Before an Independent Hearings Panel
Appointed by Waimakariri District Council

under:	the Resource Management Act 1991
in the matter of:	Submissions and further submissions on the Proposed Waimakariri District Plan
and:	Hearing Stream 12: Rezoning requests (larger scale)
and:	**Carter Group Property Limited** *(Submitter 237)*
and:	**Rolleston Industrial Developments Limited** *(Submitter 160)*

Statement of evidence of Carl Cedric Steffens (Water Supply) on behalf of Carter Group Limited and Rolleston Industrial Developments Limited

Dated: 5 March 2024

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STATEMENT OF EVIDENCE OF CARL CEDRIC STEFFENS ON BEHALF OF CARTER GROUP LIMITED AND ROLLESTON INDUSTRIAL DEVELOPMENTS LIMITED

INTRODUCTION

1 My full name is Carl Cedric Steffens and I am a Technical Director, Water Resources at Pattle Delamore Partners Ltd. My qualifications are Post Graduate Diploma in Science (Engineering Geology) and Bachelor of Science (Geology) from the University of Canterbury. I am a member of the New Zealand Hydrological Society.

2 I have 19 years of professional work experience as a hydrogeologist and environmental scientist. I specialise in groundwater assessments and have carried out numerous assessments relating to groundwater sources for community supply throughout Canterbury and New Zealand.

3 Since 2004, I have been employed by Pattle Delamore Partners Ltd (*PDP*), an environmental consulting firm, with my specialist focus being groundwater investigations. During my employment with PDP, I have carried out and presented evidence for district and regional authorities, and for water users. In addition, I have also presented evidence for arbitration. I have recently undertaken the following projects related to new groundwater community supply sources or related groundwater supply assessments specifically related to urban development:

3.1 Pump testing, groundwater technical assessments and consenting work related to proposed new Christchurch City community supply bores.

3.2 Groundwater technical assessments and consenting relating to new Marlborough District Council water supply bores in Blenheim, Picton, Wairau Valley and Havelock.

3.3 Expert witness acting for Rau Paenga at arbitration hearing to decide a claim by the contractor relating to construction dewatering at the Christchurch Metro Sports Centre (Parakiore Recreation and Sports Centre).

3.4 Investigation of maximum abstraction yields and discharge capacity of confined aquifer bores used for heating and cooling of a Christchurch City office development.

3.5 Effects of construction dewatering effects at proposed Bellgrove Subdivision near Rangiora and long-term development effects on nearby spring flows.

4 I am familiar with the Submitters' request to rezone land bound by Mill Road, Whites Road, Bradleys Road (the *Site*).

5 I was involved in private plan change 31 (*PC31*) to rezone this land under the operative District Plan.

CODE OF CONDUCT

6 Although this is not an Environment Court hearing, I note that in preparing my evidence I have reviewed the Code of Conduct for Expert Witnesses contained in Part 9 of the Environment Court Practice Note 2023. I have complied with it in preparing my evidence. I confirm that the issues addressed in this statement of evidence are within my area of expertise, except where relying on the opinion or evidence of other witnesses. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

SCOPE OF EVIDENCE

7 My evidence will address:

7.1 A brief overview of the hydrogeological setting of the Site, including groundwater flow patterns;

7.2 A review of bore and aquifer performance in the area around the Site;

7.3 The water demand considerations and likely number of new public water supply bores needed to supply the Site;

7.4 A preliminary assessment of effects based on existing aquifer test information from the nearby Ōhoka township supply bore BW24/0262, particularly including well interference and stream depletion effects; and

7.5 The viability of consenting new public water supply bores for the Site.

8 In preparing my evidence, I have reviewed:

8.1 The evidence of **Mr Tim McLeod**;

8.2 Further submissions relevant to my expertise relating to the rezoning of the Site;

8.3 The relevant documents from PC31;

8.4 Environment Canterbury (*ECan*) hydrogeological database for relevant bore details at and in the vicinity of the Site;

8.5 The Tetra Tech Coffey, 2021 Site geotechnical report;

8.6 Waimakariri District Council (*WDC*), 2021 Activity Management Plan – Ōhoka Water Supply Scheme;

8.7 PDP 2016 Assessment of Environmental Effects report relating to consent application to take groundwater from Ōhoka water supply bore BW24/0262.

SUMMARY OF EVIDENCE

9 In my evidence I have summarised a preliminary assessment of the feasibility of establishing a community drinking water supply at the Site of the rezoning request in Ōhoka. This assessment includes the water demand requirements, the potential for proposed bores to meet these requirements at the Site, a preliminary assessment of environmental effects, and planning considerations.

10 I consider it viable to establish a supply, with an estimated total of four new bores providing adequate redundancy, assuming that the performance of any new bores will be similar to that of existing Ōhoka community supply bore BW24/0262.

11 The preliminary assessment predicts that well interference and stream depletion effects are less than minor. In addition, while the groundwater allocation zone is considered by ECan to be full, the existing irrigation allocation onsite means that no additional allocation would be required, although even if it were, there is provision in the Canterbury Land and Water Regional Plan (*LWRP*) for additional allocation to be available for new community supplies, even in fully or over-allocated catchments. As a result, I consider the available information indicates there are no significant barriers to prevent consenting of new public water supply bores.

12 Overall, I consider that the preliminary assessments described in my evidence demonstrate that establishing a new public water supply that meets the anticipated demand for the Site is viable and therefore, the rezoning request can be supported from a water supply perspective.

13 At the resource consenting stage, site specific pumping tests and an assessment of environmental effects will be required to support a resource consent application (which is a typical requirement for groundwater abstraction applications).

HYDROGEOLOGICAL SETTING

14 The Canterbury Plains comprise a series of large coalescing fluvio-glacial fans built by large, braided rivers (e.g. the Rangitata, Rakaia and Waimakariri) that transported detritus (gravel with sand and silt) eastwards from rapidly rising and eroding mountains in the west. Most of the gravel deposition occurred during successive

glaciations, when glaciers partly occupied the inland valleys and extended to the eastern foothills (Brown 2001[1]).

15 The GNS geological map of the area (Forsyth *et al.*, 2008[2]) maps the near-surface geology of the Site as late Pleistocene brownish-grey river alluvium (Q2a).

16 Geotechnical investigations at the proposed subdivision Site encountered silt and clayey silt to a depth of 0.6 to 1.5 m below ground level (bgl), and sandy gravel below this (Tetra Tech Coffey, 2021[3]). The borelog for the existing Ōhoka drinking water supply bore BW24/0262 (adjacent to the Site) shows a sequence of predominantly interbedded clayey gravel and sandy gravel down to at least 84.7 m bgl, with a clay layer from 21.7 to 26.6 m bgl.

17 On the Waimakariri-Ashley Plains, groundwater is dominantly sourced from infiltrating rainwater (i.e., land surface recharge) across the inland plains (to the north-west (upgradient) of the Site), together with some seepage losses from the Ashley and Waimakariri rivers. A map showing the location of the Site within the context of the geology of the northern Canterbury Plains is provided in **Appendix 1** attached to my evidence. This appendix also shows the general direction of groundwater movement in the overall area, indicating that groundwater generally flows to the southeast, towards the coast. Some of the groundwater throughflow also discharges into spring fed streams, including Ōhoka Stream and the Cam River/Ruataniwha.

18 Hydraulic conductivity is a term used to describe the ability of strata beneath the ground surface to transmit water under the effect of a hydraulic gradient. As a result, hydraulic conductivity (which varies spatially) affects the rate of groundwater flow below the ground. Throughout the Canterbury Plains, vertical hydraulic conductivity is usually significantly lower than the horizontal hydraulic conductivity, due to the presence of silt and clay strata, and gravel layers with varying amounts of silt and clay matrix (Lough and Williams, 2009[4]). Vertical groundwater flow (also called 'leakage') is therefore usually significantly slower than horizontal groundwater flow, and pumping from greater depths generally results in drawdown and stream depletion effects at the water table that are

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[1] Brown, L. J. (2001). Canterbury. In M. Rosen, & P. White (eds), *Groundwaters of New Zealand* (pp. 441-459). New Zealand Hydrological Society Inc., Wellington.

[2] Forsyth, P., Barrell, D., & Jongens, R. (2008). *Geology of the Christchurch area.* 1:250 000 geological map 16, Institute of Geological & Nuclear Sciences, Lower Hutt.

[3] Tetra Tech Coffey. (2021). *535 Mill Road, Ōhoka - Geotechnical Assessment Report.* Report reference number 773-CHCGE288040 prepared for Rolleston Industrial Developments Ltd. Dated 1 June 2021.

[4] Lough, H., & Williams, H. (2009). *Vertical flow in Canterbury groundwater systems and its significance for groundwater management. Environment Canterbury Technical Report U09/45, 69 p.*

more widely distributed and delayed in time, compared to comparable rates of pumping from shallower depths.

ŌHOKA WATER SUPPLY

19 The 2021 Ōhoka Water Supply Scheme Activity Management Plan (WDC, 2021[5]) indicates Ōhoka is serviced by a reticulated water supply with 118 connections. The supply is owned and operated by WDC and is principally sourced from Ōhoka Well No. 2 (ECan bore number BW24/0262). This bore has a screened intake zone from 78.0 – 84.0 m deep, and its location is shown at **Appendix 2**.

20 A backup supply bore (ECan bore number M35/5609) is also owned by WDC and has a screened intake zone from 16.8 – 18.8 m deep, however I understand that this bore is not regularly used as it is less than 30 m deep which makes it more vulnerable to *E. coli* contamination. The location of this bore is also shown in **Appendix 2**.

BORE AND AQUIFER PERFORMANCE

21 Any new community water supply bores established to service the Site would likely be at a similar or greater depth than existing community water supply bore BW24/0262 to minimise the risk of *E. coli* contamination. This existing supply bore can therefore give an indication of the likely yield and performance of any new community supply bores.

22 The assessment of environmental effects (*AEE*) prepared during the consent application for BW24/0262 (PDP, 2016[6]) indicated that the bore has a potential long term sustainable yield of 13 L/s. If any new water supply bores are screened at a similar depth as BW24/0262 (i.e., approximately 78 to 84 m below ground level) it is reasonable to expect that the long-term sustainable yield would be of a similar magnitude.

23 It is not clear whether drilling to a greater depth than BW24/0262 could result in higher yields. A plot of maximum yield versus depth for bores within 5 km of the Site is shown in **Appendix 3** and does not show any clear pattern, although the greatest number of high yielding bores have generally been obtained from shallow bores in the depth range of around 10 to 30 m. However, it is also noted

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[5] Waimakariri District Council. (2021). Activity Management Plan 2021 - Ōhoka Water Supply Scheme.

[6] Pattle Delamore Partners. (2016). Application for Resource Consent to Abstract Groundwater from Bore BW24/0262 (Ōhoka Public Supply Bore): Assessment of Environmental Effects. Report prepared for Waimakariri District Council, dated January 2016.

that there are significantly more shallow bores than deeper bores, which may skew the results.

24 **Appendix 3** also identifies two relatively high yielding bores (M35/12017 and M35/10768) that are 122 m and 109 m deep respectively and situated 4 to 4.5 km south of the Site (shown in **Appendix 4**). Bore M35/12017 is screened between 118 – 120 m bgl and has a reported maximum tested yield of 50 L/s, while M35/10768 is screened between 103 – 109 m bgl with a maximum tested yield of 64 L/s. It is not known whether similar yields would be encountered at the Site over comparable depth zones. In addition, it should also be noted that the reported bore yield can also reflect the particular water requirements for a bore, i.e., domestic supply bores are generally only tested at low rates, even if higher rates may potentially be achievable.

25 Specific capacity is a measure of bore performance, measured as units of litres, per second, per metre of drawdown in a bore. This can potentially give an approximate indication of zones where higher bore yields could be achieved. A plot of specific capacity versus bore depth is presented in **Appendix 5**. As shown, higher specific capacity values have generally been obtained from bores at shallow depths. However, it is also noted that some deeper bores in excess of 100 m deep have reported specific capacities of up to 10 L/s/m (including M35/12017 and M35/10768). This is a good level of bore performance for deep bores, which have more available drawdown than shallower bores to accommodate self-induced drawdown effects.

26 Overall, the yield information from deep bores is quite variable in this area, although the nearby WDC supply bore B24/0262 provides a useful guide as to what can be expected. Consideration could be given to extending the first bore drilled for the rezoning request water supply to greater depths to investigate the performance of deeper strata at the Site.

WATER DEMAND CONSIDERATIONS AND NUMBER OF PUBLIC SUPPLY BORES REQUIRED

27 I have based my assessment on the key water demand requirements of the proposed rezoning request. In terms of consenting of a new water supply source the following will apply:

27.1 A maximum annual volume of 412,000 m^3/year.

27.2 A peak daily rate of 2,412 m^3/day.

27.3 A peak instantaneous flow rate of 33.5 L/s.

28 The water demand calculations conducted by Inovo (as set out in the evidence of **Mr McLeod**) indicate that the average daily demand would be 980 m^3. The maximum annual volume of 412,000

m^3/year includes a 15% allowance for deviation from the average and leakage (i.e., 980m^3/day + 15%).

29 WDC has indicated that for a proposed water supply of the scale proposed for the rezoning request, "N + 1" redundancy would be appropriate. This means that the water supply must be able to meet peak network demand with one bore offline. The Engineering Code of Practice also stipulates that water supply designs assume a maximum of 20 hours of pumping per day.

30 Correspondence with WDC has also indicated that any excess capacity available in existing water supply bore BW24/0262 can be included for assessment of N + 1 redundancy and the required total number of bores, taking into account any projected increase in demand from the existing water supply bore. The existing shallow (18.8 m deep) emergency backup supply bore (M35/5609) cannot be included in the existing redundancy assessment, as it is understood to be subject to water quality issues (although in my opinion this could likely be addressed through a greater level of treatment, if required).

31 The 2021 Ōhoka Water Supply Scheme Activity Management Plan (WDC, 2021[7]) indicates there are currently (as reported in 2021) 118 connections with an average daily use of 159 m^3 and a peak daily use of 532 m^3 (July 2019 to June 2020), which equates to an average continuous flow rate of 2.2 L/s and a peak continuous flow rate of 7.4 L/s respectively, assuming 20 hours per day of pumping.

32 It is projected that connections will increase to 225 between 2051/2052 to 2070/2072, with a projected average daily use of 309 m^3/day (4.3 L/s over 20 hours) and peak daily use of 807 m^3 (11.2 L/s over 20 hours).

33 The resource consent abstraction limit for the existing WDC Ōhoka supply is 1,555 m^3/day, which equates to 21.6 L/s (over 20 hours), however the duty set point for the supply is 12.8 L/s (WDC, 2021), which equates to a volume of 921.6 m^3/day over a 20 hour pumping period. This is consistent with the 13 L/s long term sustainable yield estimated from aquifer testing on the supply bore (PDP, 2016).

34 Considering the usage data and projected growth, approximately 114.6 m^3/day (1.6 L/s over 20 hours) of excess capacity is available from the existing water supply to contribute to redundancy in the proposed community water supply for the Site.

35 Therefore, based on the peak daily volume requirement of 2,412 m^3/day for this proposal noted in paragraph 27, the new water supply bores for the proposed subdivision will need to supply 2,298 m^3/day, which equates to pumping continuously at 31.92 L/s for 20

[7] Waimakariri District Council. (2021). Activity Management Plan 2021 - Ōhoka Water Supply Scheme.

hours per day. In addition, the N + 1 redundancy requirements mean that the full peak water demand of both the existing supply and the proposed Site supply can be met when one bore is offline.

36 If the maximum duty point of any new supply bores within the Site is assumed to be 12.8 L/s (i.e. the same as the existing deep supply bore BW24/0262), then three new supply bores would be required to meet (and would exceed) the Site water demand requirements. An extra bore would also be required to meet N + 1 redundancy requirements, as the full combined peak daily water demand from the Site and the existing water network (including the projected increase in the next 31 to 50 years) can only be met with a minimum of four bores.

37 Therefore, it would be expected to have to drill four new water supply bores, resulting in a total of five deep water supply bores (including existing bore BW24/0262) for the Ōhoka area. It is expected that the existing shallow backup emergency supply bore (M35/5609) would be able to be retired, unless a greater level of treatment and monitoring is carried out in that bore so as to address the current water quality issues.

38 Further to the above, it is noted that if aquifer testing of any newly drilled bores indicated that one or more of the new bores had a higher long term sustainable yield than 12.8 L/s, it may be possible for fewer bores to provide the necessary water demand and redundancy requirements. Likewise, if aquifer testing shows that one or more of the new bores had a lower long term sustainable yield, then additional bores may be required.

INTERACTION BETWEEN SUPPLY BORES (EXISTING AND NEW) AND UNCERTAINTIES AROUND YIELD/BORE PERFORMANCE

39 Following on from the preceding section of my evidence, in addition to uncertainties around the number of new bores that will be required, there is also uncertainty around the performance of any new supply bores, the required spacing between new and existing bores and the interaction between supply bores with regard to drawdown interference effects. To address these uncertainties, I have carried out the assessment summarised below.

40 When groundwater is abstracted from a bore, the water level lowers in the bore. This is known as drawdown, which also occurs outside the bore in the surrounding saturated strata. The magnitude of drawdown will decrease with distance from the pumping bore, but when the drawdown extends to a neighbouring bore it is termed 'well interference'. Well interference will occur between the existing and new water supply bores (in addition to bores owned by neighbouring groundwater users) and excessive effects can impact on the reliability of supply and yield potential from an individual bore.

41 **Appendix 6** shows the results of my assessment in the form of a plot of predicted drawdown versus distance from an individual WDC water supply bore. The drawdown profiles shown in this figure are based on abstraction from a single bore continuously at 9.3 L/s for a 150-day period. This rate represents a third of the proposed daily limit (2,412 m^3/day, equivalent to continuous pumping for 24 hours at 27.9 L/s). Therefore, the full daily volume limit under this scenario would be provided by 3 bores as assumed in the section above.

42 There are 3 separate drawdown curves shown in **Appendix 6**. As is typical, each shows the highest predicted drawdown occurs at the point of abstraction and reduces with distance from that point. Each curve in **Appendix 6** represents calculations with a different set of aquifer parameters.

43 The drawdown curve represented by the black line in **Appendix 6** was calculated from the average aquifer parameters derived by PDP from the constant rate pumping test analysis in BW24/0262. It is possible these aquifer parameters may not be representative of new bores drilled at the Site and therefore to account for this I have carried out additional drawdown assessments using a set of aquifer parameters that are less favourable (resulting in greater drawdown interference and shown by the green drawdown curve in **Appendix 6**) and a set that are more favourable (causing less drawdown interference and shown by the red curve in **Appendix 6**).

44 To estimate the total drawdown interference effect in an individual supply bore based on this assessment firstly requires determination of the distance between that bore and each of the other supply bores (three additional supply bores assumed). Secondly, the drawdown value on the appropriate curve can be read off Appendix 6 at the appropriate distances for each of the three supply bores and thirdly, the three values are summed to estimate the total drawdown effect in the bore being assessed.

45 For example, if one proposed supply bore was located 400 m from existing supply bore BW24/0262, one supply bore was 500 m from BW24/0262 and the remaining bore was 600 m distance, the drawdown interference in BX24/0262 based on the average pump test parameters (black curve in **Appendix 6**) would be the sum of 0.88 m (400 m distant), 0.7 m (500 m distant) and 0.56 m (600 m distant). That results in a total drawdown interference effect in BW24/0262 of 2.14 m. Based on that spacing from BW24/0262, it should be possible to position all three proposed supply bores north of the Ōhoka River (**Appendix 1**) within the proposed Site, while also maintaining similar spacing between all three of the proposed bores.

46 The analysis of the step-drawdown testing previously carried out in BW24/0262 (June 2015) predicts self-induced drawdown of 61.4 m in the bore based on 150 days of continuous operation at 12.8 L/s.

Under summer groundwater level conditions previously predicted by PDP, this leaves around 10 m of available drawdown in the bore which is more than sufficient to accommodate the 2.14 m drawdown interference effect predicted from the operation of the three proposed supply bores. This is a very conservative assessment in terms of pumping rates, because in reality it is not expected that the proposed supply will use the required daily volume limit continuously for 150 days, or that the existing bore will operate at its consented maximum rate for the same period.

47 Therefore, based on the assessment above, if the average aquifer parameters adopted from the previous constant rate testing prove to be applicable, a potential average bore spacing of around 500 m is considered appropriate for a total of three supply bores, while preventing adverse operational drawdown interference effects in BW24/0262, or the proposed new supply bores.

48 If more favourable parameters (such as those indicated by the red curve shown in the figure) were to be derived during testing of the proposed bores, the effects would be less and therefore three supply bores would still be viable within similar or lesser spacing between bores.

49 If less favourable parameters (such as those indicated by the green curve shown in the figure) were to be obtained from pump testing, the total drawdown interference calculated in BX24/0262 (from operation of the three proposed supply bores) increases to 5.4 m. This still leaves around 4 m of available drawdown remaining in BW24/0262 (once self-induced drawdown is considered) under the most conservative assessment conditions (low groundwater levels and sustained high pumping rates from all bores). If testing of new bores showed this scale of interference, then consideration could be given to additional supply bores and/or greater spacing to manage the potential effects.

50 If four or more supply bores ended up being required (+1 for redundancy), then a larger area would be required, although given the large size of the Site it should be feasible that all supply bores could be sited within less than half of the total subdivision area.

51 A greater number of bores would result in greater drilling and infrastructure related costs, however those costs will be borne by the submitters and therefore would not be a concern of WDC or ratepayers.

52 While I consider the available information indicates a viable groundwater supply is likely to be achievable at the Site, an offsite source is also likely to provide an additional option. An example of this is the Rangiora water supply, which utilises a deep high-yielding confined aquifer source in Kaiapoi.

PRELIMINARY ASSESSMENT OF EFFECTS

53 In terms of obtaining resource consents for new public water supply bores for the proposed development, there are three feasible options, that I outline at paragraph 87 below. The key environmental effects that must be considered for any consenting pathway are well interference (in bores owned by neighbouring groundwater users), stream depletion, the allocation status of the groundwater allocation zone, and community drinking water protection zones. I consider these now.

WELL INTERFERENCE

54 If significant, well interference has the potential to adversely affect neighbouring bore users by reducing the available drawdown in their bore (needed for their own yield requirements) and in the worst case, can result in the inability of neighbouring bores to abstract water. In general, pumping from shallow bores will cause the greatest drawdown interference in other shallow bores, and pumping from deep bores will cause the greatest drawdown interference effects in other deep bores.

55 Most bores surrounding the Site are shallow (i.e. less than 31 m deep), and the existing irrigation consents on the Site that are proposed to be surrendered or transferred (CRC991022 and CRC991827) involve abstraction from shallow bores (locations shown in **Appendix 2**). Therefore, it is expected that the transfer of abstraction from shallow irrigation bores to deep water supply bores will result in less well interference effects for most shallow neighbouring bores than might currently be experienced.

56 Schedule 12 of the LWRP outlines the approach ECan uses to assess and manage well interference effects. As a conservative (though not realistic) approach, I have used the Schedule 12 methodology and assumed that the long-term (150-day) pumping rate assessment required by Schedule 12 would be 2,412 m^3/day, i.e. the maximum daily volume, which results in a 150-day volume of 361,800 m^3/day and which is 88% of the total proposed annual volume. A short term (7-day) pumping rate assessment is also required under Schedule 12, however the rate cannot exceed the maximum proposed daily volume and therefore this would also be 2,412 m^3/day.

57 There are many very shallow bores near the Site, and Schedule 12 states that "*where an existing bore inadequately penetrates an aquifer, the interference effect of a new bore will be assessed as if the existing bore is also adequately penetrating".* The adequate penetration depth is defined as a "*… level to which 50% of bores within 2 km penetrating the aquifer are already established at 1 January 2002".* Based on that definition, the adequate penetration depth for the Site has been calculated at 15 m.

58 As stated above, drawdown effects in neighbouring shallow bores can generally be expected to reduce due to the transfer of groundwater abstraction from the existing shallow irrigation bores to deeper community drinking water supply bores. Drawdown effects in neighbouring bores of similar depth to the new drinking water supply bores would be expected to increase, however these bores have more available drawdown to accommodate well interference due to their greater depth.

59 This has been demonstrated by way of carrying out Schedule 12 assessments comparing the drawdown interference effects resulting from the consented abstractions via the shallow onsite irrigation bores with the proposed abstraction from deep bores as follows:

59.1 Simulated abstraction from deep bores, with drawdown estimated using the average aquifer parameters estimated from bore BW24/0262 and a pumping rate of 27.92 L/s (2,412 m^3/day over 24 hours) for 150 days. Five individual assessments have been carried out, each of which conservatively assumes abstraction of this quantity of groundwater via a single deep bore. These five simulations cover a wide range of potential bore sites to consider potential impacts of variations in bore locations. The locations of each of the five assessment sites are shown in **Appendix 7** (grey circles labelled virtual wells) of my evidence. The Hunt and Scott (2007[8]) solution was used to estimate drawdown for this scenario.

59.2 Simulated abstraction from the existing shallow irrigation bores based on the consented short term and long-term rates as per the ECan Schedule 12 program. In this case, drawdown is estimated using the Theis (1935[9]) solution, with a transmissivity of 975 m^2/day, and a storativity of 0.1. The transmissivity was estimated from an empirical relationship between the specific capacity of a bore and transmissivity derived from pumping tests in Canterbury (Bal, 1996[10]). Based on bores less than 31 m deep within 2 km of the pumped bore, the average transmissivity using that empirical relationship was 975 m^2/day (PDP, 2016).

59.3 Comparison of the five deep simulations with the existing shallow scenarios was done to show the potential change in well interference from replacing the current consented

[8] Hunt, B., & Scott, D. (2007). Flow to a well in a two-aquifer system. *Journal of Hydraulic Engineering, 12*(2), 146-155.

[9] Theis, C. (1935). The relation between lowering of the piezometric surface and the rate and duration of discharge of a well using groundwater storage. *Transactions of the American Geophysical Union, 16*, 519-524.

[10] Bal, A. A. (1996). Valley fills and coastal cliffs buried beneath an aluvial plain: evidence from variation of permeabilities in gravel aquifers, Canterbury Plains, New Zealand. *New Zealand Journal of Hydrology*, 1-27.

shallow irrigation takes at the Site with a deep groundwater take for community supply.

60 I note that the separation distances of each simulated deep bore in the assessment are greater than 700 m in all cases and up to nearly 2 km for the largest separation (between sites 1 and 3 as per **Appendix 7**) due to the large size of the Site. In my opinion, the deep abstraction bores could be separated by between 300 to 500 m to minimise excessive drawdown interference effects between individual supply bores. However, onsite testing following drilling could also confirm that closer spacing may be acceptable.

61 The results of the Schedule 12 assessments are consistent with the assumptions in paragraph 54 of my evidence, where the predicted effects indicate a reduction in drawdown interference in the majority of neighbouring shallow bores within 2 km of each of the five separate deep water supply bore assessments simulated. There were a low number of shallow neighbouring bores where there was an increase in drawdown interference, however the assessments indicated that all of these bores still had sufficient available drawdown based on the Schedule 12 methodology (once cumulative effects were also considered), with the exception of one bore (M35/0593) which had cumulative effects that slightly exceeded the Schedule 12 criteria) under the assessment for location 1 (**Appendix 7**). Closer inspection of the results relating to this bore indicate that the cumulative effects are only 0.017 m above the Schedule 12 criteria and that there is likely to still be sufficient available drawdown in the bore for it to achieve its yield for stock supply. As a result, I consider the potential effects in that bore are not a barrier to gaining consent.

62 As expected, there are some deep neighbouring bores where drawdown interference effects increase, however they all have significant available drawdown (due to their depth) and therefore the remaining drawdown is also still within the Schedule 12 criteria for deep bores. Overall, the assessments indicate a level of effects that are less than minor.

63 Based on the assessments carried out, I consider it is reasonable to expect that drawdown interference effects are likely to be less than minor. While the actual assessments that will be required during consenting will need to be based on Site specific pump tests in the actual community supply bores (following drilling) and these tests may show different aquifer parameters, the assessments that have been carried out and the nature of the proposal (replacing shallow abstraction with deep abstraction) is supportive of a reduction in effects on existing shallow bores and indicates existing deep bores are not particularly sensitive to drawdown interference.

64 It is also noted that many of the shallow neighbouring bores are listed as being used for domestic supply. In the unexpected event that a full well interference assessment identifies neighbouring bores

that could be adversely affected by well interference, mitigation options are available for potentially affected bore owners, which could include expanding the extent of the Ōhoka reticulated public water supply network.

STREAM DEPLETION

65 Stream depletion is a reduction in stream flow resulting from groundwater pumping. In general, pumping from a deeper bore will result in a lesser and more widely distributed stream depletion effect than pumping from a shallow bore, assuming the pumping rate and location are the same.

66 There are a large number of streams across the Site, the most significant of which is the South Branch of Ōhoka Stream, which crosses the northern part of the Site (**Appendix 2**). Due to the number of streams across the Site, the overall potential stream depletion effects from any proposed water supply bores are not expected to be highly dependent on the exact placement of the supply bores.

67 Stream depletion is assessed according to Schedule 9 of the LWRP. A low degree of stream depletion effect is defined as *"… where the effect of 150 days of continuous groundwater abstraction on the surface waterbody is less than 40% of that abstraction rate and the effect of pumping the proposed annual volume over 150 days at a continuous steady rate is less than 5 L/s…".* Schedule 9 also indicates that when there is more than one bore on a property abstracting water, the stream depletion effect for each bore must be determined independently and the stream depletion effect of the bores shall be determined in combination as a borefield.

68 A preliminary stream depletion assessment has been conducted, using the same aquifer parameters as for the well interference assessment. The Ward and Lough (2011[11]) solution is considered most applicable to the conceptual setting at Ōhoka, where the proposed pumped bore(s) is in a semi-confined aquifer, overlain by an unconfined aquifer that is hydraulically connected with the surface waterway(s). The stream depletion effect is generally highly sensitive to the streambed conductance (λ), which for Ward and Lough (2011) is defined as the streambed width multiplied by the depth of the streambed "clogging" layer multiplied by the hydraulic conductivity of the streambed.

69 The streambed conductance of Ōhoka Stream has been estimated from field measurements in several locations near the Site, as presented in Appendix C of the ECan guidelines for the assessment of groundwater abstraction effects on stream flow (PDP and ECan,

[11] Ward, N., & Lough, H. (2011). Stream depletion from pumping a semiconfined aquifer in a two-layer leaky aquifer system. *Journal of Hydrologic Engineering, 16*, 955-959.

2000[12]). A streambed conductance of 0.8 m/day was estimated, and this value has been used for this preliminary assessment.

70 The LWRP Schedule 9 assessment is focussed on irrigation abstractions, based on its specification of the proposed annual volume being taken over 150 days, which would be unrealistic for a subdivision water supply. Therefore, for this assessment I have assumed a 150-day pumping rate of 1,696 m^3/day, which is equivalent to 75 days of abstraction at the maximum daily rate (2,412 m^3/day) and 75 days of abstraction at the average daily rate (980 m^3/day). This results in a 150-day volume of 254,400 m^3 which represents over 60% of the proposed annual volume over the 150-day assessment period and is therefore considered to be a conservative representation of actual use, given that sufficient volume must still be available for the additional 215 days of a year.

71 The preliminary assessment using the parameters described above indicates that the stream depletion effect would be considered 'Low' at all distances from any surface water bodies, based on the aquifer parameters derived from bore BW24/0262. This would mean that rule 8.5.9 of the LWRP would likely be applicable to the proposal and provide a consenting pathway, as discussed in paragraphs 91 and 92 below.

72 I note that a stream depletion assessment is highly dependent on the aquifer parameters estimated from a constant rate pumping test, and a final stream depletion assessment would have to be conducted after a pumping test has been carried out in each new proposed water supply bore.

73 However, stream depletion will also be occurring as a result of the existing shallow irrigation abstractions onsite. In addition, where existing individual shallow bores are close to existing streams (most are), the existing effects are likely greater than the proposed abstraction from deep bores. Therefore, there is a high likelihood that actual depletion will be less than is currently occurring from the shallow bores and even if that were not the case, it is reasonable to expect the degree of connection would be 'Low' as discussed above and therefore management of any effect would not be required.

ALLOCATION STATUS OF THE GROUNDWATER RESOURCE

74 The Site is in the Eyre Groundwater Allocation Zone, which based on information provided by ECan on 18 January 2023, I understand the status of the zone is 97.3 % allocated. That represents a total allocated volume from the zone of 98.76 million m^3/year from a total allocation limit of 99.07 million m^3/year. ECan also indicated there were some additional consents being processed at that time

[12] Pattle Delamore Partners and Environment Canterbury. (2000). Guidelines for the Assessment of Groundwater Abstraction Effects on Stream Flow. Report dated June 2000.

which could increase the total allocation closer to the limit and therefore they consider the zone is fully allocated.

75 The Site currently has two active groundwater take consents, CRC991022 and CRC991827, which both expire on 12 September 2041. The bore locations relating to these consents are shown in **Appendix 2**:

75.1 Consent CRC991022 authorises abstraction from three bores (M35/9423 – 30 m deep, M35/3064 – 12.5 m deep and M35/3065 – 12 m deep). The consent allows for a maximum instantaneous rate of take from each bore of 30 L/s, a combined maximum instantaneous rate of 60 L/s, a maximum daily volume of 2,484 m^3/day for each bore and a maximum combined daily volume of 4,968 m^3/day. No annual volume is specified in the consent documents, although ECan has calculated an annual volume of 566,032 m^3 for their accounting tally in the Eyre Groundwater Allocation Zone.

75.2 Consent CRC991827 authorises abstraction from two bores (M35/0326 – 13.7 m deep and M35/0367 – 9.4 m deep). The maximum consented instantaneous rate from each bore is 22.8 L/s and the maximum daily volume from each bore is 1,806 m^3/day. No annual volume is specified in the consent documents, although ECan has calculated an annual volume of 113,536 m^3 for their accounting tally in the Eyre Groundwater Allocation Zone. The maximum instantaneous rate and daily volume are also limited according to the flow in Ōhoka Stream, taken from measurements at the confluence with the Kaiapoi River.

76 It is intended that the groundwater take consents described above would be surrendered or transferred if the proposed development proceeds. The combined maximum daily volume authorised by the two existing consents is 6,774 m^3/day, which is significantly higher than the maximum proposed daily volume of 2,412 m^3/day for public water supply for the proposed development. Similarly, the combined existing annual volume assumed in ECan's allocation tally is 679,568 m^3 and is significantly more than the 412,000 m^3/year required for the subdivision.

77 The proposed rezoning request would therefore result in a significant reduction in the maximum consented daily volume of groundwater that is authorised to be abstracted from the Site.

78 Depending on the consenting pathway used for any new public water supply bores, actual past usage of the irrigation consents may be considered, rather than the allocated volume. Possible consenting pathways are discussed further in paragraphs 87 to 94 of my evidence.

79 It is also noted that Policies 4.49 and 4.50 allow a pathway for the allocation of groundwater for community supply purposes even where the groundwater allocation limit is exceeded for the applicable allocation zone (in this case ECan consider the zone is fully allocated and therefore additional allocation could lead to over allocation). Therefore, it is not strictly necessary for the proposal to rely on the transfer of existing allocation.

COMMUNITY DRINKING WATER PROTECTION ZONES AND WATER QUALITY

80 Any new drinking water supply bore would have a surrounding Community Drinking Water Protection Zone, the size of which would be determined in accordance with Schedule 1 of the LWRP.

81 Schedule 1 of the LWRP states that any consent for a new community drinking-water supply must provide the dimensions of a specific protection zone, determined using Site specific information, including the geology of the Site, the depth of the bore, the bore construction, pumping rates, the type of aquifer, types of actual or potential contaminants, the proposed level of treatment and any potential risk to water quality.

82 As has been discussed earlier in this evidence, it would be prudent for water quality and safety reasons for the new supply bore to be relatively deep, similar to existing neighbouring supply bore BW24/0262. The protection zone around BW24/0262 is circular, extending 100 m in all directions and is a provisional protection zone due to it being an existing water supply at the time Schedule 1 of the LWRP became operative.

83 Generally speaking, deep bores have a relatively small protection zone. The default protection zone for bores deeper than 70 meters at the Site is 100 meters (extending in all directions from the bore). The final dimensions of any proposed site-specific Community Drinking Water Protection Zone will depend on the results of hydrogeological investigations.

84 Information from WDC (as of 2016) indicated that bore BW24/0262 was fully compliant with the Drinking Water Standards for New Zealand (DWSNZ) at that time in terms of bacterial and protozoal compliance. This provides an indication that the deeper water quality in the vicinity of the Site and for a potential new deep bore supply should be of a quality that satisfies drinking water criteria.

85 In addition, I have recently been provided with information from WDC, including monthly bacterial sampling results from BW24/0262 between December 2022 and January 2024. In addition, I have been provided with a full chemical analysis from the bore during sampling in October 2023. This information indicates that the Ōhoka water supply meets relevant new chemical and bacterial standards set in the Water Services (Drinking Water Standards for

New Zealand) Regulations 2022. A more detailed review of water quality in bore BW24/0262 and in the vicinity of the Site should be undertaken at the subdivision consent stage to confirm that there are no potential water quality issues.

86 If in the unexpected situation that shallower bores (such as the existing irrigation bores at the Site) are required to be utilised for the proposed supply, it is likely they are still able to meet the Drinking Water Quality Assurance Rules (2022) specified by Taumata Arowai. The difference would be that a shallow source requires a higher level of treatment and monitoring to ensure it is a safe drinking-water source.

VIABILITY OF CONSENTING NEW PUBLIC WATER SUPPLY BORES

87 I consider there are three primary viable consenting pathways for new public water supply bores under the LWRP, which are as follows:

87.1 Apply for a transfer under rule 5.133, which should also incorporate additional Waimakariri sub-regional area conditions as per rule 8.5.15.

87.2 Apply for a transfer under rule 8.5.9 for substitution of a stream depleting take with a take with a low stream depletion effect.

87.3 Apply for a new take and use under rule 5.115.

88 Rule 5.133 is relevant to transfers within a groundwater allocation zone where the annual volume is less than or equal to the existing take, and the stream depletion effect is no greater than the original take. Such a transfer is a restricted discretionary activity.

89 It is expected that all of the conditions of rule 5.133 (as supplemented by rule 8.5.15) will be able to be met, however, a full well interference assessment will need to be conducted after the bores have been drilled and pump testing conducted.

90 Waimakariri sub-regional rule 8.5.15 provides additional conditions for rule 5.133 and states that the volume of water able to be transferred is restricted to the annual average volume of water used in the preceding five years. If the usage records indicate that sufficient volume would be available to meet the rezoning request water demand requirements, then the application would still be restricted discretionary. If the annual volume applied for is larger than average use over the previous 5 years (but lower than the allocated annual volume) then it would default to rule 5.134 and the application would be non-complying.

91 Rule 8.5.9 indicates that substitution of a stream depleting take (i.e., a take with at least a moderate stream depletion effect) with a take with a low stream depletion effect is a restricted discretionary activity. For a transfer under this rule, the allocated annual volume (i.e., from Irricalc) would be relevant, not actual use over the previous 5 years, in contrast with rule 8.5.15.

92 Rule 8.5.9 is a potential consenting pathway for the Site, as the existing irrigation takes are relatively shallow and are expected to have at least a moderate degree of stream depletion effect. Deeper takes for drinking water supply would be expected to have a lower degree of stream depletion effect, though assessment of whether the effect is low will need to be confirmed by the results of site-specific pump testing.

93 Rule 5.115 is a consenting pathway allowed for in the LWRP for establishing a community drinking water supply, in accordance with policies 4.49, 4.50 and 8.4.14. The groundwater take application for community drinking water supply would be assessed as a restricted discretionary activity.

94 The rules and policies discussed above indicate that there are three viable consenting pathways for the establishment of new community drinking water supply bores on the Site. The preferred pathway is likely to depend on the results of pump testing, and subsequent stream depletion assessment, as well as the final groundwater usage records from the existing groundwater take consents over the five years preceding the consent application.

CONCLUSION

95 A preliminary assessment of the feasibility of establishing a community drinking water supply at the Site of the proposed rezoning request in Ōhoka has been undertaken. This has considered water demand requirements and associated issues, preliminary assessment of environmental effects, and planning considerations.

96 The available information indicates it is viable to establish a deep community supply at the Site, with an estimated total of four new bores providing adequate redundancy, assuming that the performance of any new bores is similar to that of existing community supply bore BW24/0262.

97 In the unlikely situation where a suitable deep groundwater supply could not be provided at the Site, I consider there are still viable options. These include utilising the existing shallow bores (although that would likely require a higher level of treatment and monitoring than a deep source) or using an offsite source.

98 The preliminary assessment suggests that well interference and stream depletion effects are estimated to be less than minor and it

is reasonable to assume that effects of a deep supply source on the majority of neighbouring bores in the area (mostly shallow) will be less than that which currently occurs via abstraction from the onsite shallow irrigation bores. Therefore, potential interference effects, are not likely to prevent consenting of new public water supply bores.

99 At the resource consenting stage, Site specific pumping tests and an assessment of environmental effects will be required to support the resource consent application which is typical for all groundwater take applications.

100 The fully allocated status of the groundwater in the area is ultimately not a significant concern because there is a pathway in the LWRP for consenting of groundwater for community supply even when allocation limits are at capacity or exceeded.

101 Overall, I consider that the preliminary assessments described in my evidence demonstrate that establishing a new public water supply that meets the anticipated demand for the Site is viable and therefore, the rezoning request can be supported from a water supply perspective.

Dated: 5 March 2024

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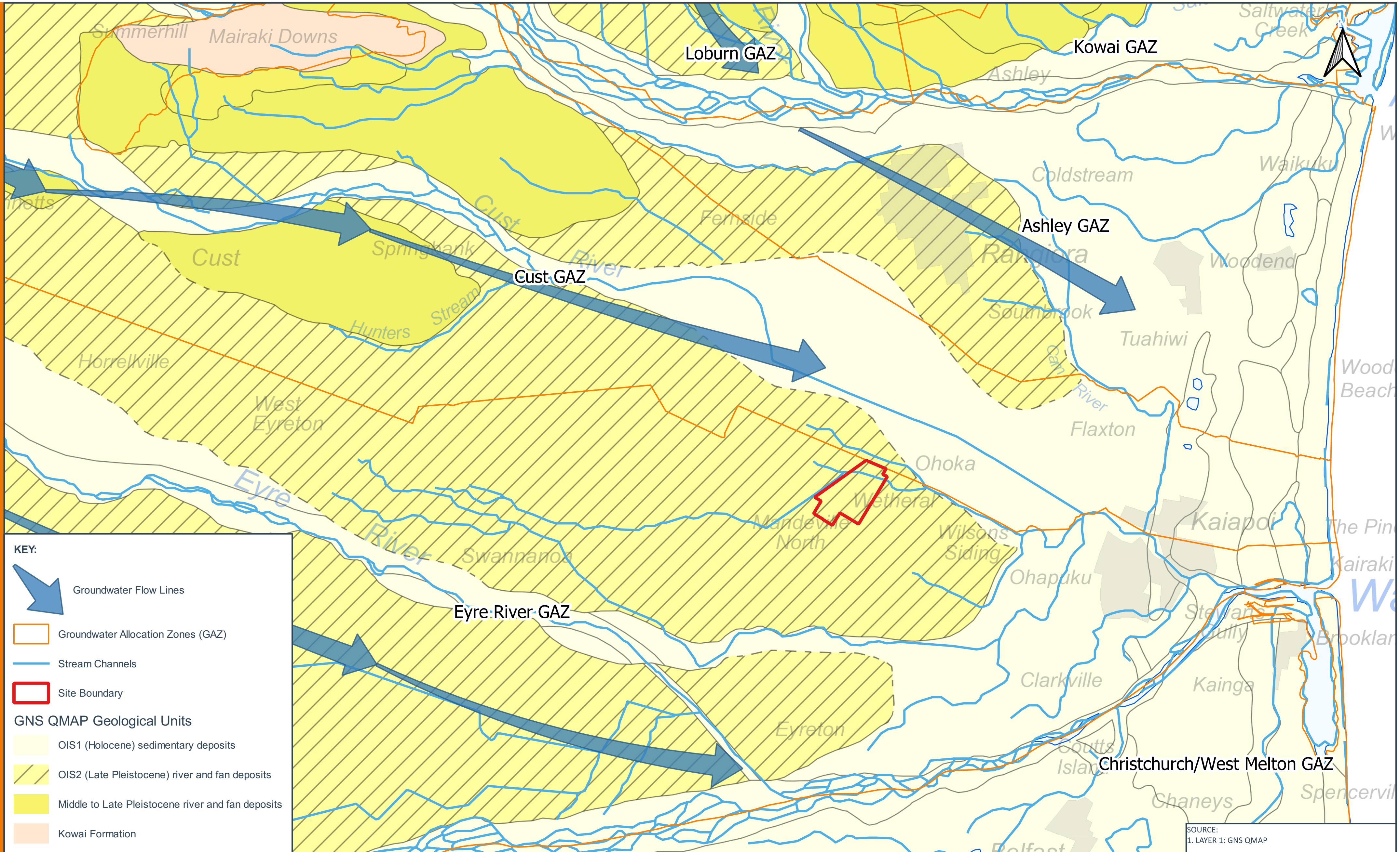
Carl Cedric Steffens

APPENDIX 1 - GROUNDWATER FLOW PATHS AND HYDROGEOLOGICAL SETTING



0 1 2 km

KILOMETRES

SCALE : 1:120,000 (A4)

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A	FINAL	FEB 24	TG

CLIENT

ROLLESTON INDUSTRIAL DEVELOPMENTS LTD

FIGURE

APPENDIX 1: GROUNDWATER FLOW PATHS AND HYDROGEOLOGICAL SETTING

PROJECT

PRELIMINARY WATER SUPPLY ASSESSMENT - OHOKA PLAN CHANGE

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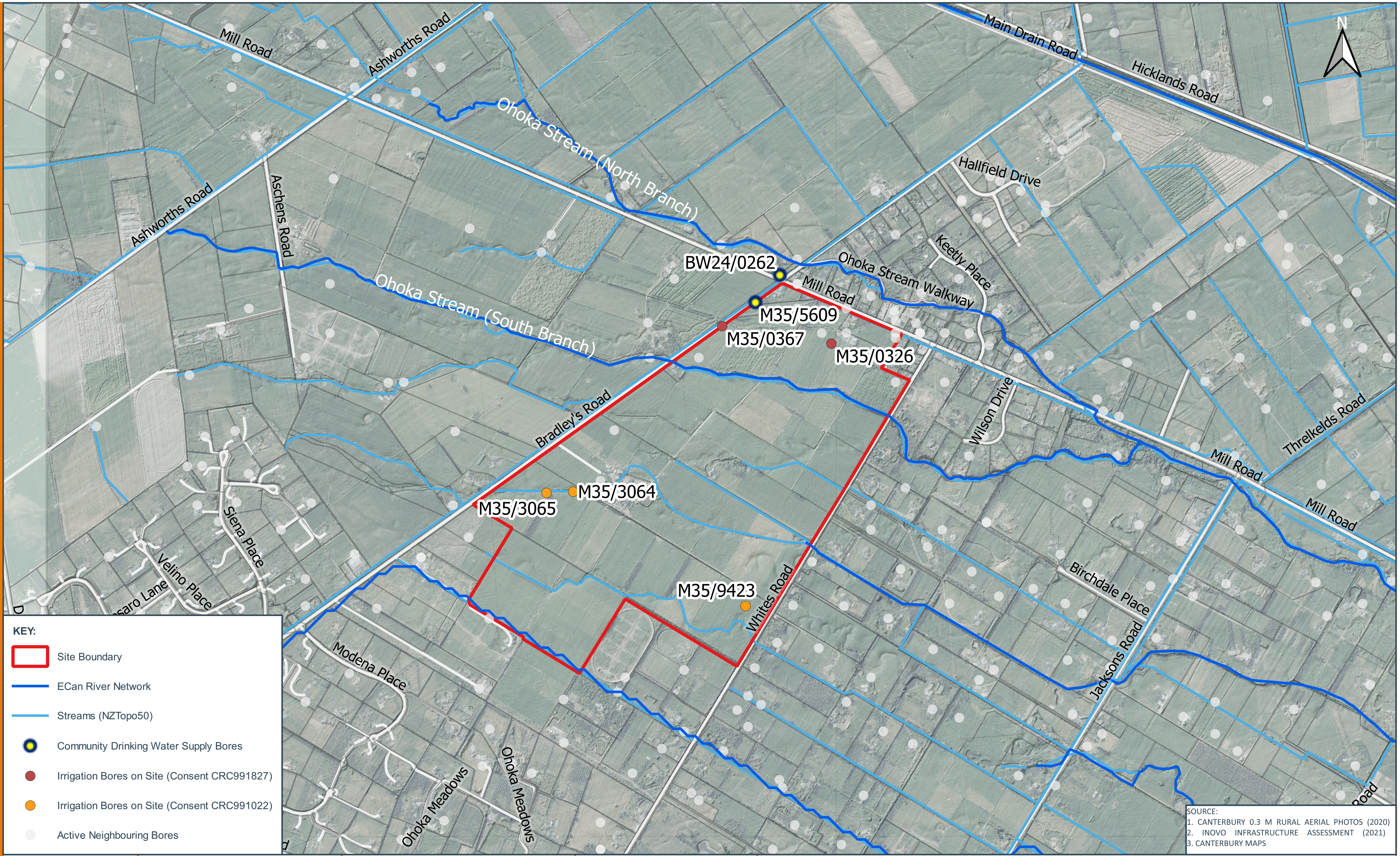
APPENDIX 2 - SITE OVERVIEW



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METRES

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ROLLESTON INDUSTRIAL DEVELOPMENTS LTD

FIGURE

APPENDIX 2: SITE OVERVIEW

PROJECT

PRELIMINARY WATER SUPPLY ASSESSMENT - OHOKA PLAN CHANGE

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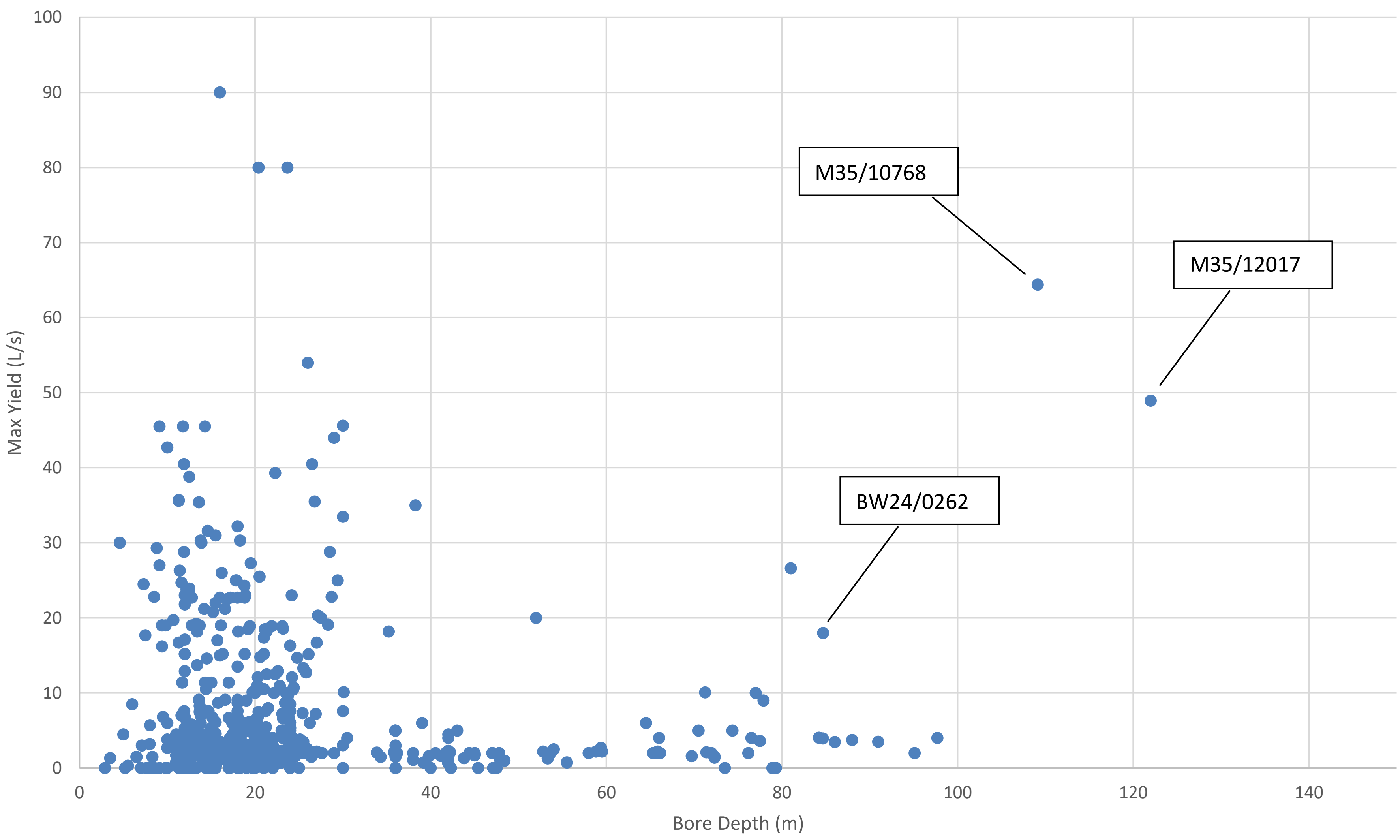
APPENDIX 3 - MAXIMUM YIELD VERSUS DEPTH FOR BORES WITHIN 5 KM OF SITE



APPENDIX 3: MAXIMUM YIELD VERSUS DEPTH FOR BORES WITHIN 5 KM OF SITE

APPENDIX 4 - NEIGHBOURING BORE DEPTH

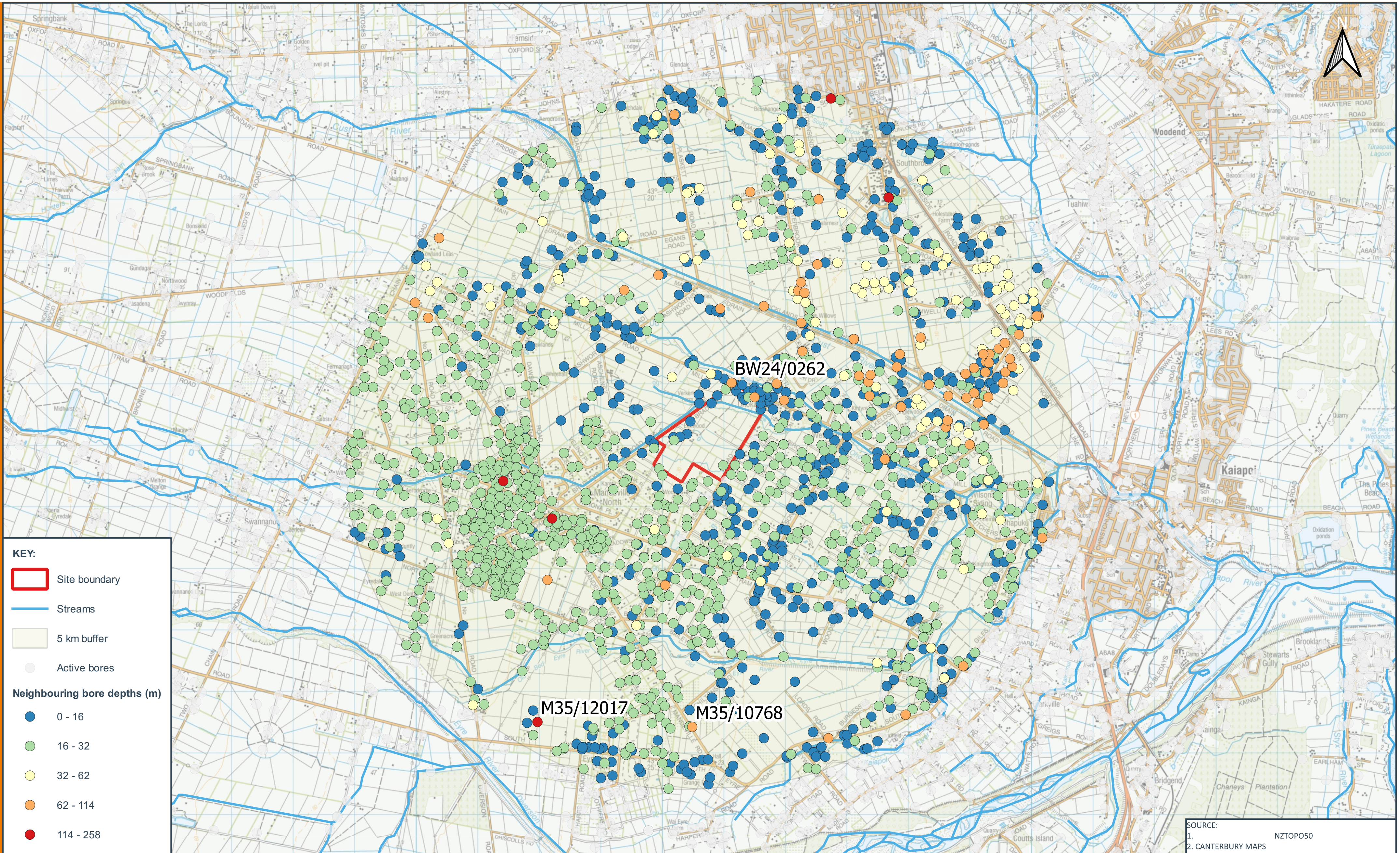


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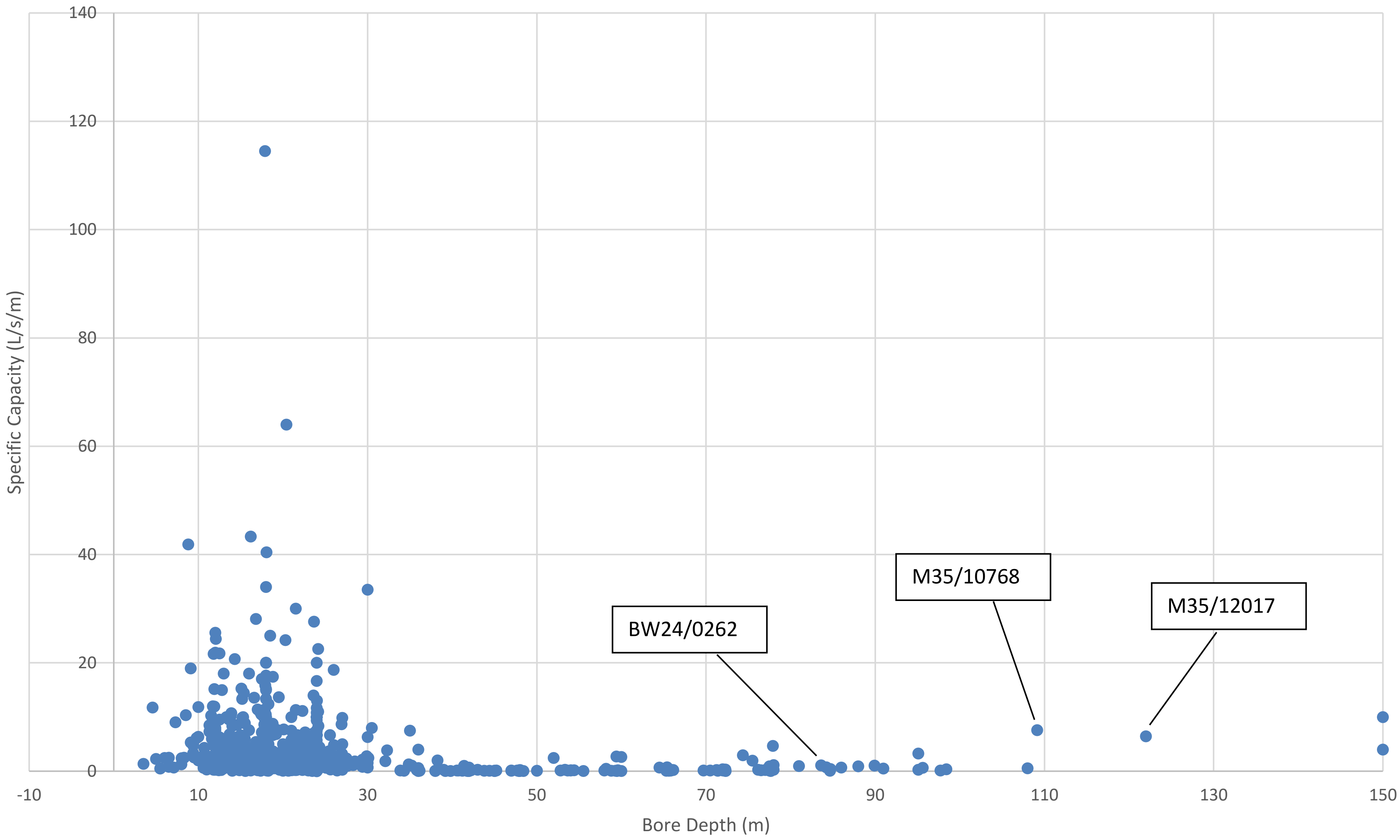
FIGURE
APPENDIX 4: NEIGHBOURING BORE DEPTHS

PROJECT
PRELIMINARY WATER SUPPLY ASSESSMENT - OHOKA PLAN CHANGE

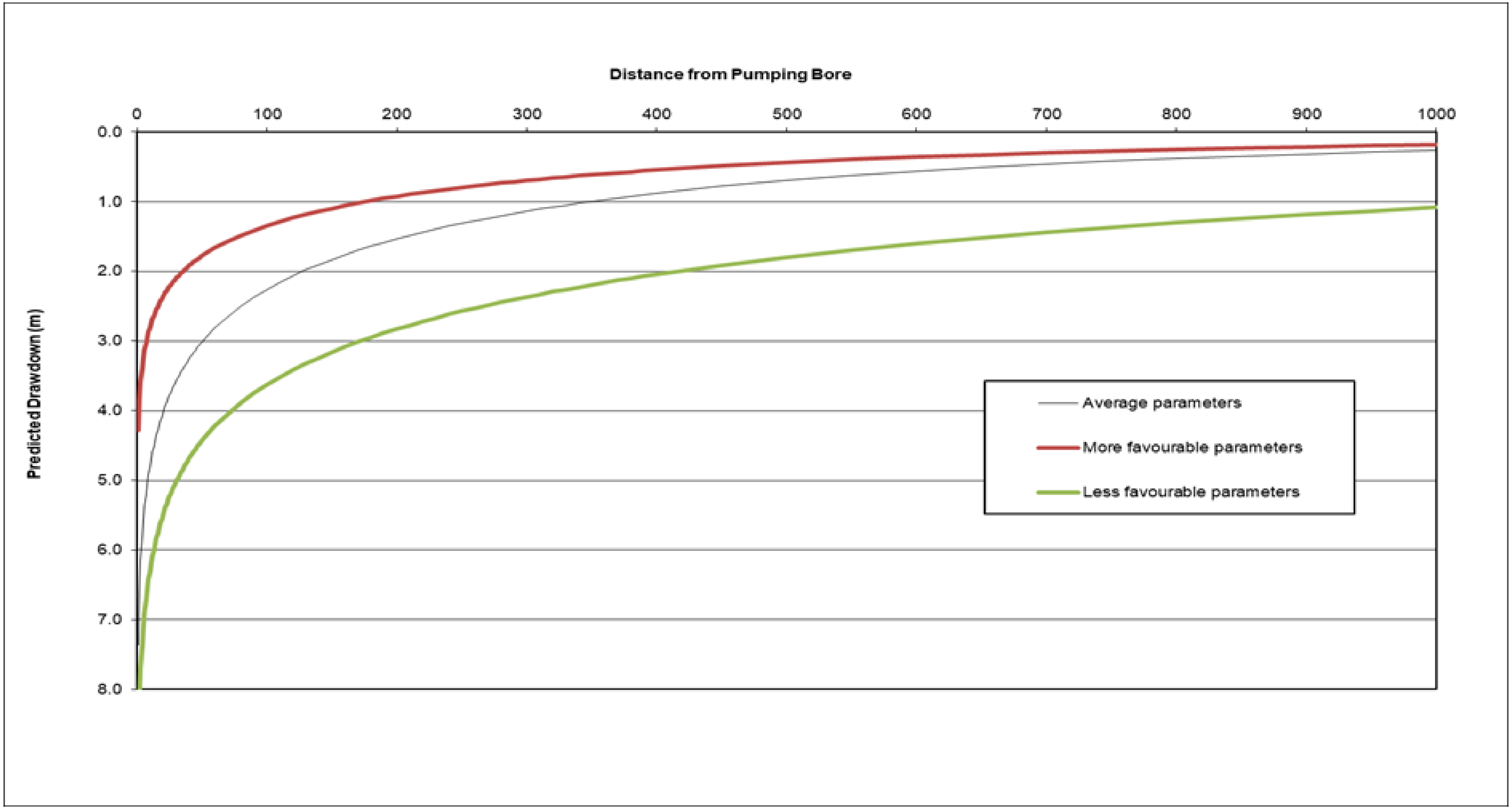
S:\C04518\500\Projects\R002 Projects\C04518500_Z004_neighbouring_bores.qgz

APPENDIX 5 - SPECIFIC CAPACITY VERSUS DEPTH FOR BORES WITHIN 5 KM OF SITE



APPENDIX 5: SPECIFIC CAPACITY VERSUS DEPTH FOR BORES WITHIN 5 KM OF SITE

APPENDIX 6 - DRAWDOWN VERSUS DISTANCE FROM WDC PUMPING BORE ASSESSMENTS



APPENDIX 6: DRAWDOWN VERSUS DISTANCE FROM WDC PUMPING BORE ASSESSMENTS

APPENDIX 7 - VIRTUAL BORE LOCATIONS AND NEIGHBOURING BORE DEPTHS

S:\C04518\500\Projects\R002 Projects\C04518500_Z006_well_interference.qgz

pdp

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METRES

SCALE : 1:40,000 (A4)

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FIGURE

APPENDIX 7: VIRTUAL BORE LOCATIONS AND NEIGHBOURING BORE DEPTHS

PROJECT

PRELIMINARY WATER SUPPLY ASSESSMENT - OHOKA PLAN CHANGE