, irrigation soil water balance modelling was undertaken to quantify soil moisture for all irrigation runs over the full period of available irrigation data (September 2010-September 2017) and the available soil moisture data was used to validate the model. A summary of the model input data and all key input parameters is given in the attached technical memorandum prepared for Silver Fern Farms by PDP (2019). The model results are relatively similar across all irrigation blocks, with the exception of gley soil areas in Block E where drainage is inhibited by a tight clay layer approximately 200 mm below the surface.

Figure 1 shows an example of the modelled soil moisture content for Run 15 in Block D against the telemetered soil moisture data collected from the three sensors located in the run area. The run area was modelled as Takapau soil planted with grass pasture and an assumed rooting depth of 0.60 m. The modelled soil moisture content follows the trends of the measured soil moisture content closely but does drop as low as the measured data. This offset is expected to be caused by slight differences in the soil water holding properties and/or rooting depth assumed in the run compared to what was used to calibrate the soil moisture meters. Note the three soil moisture meters in this run also show slightly different readings as they are at different locations and presumably recording data at different depths.

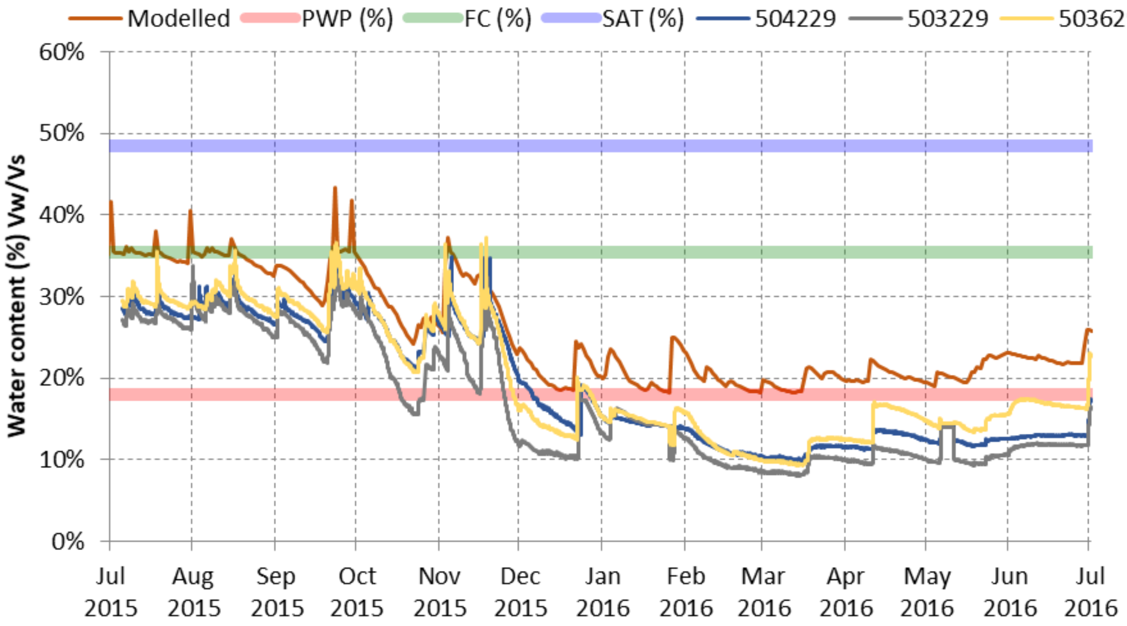


Figure 1: Run 15, Block D soil moisture content (2015-2016)

Figure 2 shows an example of the modelled soil moisture content for a different run (Run 4 in the A South Block - shallow Takapau and Tikokino soils with grass pasture) with rainfall and irrigation events plotted on the secondary axis. For clarity, only the daily median of soil moisture sensors in the run area has been plotted (the sudden dips to zero represent gaps in the available data). The model still provides a good estimate of the trends in soil moisture, but the water content predicted diverges from the recorded median as the soil dries out over summer. The measured data gradually shows less and less of a response to rainfall and irrigation events, until a large gap in the data in July 2016, after which the recorded data returns to following the modelled data closely. This could be an issue with the meters malfunctioning, or possibly caused by the meters not having good contact with the soil if it shrinks slightly when it dries out.

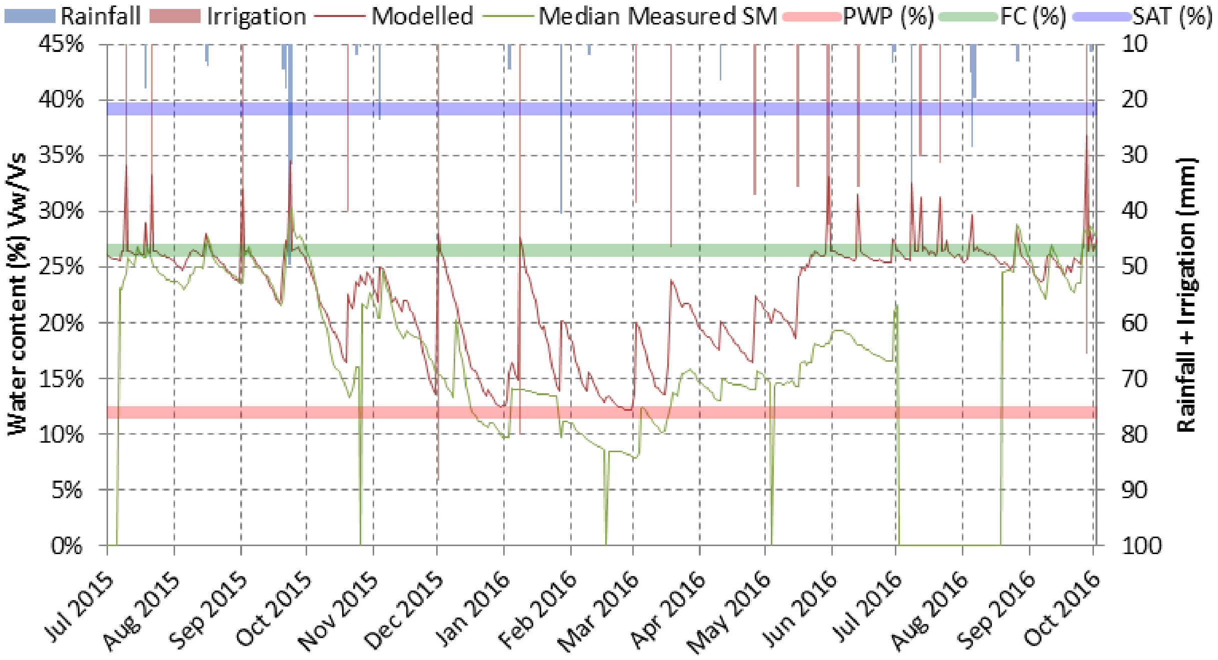


Figure 2: Run 4, Block A South soil moisture content and irrigation events (2015-2016)

Figure 3 shows the modelled soil moisture content for Run 4 in Block E6 (drainage impeded in this area - gley Poporangi soil with grass pasture). In this case the modelled soil moisture content shows much greater spikes in response to rainfall and irrigation events – often exceeding saturation for long periods of time. This is due to the conservative assumption that drainage from the gley soils in the E-block is limited to 1 mm/day due to the tight clay layer 200 mm below ground. The actual soil moisture data indicates that the soil does not retain as much water and is less responsive to irrigation and rainfall events than the model. This could indicate that a higher drainage rate can be expected from the gley Poporangi soils, or that the soil moisture meters may be recording the averaged water content which includes drier soil below the tight clay horizon at 200 mm below ground.

The modelled soil water content indicates that irrigation events, which only occur during summer months on the E-block gley soils, are generally occurring when there is a deficit.; however, because the modelled soil profile is limited to a 200 mm rooting depth, the modelled soil moisture content increases above field capacity (and sometimes up to saturation) in response to these events. This could indicate a risk for the soils becoming waterlogged and possible runoff to other areas (when the soil is saturated).

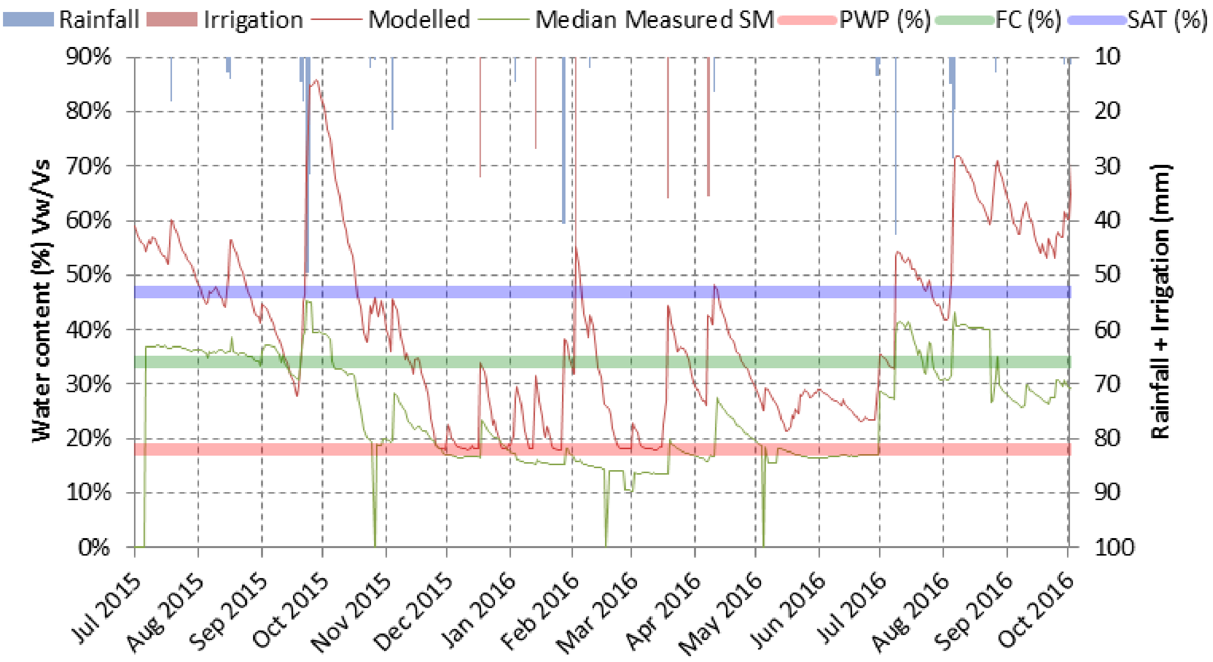


Figure 3: Run 4, Block E6 soil moisture content and irrigation events (2015-2016)

Overall, the model results show that irrigation events in summer on most areas (excluding E block gley soil areas) generally are not expected to cause exceedances of field capacity; however, during the May-September period soil moisture levels are constantly elevated due to low evapotranspiration rates from cooler temperatures and more frequent rainfall. Irrigation applications in this period will always be expected to cause the soil to exceed field capacity and result in drainage to groundwater. This is unavoidable if irrigation is to be carried out year-round, although the impact can potentially be reduced if irrigation events involved applying less water more frequently rather than large periodic doses.

On this basis, it is suggested that Condition 42 be removed, or appropriately amended, from the consent from all areas that are irrigated year-round. The condition is feasible for areas that receive irrigation only during summer months (such as the E-block gley soils).

2.10 Question 15

15. Provide a TKN mass balance that includes a description of all of the input data and assumptions made in the calculations.

The OVERSEER modelling undertaken and presented in Appendix C of PDP (2018) provides a full nutrient balance for the Silver Fern Farms land holdings and describes the input data used for this for the 2015/16 season. As outlined in the memo, this record year was chosen as the most recent full year of records without discrepancies. Table 6 of the report presents the nutrient budget summary, which is also included below.

Table 6: Whole Land Holdings Nutrient Budget Summary

	Nitrogen	Phosphorus
Nutrients Added (kg/ha/yr)		
Rainfall	2	0
Biological Fixation	17	0
Irrigation (Modelled as Fertiliser)	120	19
Total	**139**	**19**
Nutrients Removed (kg/ha/yr)		
Supplements Removed	119	15
To Atmosphere via Denitrification, and Fertilizer and Urine Volatilisation	11	0
To Water via Leaching	17	0
To Water via Runoff	0	0.1
Changes in Nutrient Pools (kg/ha/yr)		
Organic Pool	-10	18
Inorganic Mineral	0	5
Inorganic Soil Pool	0	-19

2.11 Question 16

16. Provide the collated and plotted lysimeter time series data to show the drainage concentrations of each lysimeter and to enable comparison between shallow and deep lysimeters and input loads.

The Silver Fern Farms lysimeter data spreadsheet provided to us has been amended to include the wastewater irrigation data and input loads. This is provided together with this Section 92 response.

Domestic wastewater (DP180250L) – treatment

2.12 Questions 17 – 21

Questions 17-21 of the Section 92 request relate to domestic wastewater treatment. Silver Fern Farms are providing responses directly to these.

Domestic Wastewater discharge effects

The Section 92 request includes the following comment:

The maximum application rate sought is 93.75 mm/day. Given the drainable nature of the soils on the site, this is likely to result in significant drainage to groundwater. This rate is far in excess of any guideline levels for domestic wastewater application, which would often limit wastewater application to a maximum of 50 mm/day. It was observed on the site visit that the discharged wastewater often does

not reach the end of the border dyke run, meaning that the application rate will be in excess of that proposed.

2.13 Question 22

22. Supply a soil moisture water budget calculation for the worst-case wet conditions and dry conditions, to provide context on the ability of the soil to store water and reduce excess percolation to groundwater. The calculation should define all parameter values and assumptions, such as soil depth, average porosity, soil moisture capacity, unsaturated and saturated infiltration rates, and unsaturated and saturated sub-soil drainage rates.

A soil water balance irrigation model was developed for the domestic wastewater border-dyke irrigation system over the period over available irrigation records (2005-2017). A summary of the model input data and all key input parameters is given in the attached technical memorandum prepared for Silver Fern Farms by PDP (2019).

The modelled soil moisture results for one of the two border-dyke irrigation blocks which receive irrigation alternately are shown for the worst case wet and dry seasons in the model period in Figure 4 and Figure 5, respectively.

The results illustrate how the irrigation is applied consistently (in large doses in accordance with the consent) to an individual area every 42 days. This method of application means the irrigation applications always cause the soil to exceed field capacity, even during a dry year, which results in drainage to groundwater. The large return interval also means that the soil is also expected to dry out to permanent wilting point (PWP) in between irrigation events, which inhibits grass growth and reduces the amount of actual evapotranspiration (ET) from the soil, as water becomes harder for plant roots to extract from the soil.

The model calculated the irrigation applied across the domestic border-dyke areas averages at 680 mm/year over the entire modelling period. Annual average rainfall over this period is approximately 660 mm/year, and actual ET from the border-dyke areas was calculated to be approximately 640 mm/year (compared to PET of 950 mm/year over the model period). These figures indicate that the water lost to drainage (approximately 690-700 mm) is largely due to the high hydraulic loading and low actual ET by plants.

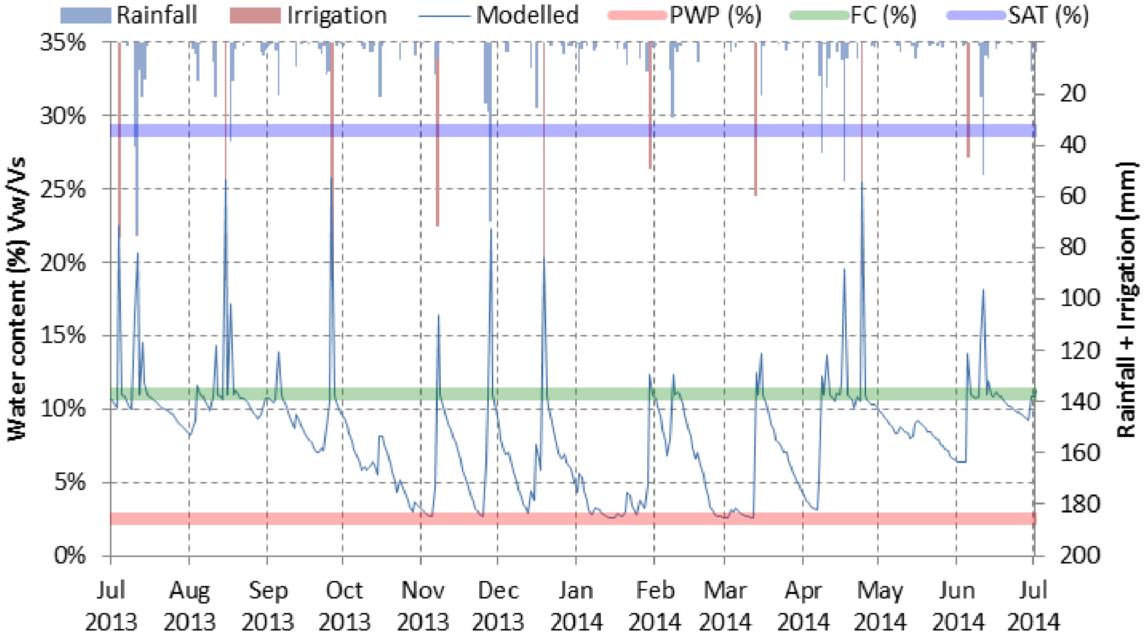


Figure 4: Border Dyke area 1-10, soil moisture content during wet season (2013 – 2014)

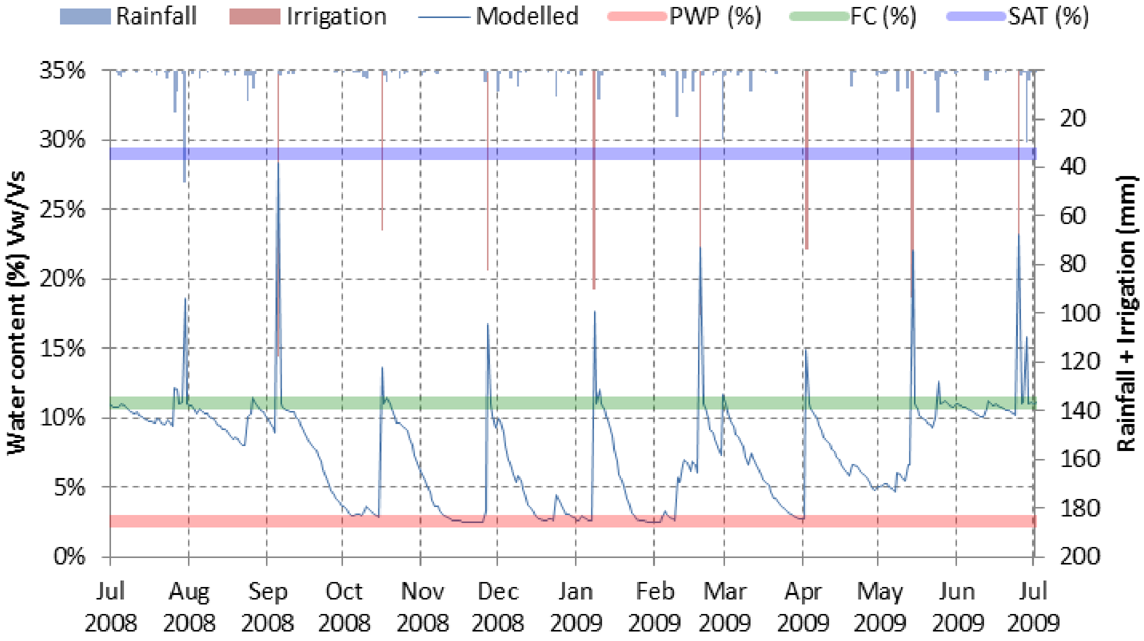


Figure 5: Border Dyke area 1-10, soil moisture content during dry season (2008 – 2009)

During the 2013-2014 wet year, average irrigation was approximately 630 mm, annual rainfall was 1,020 mm and actual ET was calculated to be approximately 720 mm (compared to PET of 994 mm). During this year, drainage was approximately 930 mm. During the 2008-2009 dry year, average irrigation was approximately 640 mm, annual rainfall was 430 mm and actual ET was calculated to be approximately 600 mm (compared to PET of 930 mm). During this year, drainage was approximately 460 mm.

These figures indicate that the high and infrequent dose rates and high hydraulic loading results in high drainage to groundwater and underutilisation of ET – even during a dry year. A model simulation was run where the overall hydraulic loading on the soil remained the same, but it was assumed wastewater was irrigated daily to the whole area, rather than on alternating halves of the available area every 42 days. The model indicated making this change will reduce the annual average drainage from approximately 690 mm to approximately 550 mm.

2.14 Question 23

23. Confirm the down-gradient impact on groundwater quality, showing input concentration and resulting groundwater concentration immediately down-gradient of the irrigation system.

For this to be confirmed, a monitoring bore would be required down-gradient of the disposal field. While there are no bores at present immediately down-gradient of the system, as outlined in PDP (2018), we have recommended that at least one bore be installed down-gradient of the field. An additional bore up-gradient of the systems and an additional bore between the system and the Porangahau Stream would also be helpful.

Silver Fern Farms will accept a consent condition requiring installation of at least one down-gradient bore and monitoring of this to provide further information on the effects of the system.

The OVERSEER modelling results in Appendix B of PDP (2018) specifically for the border dyke system indicated nitrogen drainage concentrations of 12-13 mg/L. The whole land holdings system modelled with a more recent version of OVERSEER indicated the concentrations could be higher beneath the border dyke system (around 23 mg/L). The resulting concentrations in the groundwater immediately below the irrigation system would be expected to be less following mixing with the underlying groundwater.

2.15 Question 24

24. Comment on whether it is possible to discharge domestic wastewater over a larger area using the process wastewater irrigation system.

Our recommendation is that the discharge would be best kept separate to the process wastewater irrigation system, to minimise the risk to human health of the irrigation system operators. It could also impact on the ability to cut-and-carry from the site. We would suggest that if a spray system is considered, that it would best for this to occur in the vicinity of the oxidation pond and separate to the process wastewater.

<u>Tukituki Catchment Plan</u>

The Section 92 request includes the following comment prior to Question 25 on the Tukituki Catchment Plan (TCP).

Policy TT2 is specific to managing groundwater quality and is relevant to the proposal, but is not considered in the application. It states that the adverse effects of activities that are likely to affect the quality of groundwater located at a depth of 10 m or more should be managed in accordance with the limits and targets set out in Table 5.9.2.

2.16 Question 25

25. Please provide an assessment of the discharge to land activities proposed against POL TT2 and Table 5.9.2 of the TCP and comment on whether or not the activity is consistent with this policy.

Policy TT2 is as follows:

POL TT2 GROUNDWATER QUALITY LIMITS

1. For groundwater Hawke's Bay Regional Council will:

> *(a) Manage the adverse effects of activities likely to affect the quality of groundwater located 10m or more below ground level in accordance with the limits for aesthetic, organic and inorganic determinands; Escherichia coli and nitrate-nitrogen set in Table 5.9.2;*
>
> *(b) Set (in Table 5.9.2) an environmental state indicator for the annual average concentration of nitrate nitrogen;*
>
> *(c) Manage activities likely to affect the quality of groundwater connected to and affecting surface water quality having regard to effects on the achievement of the limits and targets set in Tables 5.9.1A and 5.9.1B;*
>
> *(d) Manage point source discharges and the use of production land upstream of any registered drinking water supply takes to ensure compliance with the Resource Management (National Environmental Standards for Sources of Human Drinking Water) Regulations 2007 and the Drinking-Water Standards for New Zealand (2005 Revised edition 2008).*
>
> *2. The implementation of POL TT2(1) shall take into account uncertainties associated with variables such as the location of the activity, the spatial and temporal nature of groundwater flows, seasonal variations in groundwater levels, and the effects of historical production land use activities on existing and future groundwater quality.*

Table 5.9.2: Groundwater Water Quality Limits and Indicators Applicable 10m or More Below Ground Level in Productive Aquifer Systems, sets out limits for aesthetic determinands, *E. coli,* nitrate-nitrogen and other determinants. It sets out that:

- aesthetic determinands shall not exceed the relevant guideline value (GV) in the Drinking-Water Standards for NZ (DWSNZ)
- *E. coli* shall not exceed the MAV in the DWSNZ of 1 cfu/100 ml
- the maximum 95th percentile concentration of nitrate-nitrogen, measured over a five year period, shall not exceed the MAV of 11.3 mg/L
- the maximum annual average of nitrate-nitrogen, measured over a five year period, shall not exceed half the MAV of (5.65 mg/L)
- all other inorganic or organic determinands of health significance shall not exceed the relevant MAV.

The monitoring information from Silver Fern Farm's monitoring bores can be used to assess the concentrations against the limits in this table, where relevant measurements are made, because the bores are generally deeper than 10 metres below ground level, with the exception of 15958 (2b), 15957 (7b), 15962 (5b) and 4455 (Z). This information shows the following.

- The aesthetic determinands monitored are sodium, chloride and pH. Sodium and chloride are well within the GV's of 200 and 250 mg/L, respectively. pH is generally within the upper end of the GV range of 7.0 to 8.5, although both upstream and downstream bores record values lower than the lower end. Lower pH values naturally occur in groundwater systems. Values above the upper end of the GV occur in some downstream deep bores. The process wastewater quality data provided to us gives a maximum measured value of 8.2, so it is considered unlikely that the wastewater would be causing the higher values. Given this, it is not considered that improved management of the effects of Silver Fern Farm's activities would result in a significant change in measured pH concentrations.

- For *E. coli*, as outlined in PDP (2018), both upstream and downstream bores have *E. coli* detections, as expected for shallow groundwater in a rural area. There is no clear difference in upstream and downstream bores. Given this, it is not considered that improved management of the effects of Silver Fern Farm's activities would result in a significant change in measured *E. coli* concentrations.
- In terms of nitrate-nitrogen in shallow bores, as outlined in PDP (2018), most upstream bores have generally remained stable, expect for bore 15960 which has shown a steady reduction since 2012. As identified in Table 5, 15960 is technically a down-gradient/downstream bore relative to Block D. This bore and bore 15957 exceed the limits in Table 5.9.2. The downstream bores generally reflect the same patterns as upstream, with bore 4455 showing significant improvements since 2000. The only significantly elevated bore is 15958, although this shows a gradual reduction from elevated levels since 2012. Levels in bore 15638 have increased over time. Neither bore 15958 or 15638 meet the limits in Table 5.9.2. Management for nitrate-nitrogen is discussed further below.
- In terms of nitrate-nitrogen in deep bores, both upstream bores have only returned detections sporadically. In contrast, downstream bore 15871 has remained elevated for most of its monitoring period, while bore 2898 showed an increasing trend and is now more stable. Neither bore 15871 or 2898 meet the limits in Table 5.9.2. The sampling undertaken in June 2019 and described in the response to Question 9, shows bore 15639 also exceeds the limits in Table 5.9.2. Management for nitrate-nitrogen is discussed further below.
- There are no other inorganic or organic determinands of health significance included in the monitoring.

As outlined above, nitrate-nitrogen exceeds the limits in Table 5.9.2 in some bores. This includes two upstream bores (15957 and 15960), although 15960 is technically a down-gradient/downstream bore relative to Block D. The downstream bores exceeding the limit are shallow bores 15958 and 15638, and deep bores 15871 and 2898.

As outlined in PDP (2018), a detailed assessment of the historic elevated nitrate-nitrogen concentrations in some downstream bores was undertaken by PDP (2010). This was attributed to the historic high nitrogen loadings via border dyke irrigation of the wastewater, which had occurred on Blocks B, C and D. In general, bores 15960, 15958, 2898 and 15871 appear to be experiencing the on-going effects of the historic loadings. Overall, the more recent information indicates that the effects are generally less.

Bore 15638 is the only downstream bore that has had an increasing trend in nitrate-nitrogen, although the levels have stabilised over the last few years. This bore is located down-gradient of Block A, and generally down-gradient from the other irrigation blocks. This bore is located on neighbouring land and it is understood that this land has been used to grow potatoes and other crops in between harvest. This land use may be contributing to the change in water quality, which means it is difficult to isolate any effects due to Silver Fern Farms activities.

Nutrient modelling undertaken using OVERSEER and presented in Appendix C of PDP (2018) indicates rates of nitrogen leaching across the solids and process water discharge areas are low for this type of wastewater management system; although it is acknowledged that the monitored lysimeters show higher concentrations than expected from OVERSEER. The OVERSEER modelling, despite being for a wastewater discharge rather than farming, indicates that the nitrogen leaching rate for Silver Fern Farms land holdings (17 kg/ha/yr for the 2015/2016 season) is in accordance with the farm/farm enterprise limits provided in Table 5.9.1D of the Tukituki Catchment Plan. As outlined in PDP (2018), the majority of the property is located over land mapped as Land use capability (LUC) 3. This has a nitrogen leaching rate limit of 24.8 kg/ha/yr in Table 5.9.1D.

While OVERSEER predicts the nitrogen leaching to be low and in line with that expected for farming in the area, in light of the lysimeter results and in line with good practice, it was recommended in PDP (2018) that some consideration be given to further optimising management to minimise nitrogen leaching. Options put forward in PDP (2018) included increasing pasture yield, for example by re-sowing some irrigation areas with high-yield ryegrass species, particularly where pasture has become patchy, and considering irrigation with clean water to prevent grass die-off. A small amount of water is now available to use for irrigation for this purpose under Silver Fern Farm's groundwater abstraction consent. In light of the soil moisture modelling, changes to the irrigation methods may result in an additional reduction in nitrogen leaching.

Overall, it is considered that the discharge to land activities are generally consistent with Policy TT2. *E. coli* concentrations exceed the limit in Table 5.9.2 but there is no clear difference between both upstream and downstream bores and exceedances of the MAV are expected for shallow groundwater in rural farming areas. pH values occur outside the GV range, but are within the range naturally expected for groundwater. Nitrate-nitrogen values exceed the limits in Table 5.9.2, which is predominantly expected to be due to historic land use activities, but there is an increasing trend in Bore 15638 downstream of Block A. Leaching rates predicted using OVERSEER are as expected for farming, but lysimeter results indicate actual leaching could be higher. Silver Fern Farms are considering options for irrigation improvement, and the soil moisture modelling undertaken in this letter will be used to optimise irrigation to reduce drainage, and therefore nitrogen leaching.

3.0 Summary

We trust this further information provided will be of value for the consent process. If you have any questions or matters you would like to discuss on the work described in this letter, please feel free to contact us.

4.0 References

Pattle Delamore Partners Ltd. (2010). *Discharge to Land – Resource Consent Application & S127 Change Assessment of Environmental Effects. Prepared for Silver Fern Farms Limited, Takapau.*

Pattle Delamore Partners Ltd. (2018). *Technical assessment of environmental effects of discharging wastewater, stormwater and solid organic waste to land - Silver Fern Farms Takapau. Prepared for Silver Fern Farms Limited, Takapau.*

5.0 Limitations

This report has been prepared by Pattle Delamore Partners Limited (PDP) on the basis of information provided by Silver Fern Farms Limited. PDP has not independently verified the provided information and has relied upon it being accurate and sufficient for use by PDP in preparing the report. PDP accepts no responsibility for errors or omissions in, or the currency or sufficiency of, the provided information.

This report has been prepared by PDP on the specific instructions of Silver Fern Farms Ltd for the limited purposes described in the report. PDP accepts no liability if the report is used for a different purpose or if it is used or relied on by any other person. Any such use or reliance will be solely at their own risk.

Yours faithfully

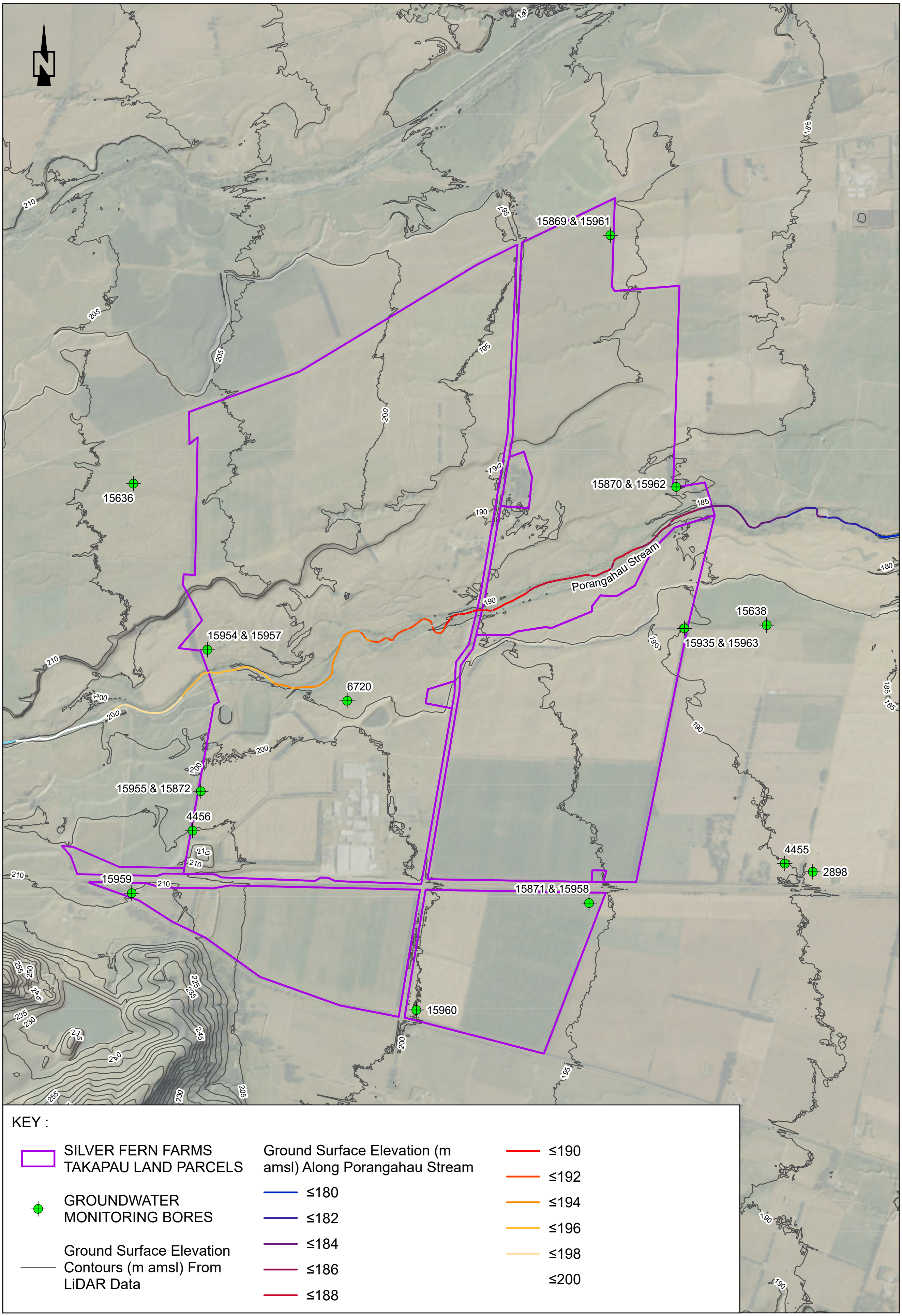
PATTLE DELAMORE PARTNERS LIMITED

Prepared by	and
H Lough	
Hilary Lough	**James Scouller**
Technical Director – Water Resources	Environmental Engineer

Reviewed and approved by

Daryl Irvine

Technical Director – Wastewater



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2. LIDAR: HBRC

FIGURE 1 : Bore Locations and Ground Surface Elevation

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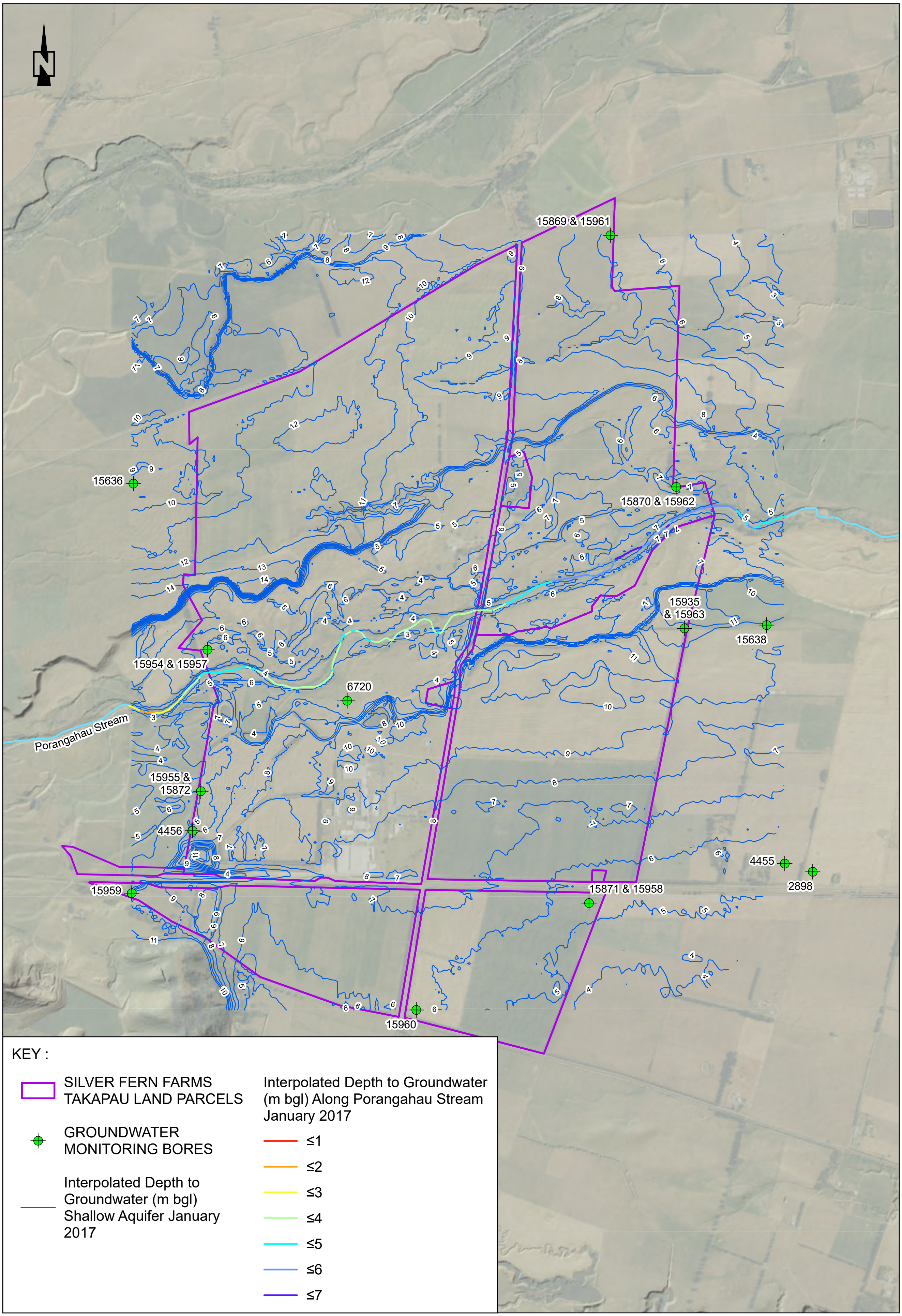
SILVER FERN FARMS TAKAPAU RECONSENTING



KEY :

▭	SILVER FERN FARMS TAKAPAU LAND PARCELS
⊕	GROUNDWATER MONITORING BORES
—	Interpolated Depth to Groundwater (m bgl) Shallow Aquifer January 2017

Interpolated Depth to Groundwater (m bgl) Along Porangahau Stream January 2017

- — ≤1
- — ≤2
- — ≤3
- — ≤4
- — ≤5
- — ≤6
- — ≤7

SOURCE:
1. AERIAL IMAGERY: ArcGIS Imagery NewZealand
2. LIDAR: HBRC

FIGURE 2A : Interpolated Depth to Groundwater: Shallow Aquifer January 2017

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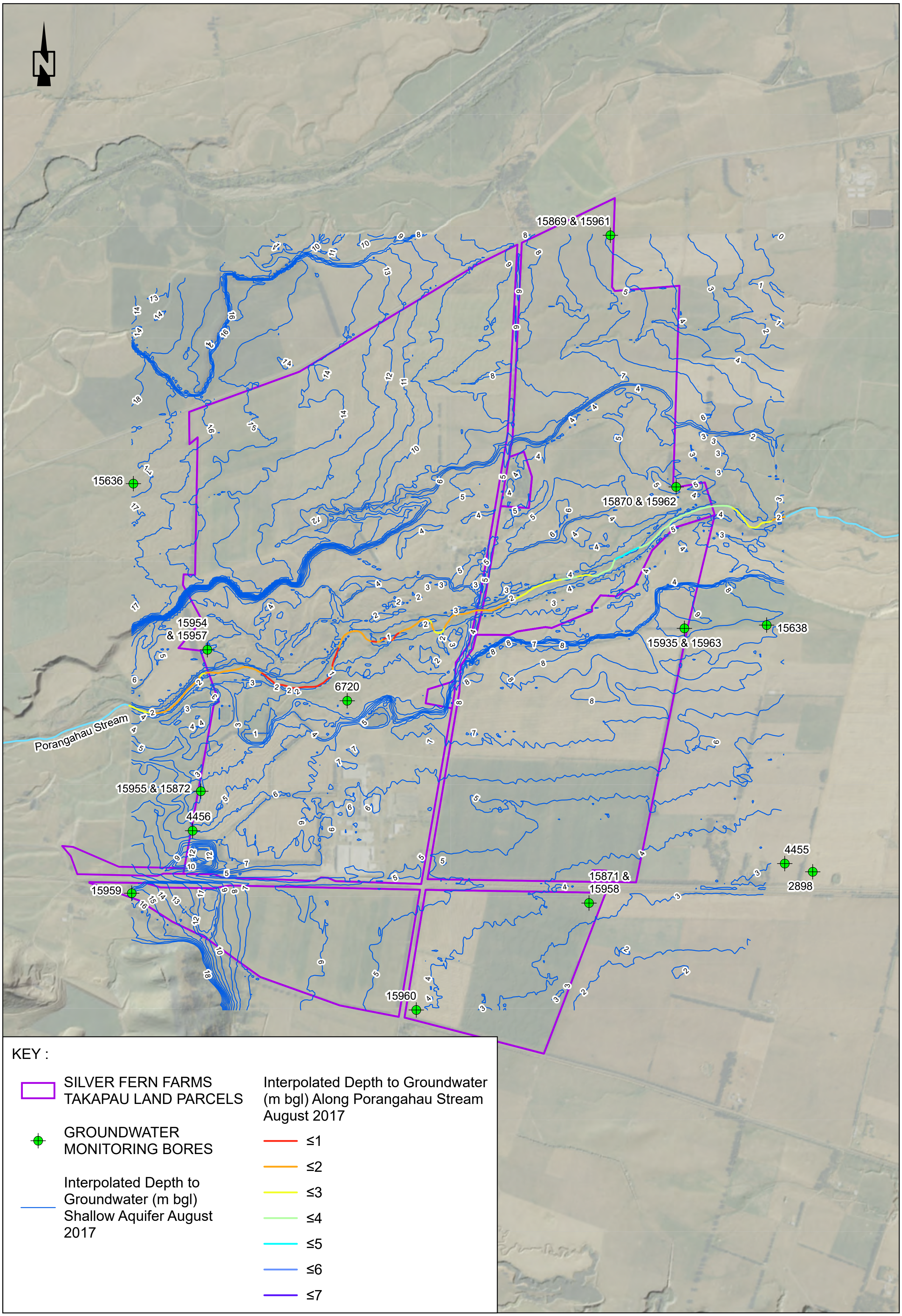

SOURCE:
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FIGURE 2B : Interpolated Depth to Groundwater: Shallow Aquifer August 2017

SCALE : 1:20,000 (A4)
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METRES

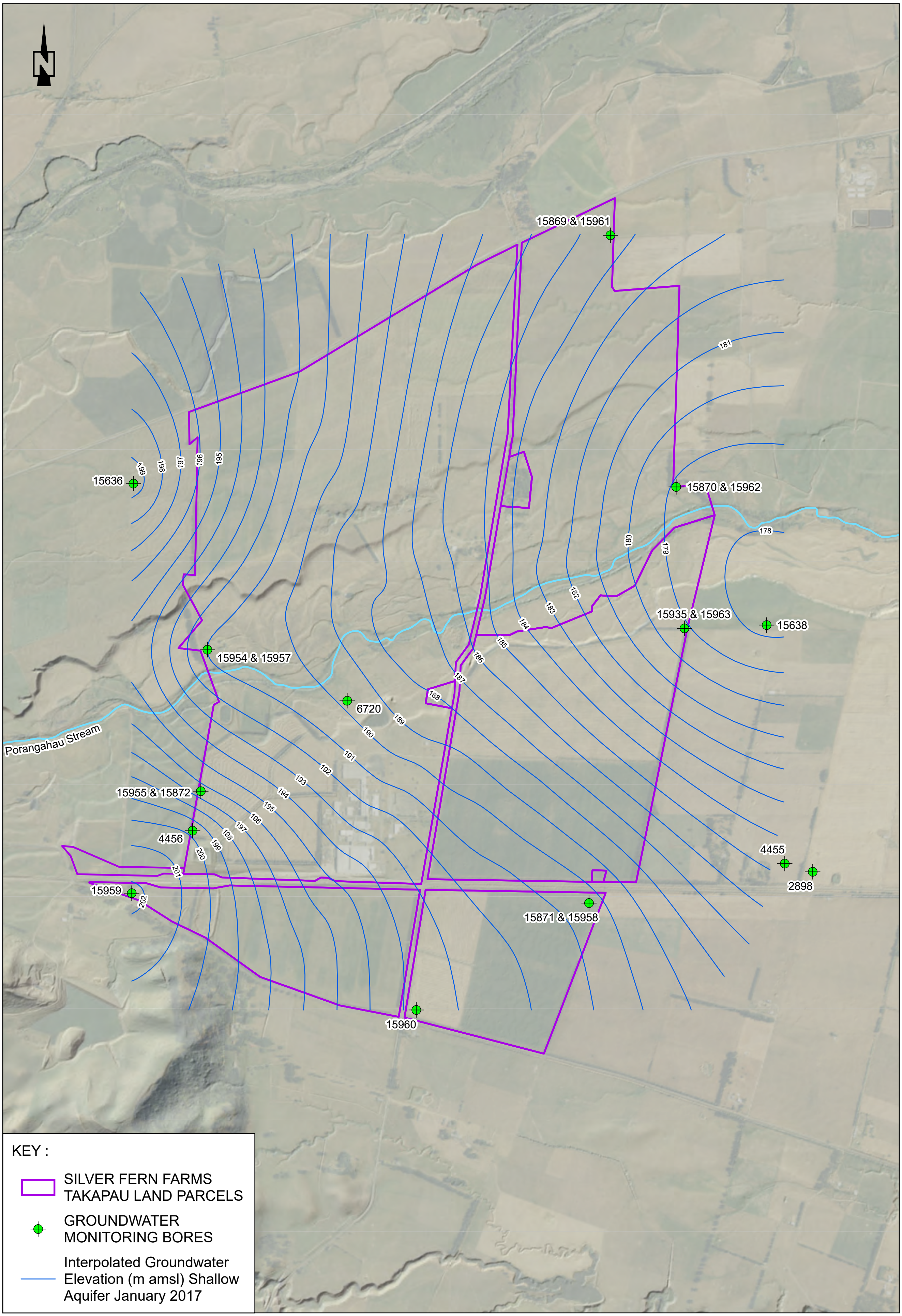

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FIGURE 2C : Interpolated Groundwater Elevation:
Shallow Aquifer January 2017

SCALE : 1:20,000 (A4)
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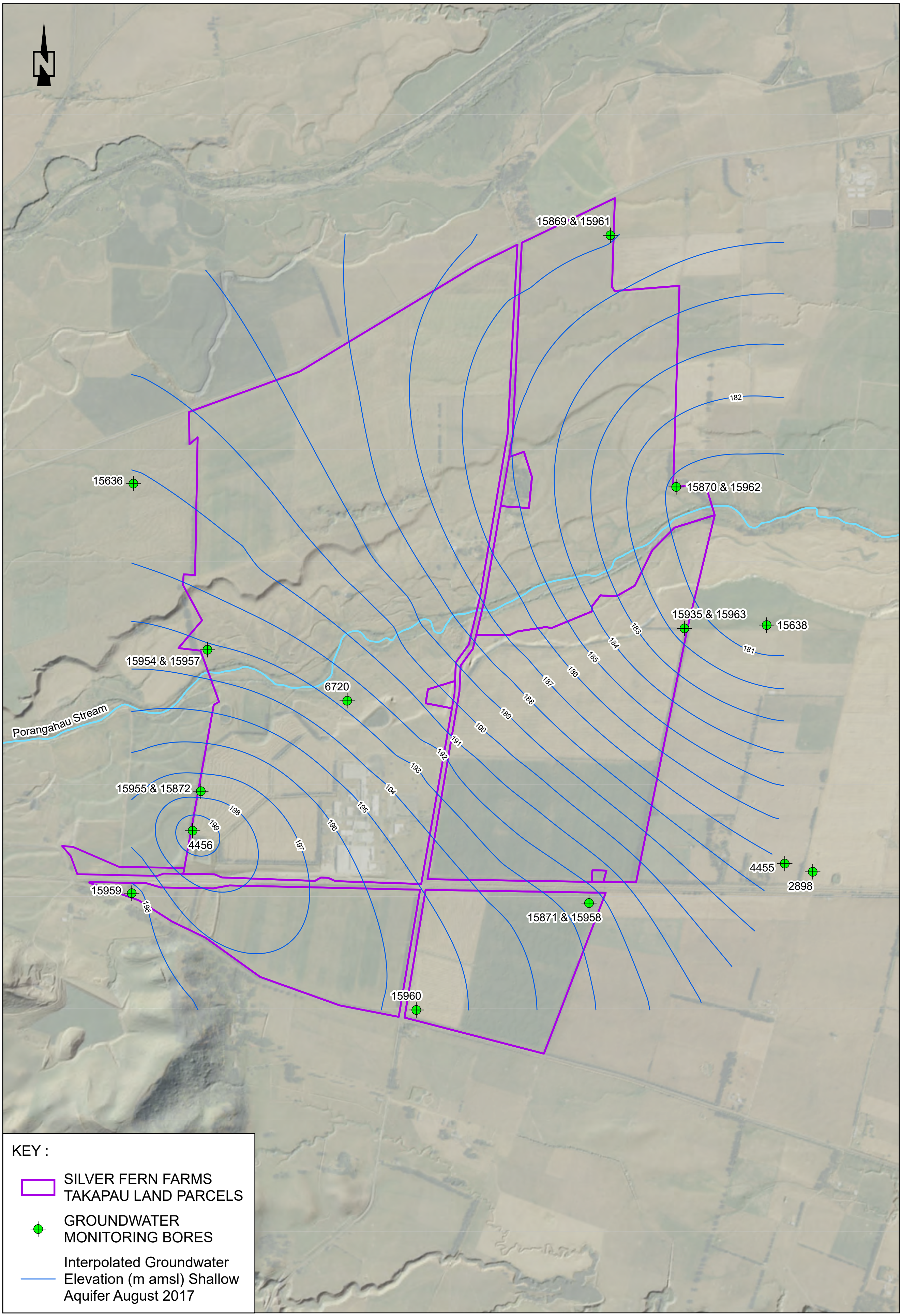

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FIGURE 2D : Interpolated Groundwater Elevation: Shallow Aquifer August 2017

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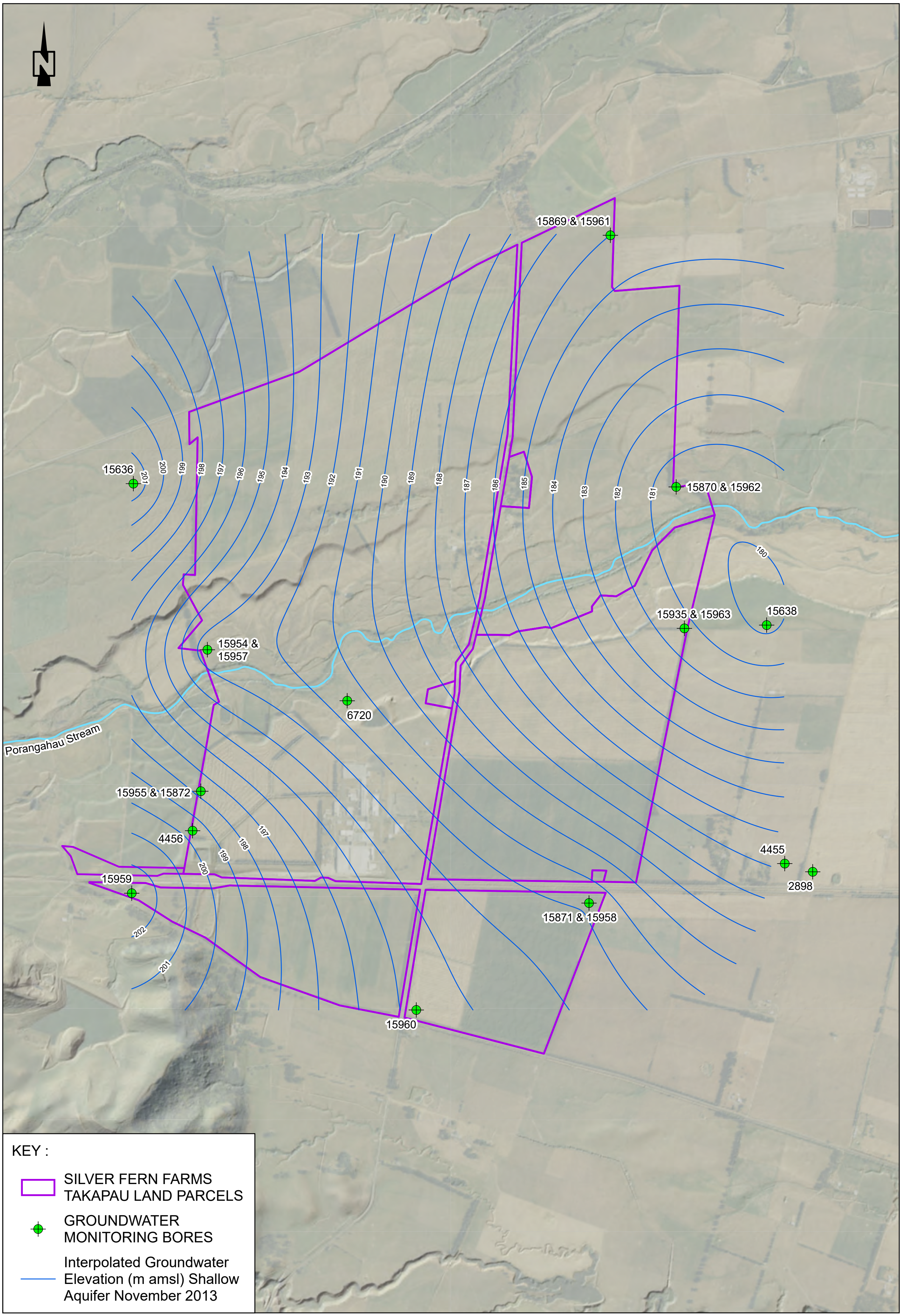

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FIGURE 3A : Interpolated Groundwater Elevation: Shallow Aquifer November 2013 (High Stage Period)

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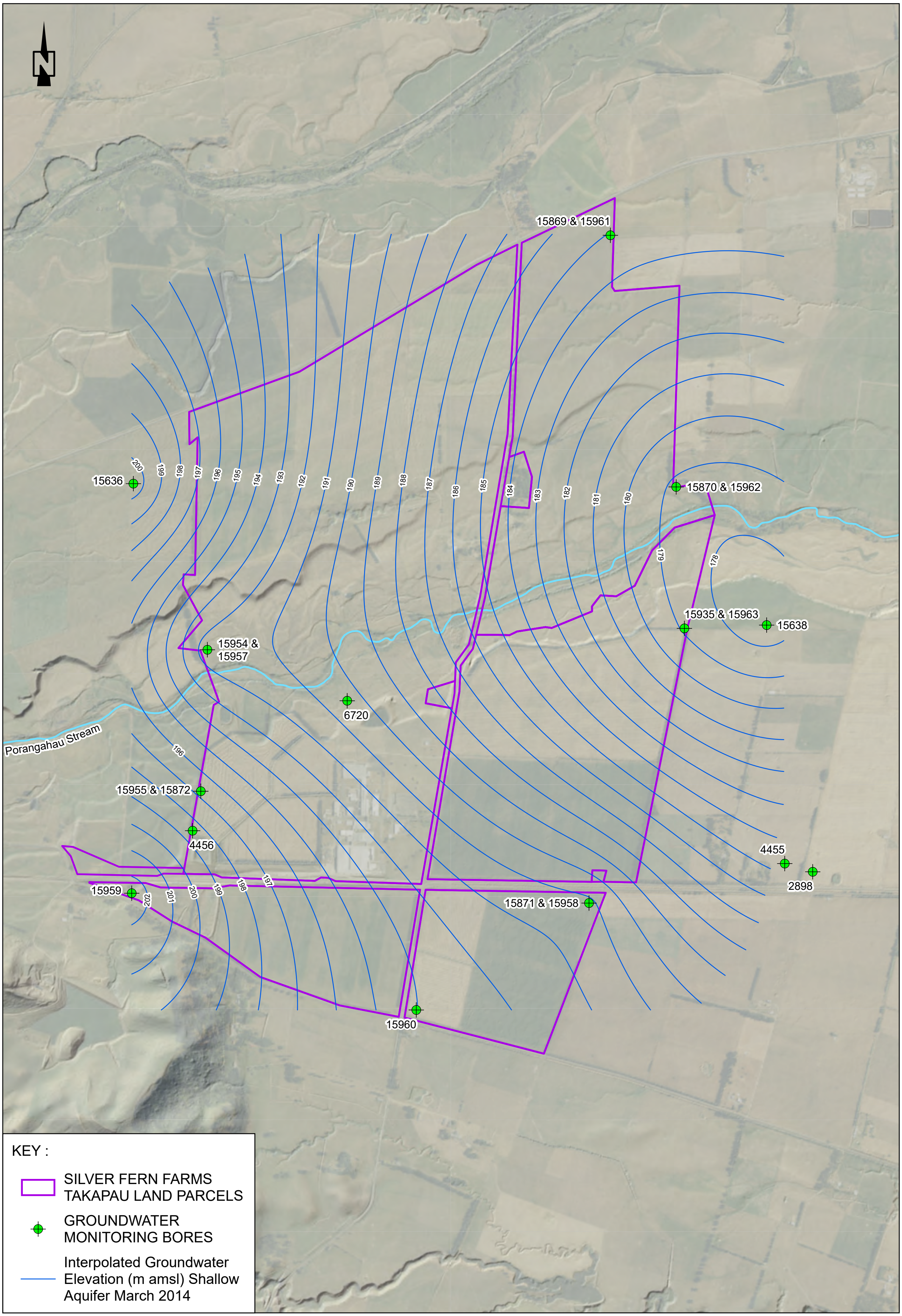
METRES



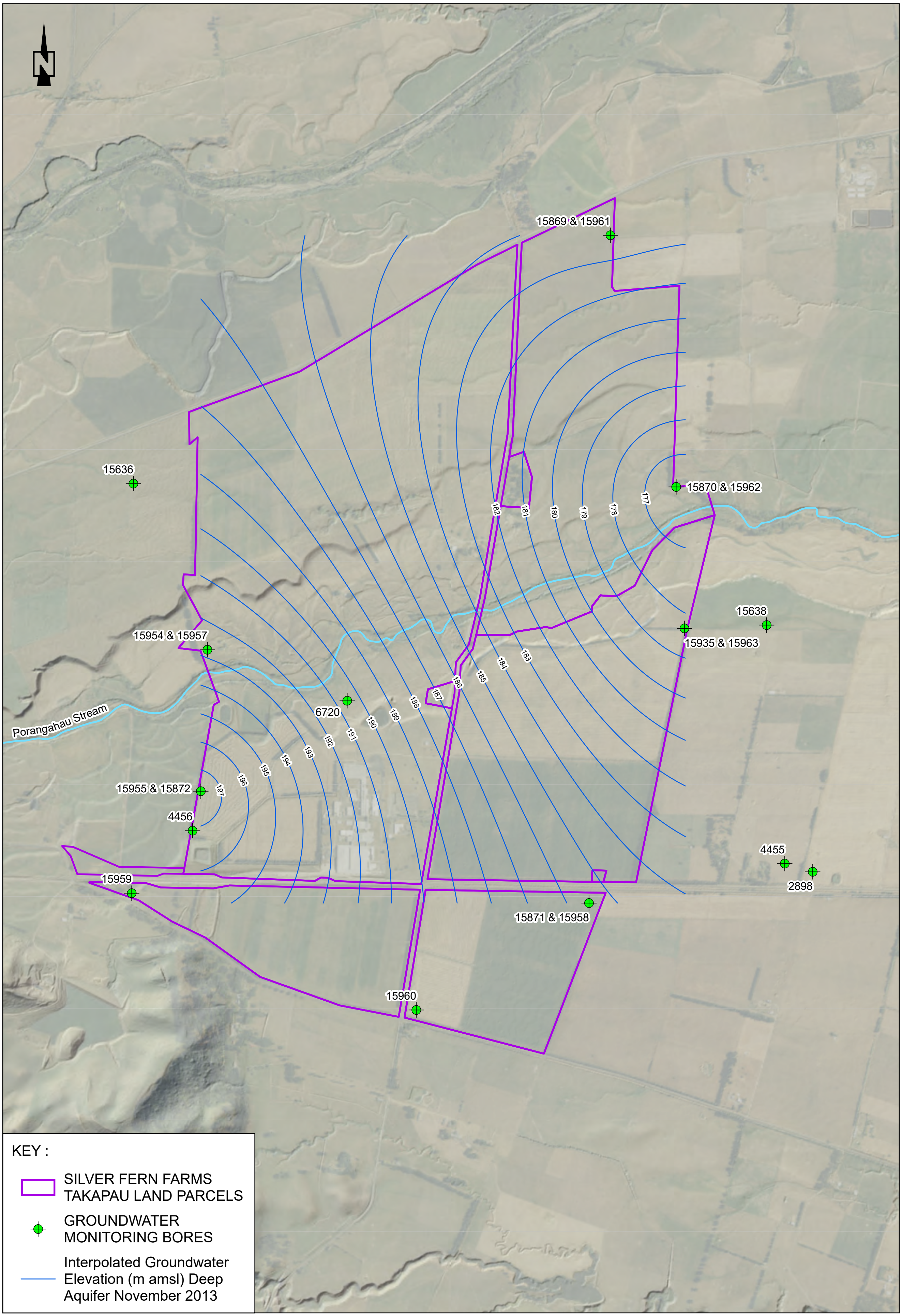
KEY :

▭	SILVER FERN FARMS TAKAPAU LAND PARCELS
⊕	GROUNDWATER MONITORING BORES
—	Interpolated Groundwater Elevation (m amsl) Shallow Aquifer March 2014

SOURCE:
1. AERIAL IMAGERY: ArcGIS Imagery NewZealand
2. LIDAR: HBRC

FIGURE 3B : Interpolated Groundwater Elevation: Shallow Aquifer March 2014 (Low Stage Period)

SCALE : 1:20,000 (A4)
0 100 200 400 600
METRES



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2. LIDAR: HBRC

FIGURE 3C : Interpolated Groundwater Elevation:
Deep Aquifer November 2013 (High Stage Period)

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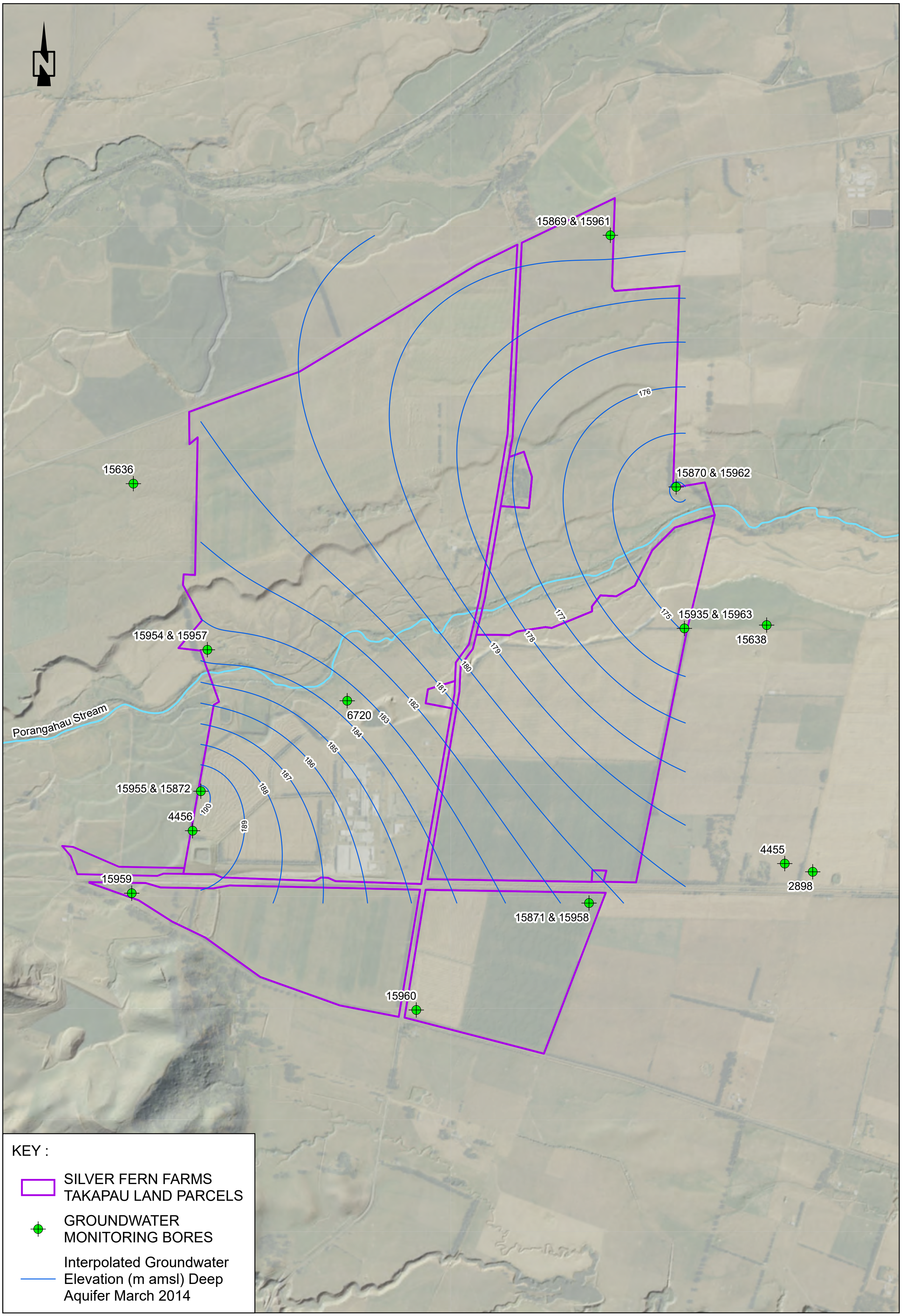

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FIGURE 3D : Interpolated Groundwater Elevation:
Deep Aquifer March 2014 (Low Stage Period)

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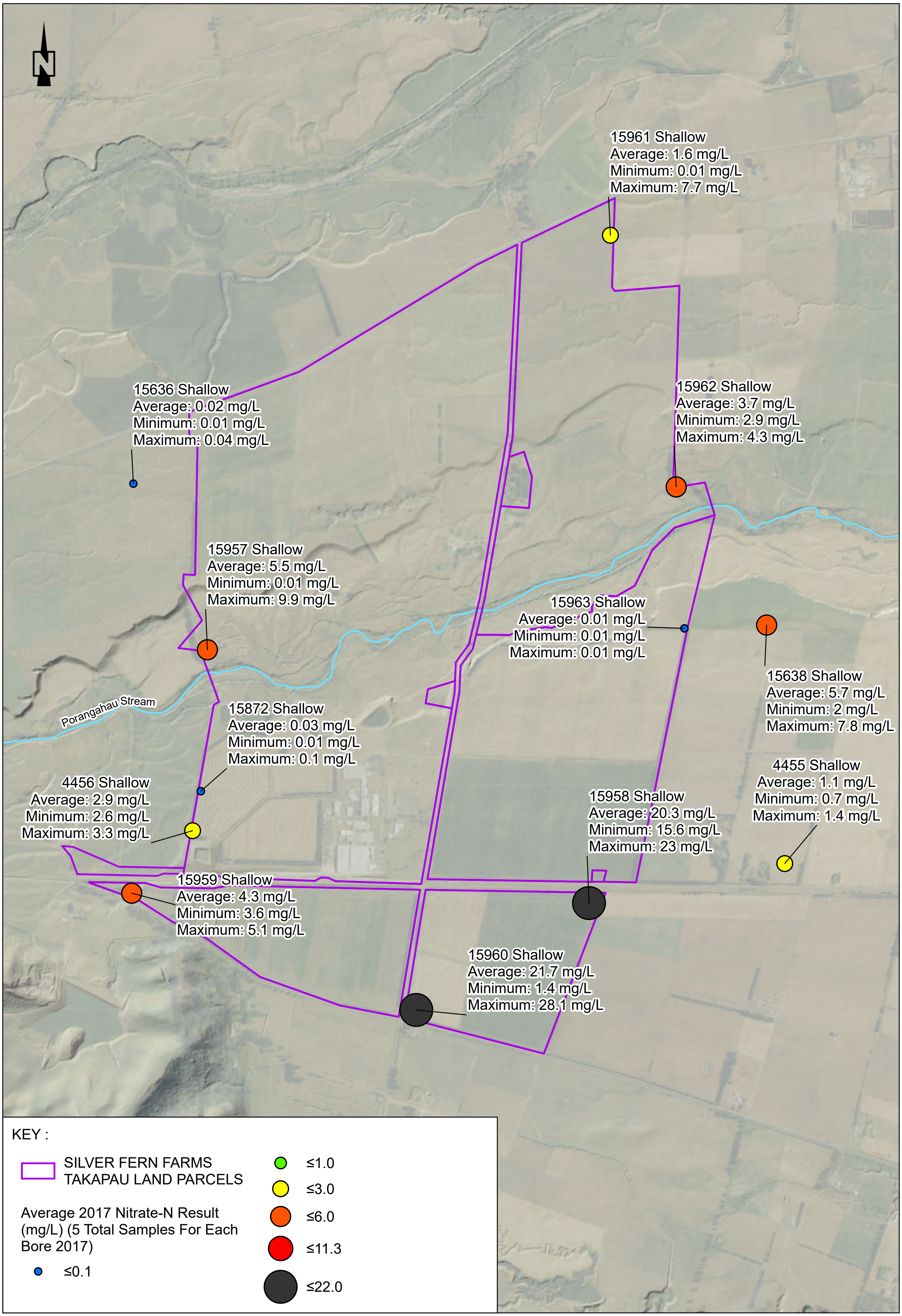

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FIGURE 4A : Nitrate-Nitrogen Results 2017
Shallow Aquifer

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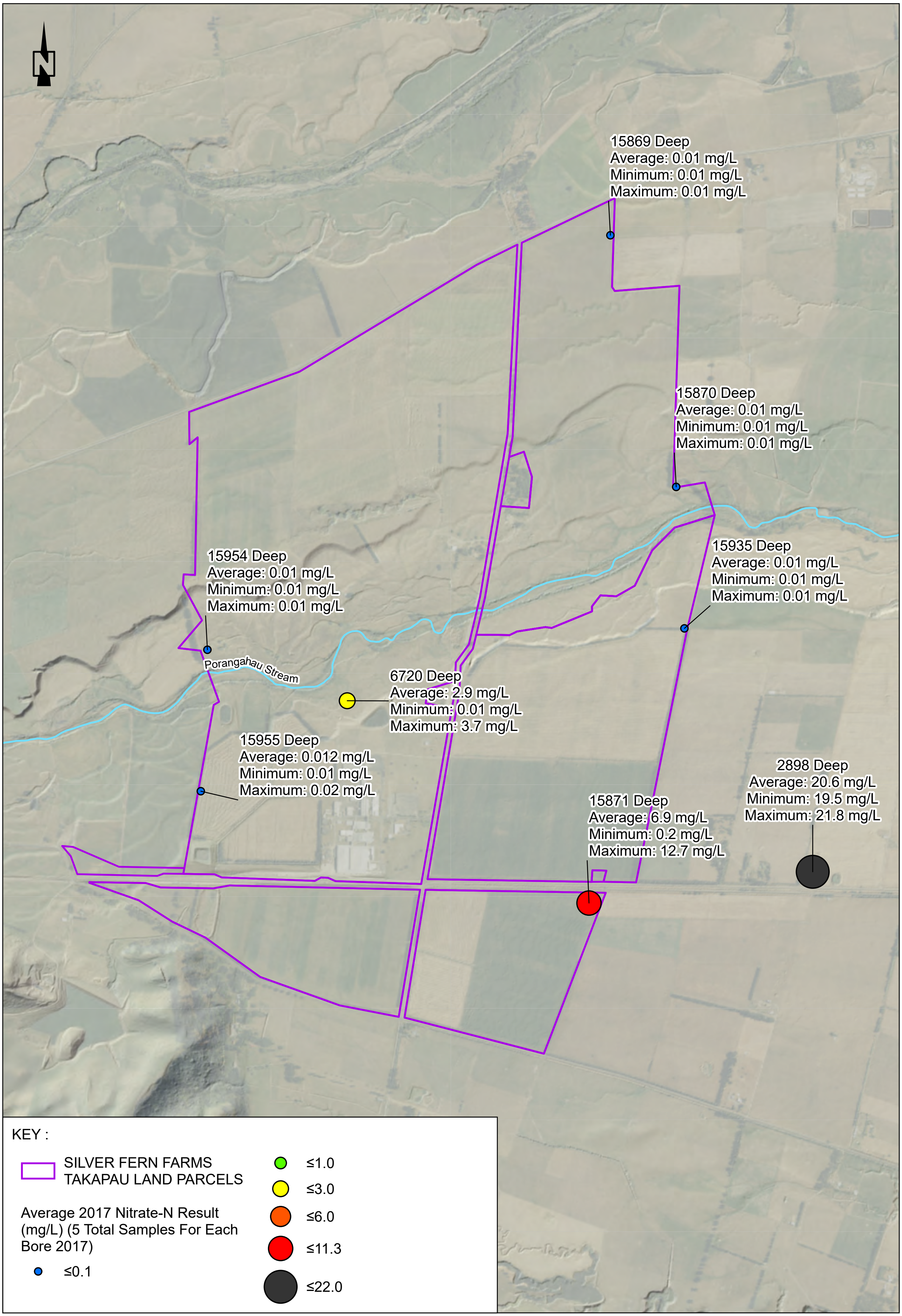

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FIGURE 4B : Nitrate-Nitrogen Results 2017
Deep Aquifer

SCALE : 1:20,000 (A4)

SOURCE:
1. AERIAL IMAGERY: ArcGIS Imagery NewZealand
2. LIDAR: HBRC

FIGURE 5 : Nitrate-N Results for Down-gradient Bores (June 2019) and Silver Fern Farms Groundwater Monitoring Bores (2017)

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