Before the Hearings Commissioners
at Christchurch

in the matter of: a submission on the proposed Hurunui and Waiau River Regional Plan and Plan Change 3 to the Natural Resources Regional Plan under the Resource Management Act 1991

to: **Environment Canterbury**

submitter: **Meridian Energy Limited**

Statement of evidence of Victor Mkurutsi Mthamo

Dated: 12 October 2012

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STATEMENT OF EVIDENCE OF VICTOR MKURUTSI MTHAMO

INTRODUCTION

1 My full name is Victor Mkurutsi Mthamo.

2 I am a Principal Consultant for the environmental science, engineering and project management consultancy Reeftide Environmental and Projects. Prior to this I was a Senior Associate with the surveying, environmental science and engineering, and resource management consulting firm CPG New Zealand Limited (now rebranded to Spiire Limited), where I was also the South Island Environmental Sciences Manager and Team Leader. I have worked in the area of environmental science and engineering for over 19 years.

3 I have the following qualifications: Bachelor of Agricultural Engineering (Honours) with a major in Soil Science and Water Resources (University of Zimbabwe); Master of Engineering Science in Water Resources (University of Melbourne); Master of Business Administration (University of Zimbabwe). I am a member of the Institute of Professional Engineers NZ (MIPENZ) and am a Chartered Professional Engineer (CPEng) and an International Professional Engineer (IntPE). I am a member of Water New Zealand and I am currently on their National Technical Committee. Until recently I was a member of the National Technical Committee of the New Zealand Land Treatment Collective (NZLTC).

4 I have been involved in the design and implementation of numerous on-farm irrigation schemes in New Zealand from my previous employment with the irrigation firm Water Dynamics. Prior to this I was involved in irrigation scheme development projects and water resource investigations in most southern African countries and parts of Asia. As a Consultant for the Food and Agricultural Organisation (FAO), I have worked on irrigation projects in Papua New Guinea and The Maldives. I was also involved in the preparation of an irrigation design and management manual for FAO. While working as a Senior Consultant for the audit and consulting firm PricewaterhouseCoopers (Harare Office), I was involved in the preparation of feasibility studies for large scale irrigation projects, conceptual and detailed designs, environmental impact assessments, capacity building, cost-benefit analyses and providing sustainable management expertise to the beneficiary communities.

5 Some of the infrastructure development projects and assessment of environmental effects/environmental impact assessments, I have been involved in in New Zealand include Hunter Downs Irrigation Scheme, North Bank Hydro Project, Mararoa-Waiau Rivers Irrigation Feasibility Study, North Canterbury Lower Waiau Irrigation Feasibility Assessment.

6 My roles have included: project management, irrigation engineer, abstractive users' infrastructure assessor, mitigation design expert and hydrological modelling.

SCOPE OF EVIDENCE

7 In my evidence, I have been asked by Meridian Energy Limited (Meridian) to cover two matters:

7.1 What groundwater is associated with the Amuri Plains reach of the Waiau River, how it relates to the river flows and levels; and who and where are the surface and groundwater abstractive users along this reach; and,

7.2 The effects of the changes in river flows as a result of the modelling used to assess the proposed Amuri Hydro Project (AHP) on surface and groundwater levels, and in turn on abstractive users. This allows the full practical extent of implementing the flow and allocation regime in the Proposed Waiau and Hurunui River Regional Plan (the Proposed Plan) to be assessed. This modelling is referred to here as the modelled proposal, which includes existing and future irrigation takes from the "A" and "B" allocation blocks respectively, plus the proposed AHP take which will use "C" block water, and "A" and "B" block water when it is available.

8 I am advised that the proposed plan includes specific provisions to provide for community and stock drinking water supplies and management of the reliability of existing abstractive users.

9 I have structured my evidence into the following headings:

9.1 Summary of Findings;

9.2 Abstractive Users on the Amuri Plains Reach;

9.3 Effects of Flows on Water Levels;

9.4 Effects of the Flow Allocation Regime in the Proposed Plan on Abstractive Users;

9.5 How Effects could be Mitigated; and,

9.6 Conclusions.

10 Although this is a Council hearing, in preparing my evidence I have reviewed the code of conduct for expert witnesses contained in part 5 of the consolidated Environment Court Practice Note 2011. 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. I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

11 I have also reviewed:

11.1 Other publications and these are referenced in various sections of my evidence.

11.2 Relevant evidence of others, including the evidence presented by **Ian Jowett** and **Steven Woods**.

SUMMARY OF FINDINGS

12 Abstractive users within the Amuri Plains Reach of the river comprise irrigation (private and community schemes), domestic, stockwater, industrial and community water users taking water from surface and groundwater sources.

13 There are:

13.1 two community irrigation scheme takes of surface water (for 11,450 L/s),

13.2 16 (3 of which are in-process) surface water takes (for 1,945 L/s),

13.3 36 (5 of which are in-process) groundwater consents (for 2,813 L/s),

13.4 59 (approximately) unconsented domestic takes, and

13.5 two district council takes of riparian groundwater (for 36.8 L/s).

14 The likely changes in surface water levels have been assessed based on the Flow to Head (Q-H) relationships established by **Mr Jowett**. The maximum change in river surface water levels, as a result of the Amuri Hydro Project (AHP) being operated at the maximum rate of take will be:

14.1 0.24 m when the irrigation takes are not operating;

14.2 0.19 m when the existing and future irrigation takes are operating taking their full A and B Block allocations and based on Meridian's preferred flow regime; and,

14.3 0.18 m when the existing and future irrigation takes are operating, taking their full A and B Block allocation and based on "the Proposed Plan" flow regimes i.e. with the 2 m^3/s gap between the A and B Blocks.

15 The neighbouring groundwater level changes (within 50 m of the river) will be less than the surface water levels changes listed above by 0.01 - 0.02 m.

16 The effects of implementing the Flow and Allocation Regime in the Proposed Plan on Abstractive Users has been assessed and the maximum effect is a drop in river water level of 0.18 m. This is comparable to the drop in river water level of 0.19 m under Meridian's preferred flow regime.

17 As the minimum flows under the existing flow management regime are less in some months than the minimum flows in the Proposed Plan I consider that most, if not all, of the abstractive infrastructure is already set up to take water at (for those takes with minimum flows) or below (domestic and stockwater takes) the minimum flows in the Proposed Plan.

18 It is unlikely, therefore, that any further mitigation will be required. There are however possible mitigation options in the unlikely event that the takes are impacted on.

ABSTRACTIVE USERS ON THE AMURI PLAINS REACH

Water Sources

Surface Water

19 The Waiau River is the main water source for abstractive uses along the Amuri Plains reach. There are minimal inflows to the river across the Emu and Amuri plains, with the exception of several minor tributaries which enter the river from the north around Waiau township and springs on the south near Isolated Hill. A general map of the surface water bodies is shown in **Attachment A**.

20 Some of these tributaries drain the hills to the north of Emu Plains and flow into, and via, wet areas north of the river and west of Waiau township. On the Amuri Plains, small streams drain the Lowry Peaks Range and the hills to the west and flow out into the Lowry Peaks Drain. The Lowry Peaks Drain drains all surplus surface water (including irrigation by-wash) and groundwater between Isolated Hill and the Lowry Peaks Range and subsequently flows out into the Waiau River.

21 Many of the natural streams disappear as they enter the Emu and Amuri Plains (lost to groundwater) to remerge again (gaining by groundwater inflow) further downstream near the Waiau River.

22 Springs are found in the vicinity of the St Leonard Mound in the south east of the Amuri Plains. The main occurrence of these springs is along the western side of St Leonard Mound.

Groundwater

23 Limited information exists regarding the structure and properties of the aquifers within the Amuri Basin. This is the mostly gently sloping area between the Amuri reaches of the Waiau and Hurunui Rivers. It is sometimes called the Culverden Basin.

24 Pattle Delamore Partners (PDP, 2010)[1] and Armstrong (2000)[2] both report the presence of at least two aquifers underlying the basin. The upper most of these layers forms an unconfined layer to a depth of 30 – 50 m.

25 The major water-bearing units correspond to the old channels of the river and are typically composed of fresh, coarse, sandy gravels.

26 Armstrong (2000)[2] puts the thickness of these gravels at an average of 150 m. The aquifers occupy sediments mostly formed from glacial outwash deposits and alluvial sands and gravels.

27 In general, the rivers, streams and irrigation water races recharge the aquifers in the west of the basin. All groundwater flowing eastwards is obstructed by bedrock and has to leave the basin via the Waiau or Hurunui rivers.

28 The PDP (2010)[1] review identifies the depth to water table ranging from 5 to 15 m. Groundwater flows roughly from west to east perpendicular to the groundwater level contours and a groundwater divide is present in the middle of the Amuri Plains between Mount Culverden and the middle of St Leonard Mount.

29 Measurements by Jowett (2012)[3] suggest a possible loss of 1-2 m^3/s from the Waiau River along the Amuri Plains reach, but as this is within the margin of gauging area, no loss was assumed. Further downstream the river gains flow from tributaries as well as fresh outcropping groundwater.

30 The areas with higher groundwater and less freely drained soils, occur mainly in the area immediately upstream of Waiau township where the Amuri Plains narrow.

31 Groundwater abstractions for irrigation, industrial, domestic and public water supply are present in both aquifers throughout the Emu and Amuri Plains. Most of these take from the first aquifer.

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[1] *Pattle Delamore Partners Ltd, J. Sanson, 2010, Unpublished Letter titled Depth to Groundwater in the Culverden Basin, prepared for Raymond Ford of Environment Canterbury.*

[2] *Armstrong, M (2000) Geomorphological and geophysical investigation of the effects of active tectonic deformation on the hydrogeology of North Culverden Basin, North Canterbury. A thesis submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy, University of Canterbury, New Zealand.*

[3] *Jowett, I. (2012). Instream habitat in the Waiau River. Jowett Consulting. Prepared for Meridian Energy.*

32 The average annual abstraction rates recorded in ECan's consent and wells databases were reviewed and have been used as the basis for this work. The database provides a variety of information on the well depth, and knowledge of in which aquifer the groundwater abstraction is screened.

Water Uses

Community Irrigation Schemes

33 The Amuri Irrigation Company Limited operates the Amuri Irrigation Scheme (AIS). The AIS is the predominant source of irrigation water on the Amuri Plains, serving approximately 89 properties. The AIS has three abstraction points on the Amuri Plains reach of the Waiau River. The two that are relevant to the modelled proposal are CRC951298 and CRC951305 and are shown in **Attachment A**. The third consent, CRC940459, allows up to 1.05 m^3/s to be abstracted from Lowry Peaks Stream just south of Isolated Hill. As this is outside the area potentially affected by the proposed AHP it is not discussed further here.

34 CRC951298 permits up to 11,000 L/s to be taken from the river at Twin Bridges/Leslie Hills Road (near the intake site for the proposed AHP) to serve a command area of 14,380 ha. CRC951305 permits up to 450 L/s to be taken for the Waireka Downs Irrigation Scheme, whose intake is on the north side of the river just downstream of the township of Waiau. The command area of this scheme is 419 ha.

35 Land uses in the main scheme area include sheep, dairying, beef and small orchards. The scheme was originally set up for border dyke irrigation but over the last few years there has been significant conversion to spray irrigation systems with the area under spray irrigation now estimated at over 70% of the scheme area.

Private Irrigation and Stockwater Takes

36 The Environment Canterbury (ECan) GIS database provides information on users of private surface water and groundwater close to the Amuri Plains reach of the Waiau River. These are summarised in Table 1 below and details of the actual takes are listed in Tables B1 and B2 in **Attachment B**. The location of each take is shown in **Attachment A**.

Table 1 – Summary of the Private Surface and Groundwater Takes along the Amuri Plains (Note – these exclude Community Schemes)

	Surface Water Takes (L/s)	Groundwater Takes (L/s)	Surface Water Takes (No)	Groundwater Takes (No)
NORTH OF WAIAU RIVER				
Total Consented	1,405.50	1,679.90	7	14
Total in the Processing Queue	104	196.5	1	3
SOUTH OF WAIAU RIVER				
Total Consented	181	846.3	5	17
Total in the Processing Queue	254	90	3	2
Totals	**1,944.50**	**2,812.70**	**16**	**36**

37 Seven consents presently exist to take surface water on the north side of the Waiau River along the Amuri Plains reach. These authorise a total take of up to 1,405.5 L/s from either the Waiau River or its tributaries to irrigate 2,226 ha. An application has been lodged to take a further 104 L/s to irrigate a further 159 ha (see Table B1 in **Attachment B**).

38 The main private surface water take for irrigation (David Rutherford) takes approximately 1 m^3/s from the Waiau River upstream of the twin bridges at Leslie Hills and distributes this to the western part of the Emu Plains.

39 Five consents also presently exist to take surface water for irrigation on the south side of the river in the same reach. These authorise a total take of up 181 L/s from either the Waiau River or its tributaries to irrigate 297 ha. Applications have been lodged to take up to another 254 L/s (see Table B1 in **Attachment B**).

40 **Attachment A** also shows groundwater takes within the Amuri Plains reach of the Waiau River likely to be affected by surface abstractions. All these are from shallow groundwater and are likely to be hydraulically connected to the river as estimated from the groundwater model that I will discuss in Paragraph 62 - 73.

41 There are 14 consented groundwater takes on the north bank of the river authorising up to 1,680 L/s to be taken. Further applications have been lodged to take another 196 L/s.

42 On the south bank 17 consented groundwater takes allow up to 846.3 L/s to be taken, with applications having been lodged to take another 90 L/s (see Table B2 in **Attachment B**).

43 It is assumed that irrigation takes do not occur during winter, whereas the other takes, including stockwater takes, occur all year round.

Domestic Takes

44 A review of the ECan database shows that there are approximately 59 domestic takes within the study area on either side of the river. Most are around the township of Rotherham. **Attachment C** shows the general location of most these takes.

45 The takes comprise a combination of relatively deep bores, shallow bores, open bores and galleries. Abstraction from the deep bores is by submersible pumps and the shallower bores and open pits use surface pumps. The bore depths range from 1 – 36 m.

46 Water depths above the pump suctions vary from 0.5 m to 30 m. The takes are typically small, being < 10 L/s.

District Council Water Supply Takes

47 Hurunui District Council (HDC) holds two consents within the Amuri Plains Reach of the river. These are:

47.1 CRC002024, which is located on the northern bank of the Waiau River within the margins of the river, provides water to Waiau township. HDC is consented to take 16 L/s for community and stockwater supply from a bore 10 metres deep.

47.2 CRC093817 is another HDC take located on the south side of the Waiau River the township of Rotherham. It is approximately 350 m from the Waiau River. 20.8 L/s is consented to be taken from two bores which are 9.5 metres deep) and 9.1 metres deep respectively.

48 These takes are all close to the river and will be hydraulically linked to the river – or to put it another way the effects of these takes will be predominantly on surface flows in the Waiau River. The location of these takes is shown in **Attachment A**.

49 These community water supply bores operate all year round.

EFFECTS OF CHANGES TO FLOW ON WATER LEVELS

50 The modelled scenarios undertaken for assessing the effects of the proposed AHP are described in Section 5 of **Mr Woods**' evidence.

51 **Mr Woods** points out in his evidence that the assessments of hydrological effects of operating the AHP are considered to be equivalent to the effects of full practical implementation of the allocation regime in the Proposed Plan for the Amuri Plains Reach.

52 **Mr Woods** also notes that the "modelled proposal" for AHP is based on a maximum generation flow of 50 m^3/s and does not represent the maximum scheme size that could be developed if the scheme was sized to use all the C Block allocation, as well as the A and B blocks when not used for irrigation.

Scenarios Assessed to establish Maximum Water Level Changes

53 I have summarised two scenarios likely to cause the largest change in surface water levels from the modelled scenarios. These are:

53.1 **With Irrigation under Meridian's preferred flow regime**: When the full A and B Block takes (existing plus future – a total of 19.5 m^3/s) are operating compared to the changes in the river stage heights when (i) there is no take by the proposed AHP and (ii) with the proposed AHP take of 50 m^3/s.

(a) Under this scenario, the flow in the Waiau River above the proposed AHP and AIS intakes (which are either going to be at the same point or within close proximity) is 89.5 m^3/s.

(b) In the first instance there is no take by the proposed AHP and 11 m^3/s is diverted into the AIS intake. This leaves 78.5 m^3/s below the AIS intake.

(c) In the second instance, the proposed AHP takes 50 m^3/s and AIS takes 11 m^3/s (from the 89.5 m^3/s) leaving 28.5 m^3/s (20 m^3/s for the minimum flow, 3.5 m^3/s for the A Block and 5 m^3/s for the B Block) flowing below the AIS intake.

(d) Therefore, this scenario compares the changes in water levels arising from the changes in river flows without the proposed AHP of 89.5 m^3/s (before the AIS take) or 78.5 m^3/s (after the AIS take) with the 28.5 m^3/s resulting from the proposed AHP take.

53.2 **Without Irrigation**: The flow below the intakes comprises the minimum flow, along with the HDC water supply takes and some stockwater takes that occur all year round. This scenario occurs in the winter months when the irrigation takes are shut, or during the irrigation season when soil moisture is at full capacity and irrigation is not required at the time. The quanta of these all year round takes are discussed in more detail in Table 4.3 of **Mr Woods**' evidence. This scenario compares the changes in water levels when the river flow changes from 70.3 m^3/s (the all year round abstractive takes plus the minimum flow plus the hydro take) to a flow of 20.3 m^3/s (the all year round abstractive takes plus the

minimum flow) between the proposed AHP intake and its outfall.

54 I have summarised the two scenarios in Table 2 below. In addition, I have also added a fourth column which represents the operation of the proposed AHP under "the Proposed Plan" (i.e. including the 2 m^3/s gap between the A and B blocks).

Table 2: Modelled Scenarios (flows in m^3/s)

Allocation	**Meridian's Preferred Regime - Irrigation Takes Operating[7]**	**Without Irrigation**	**HWRRP Flow Regime - Irrigation Takes Operating[8]**
Minimum Flow (Q_{min})	20	20	20
A Block (Q_A)	14.5	0.3[9]	14.5
The Gap (Q_G)		-	2
B Block (Q_B)	5	-	5
Hydro Take[1] (Q_{AHP})	50	50	50
Flow Above the AHP and AIS Intakes[2] (Q_{total})	89.5	70.3	91.5
Flow Below the AIS Intake If the proposed AHP is not Taking[3]	78.5	70.3	80.5
Flow Above the AIS Intake If the proposed AHP Takes 50 m^3/s[4]	39.5	20.3	41.5
Flow Just Below the AIS Intake After the proposed AHP Takes 50 m^3/s[5,6]	28.5	20.3	30.5

1 - A maximum hydro generation take of 50 m³/s (Q_{AHP}) has been used as discussed in Mr Woods' evidence. The AHP and AIC intakes are within close proximity. The AHP takes 50 m^3/s and the AIC takes 11 m³/s (Q_{AIS} = 11 m^3/s.) leaving 3.5 m³/s and 5 m³/s for the A and B Block takes between the AHP intake and outfall.

2 - $Q_{total} = Q_{MIN} + Q_A + Q_G + Q_B + Q_{AHP}$ (Q_G = 0 for under the Meridian preferred flow regimes)

3 - Q_{total} less Q_{AIS}.

4 - Q_{total} less Q_{AHP}

5 - Q_{total} less Q_{AHP} less Q_{AIS}

6 – AIS take is 11 m^3/s. A and B Block Takes below the AIS but above the hydro outfall are 3.5 m^3/s and 5 m^3/s respectively

7 – Based on Meridian's preferred flow regime and with irrigation takes operating at maximum.

8 – Assumes flow regime in the Proposed Plan and includes the gap between the A and B Blocks.

9 These takes are for stockwater or water supply which will operate all year round

Surface Water Levels (Waiau River)

55 In Table 2, I have outlined three scenarios that may occur during the operation of the proposed AHP. In these scenarios, the flow will change from 89.5, 70.3, and 91.5 m^3/s to 39.5, 20.3 and 41.5 m^3/s above the AIS intake respectively. As the proposed AHP and AIS intake are likely to be within close proximity I have subtracted the 11 m^3/s for the AIS and have therefore assessed changes to levels resulting when flows within the reach change from 78.5, 70.3 and 80.5 m^3/s to 28.5, 20.3 and 30.5 m^3/s respectively.

56 As flow in a river decreases, so does the stage height of the river. **Mr Jowett** demonstrates, in his evidence, how the rate of change in

water level with flow varies with the wetted width (and therefore the number of braids).

57 Jowett (2012)[3] concludes that the average rate of change in water level with flow varies from 0.04 m per 10 m^3/s for flows of 50 - 60 m^3/s, 0.05 m per 10 m^3/s for flows of 30 - 50 m^3/s, and 0.08 m per 10 m^3/s for flows of 20 - 30 m^3/s.

58 Using the stage/height relationships established by **Mr Jowett**, I assessed the changes in water levels as a result of the change in river flows below the proposed AHP and AIS Intakes from 78.5 to 28.5 m^3/s, from 70.3 to 20.3 m^3/s and from 80.5 to 30.5 m^3/s. I have summarised the results in Table 3 below.

Table 3: Changes in Surface Water Levels as a Result of the Operation of the Proposed AHP (flows in m^3/s and depths in m)

Allocation[3]	**Meridian's Preferred Regime - Irrigation Takes Operating[1]**	**Irrigation Takes <u>NOT</u> Operating**	**HWRRP Flow Regime - Irrigation Takes Operating[2]**
Flow Upstream of the Hydro and AIS Intakes	89.5	70.3	91.5
Flow Below the AIS Intake If the proposed AHP is not Taking	78.5	70.3	80.5
Flow Above the AIS Intake If the proposed AHP Takes 50 m^3/s	39.5	20.3	41.5
Flow Just Below the AIS Intake After the proposed AHP Takes 50 m^3/s	28.5	20.3	30.5
Maximum Drop in River Levels as a result of the proposed AHP take	0.19	0.24	0.18

1 – Based on Meridian's preferred flow regime and with irrigation takes operating at maximum.
2 – Assumes flow regime in the Proposed Plan and includes the 2 m^3/s gap between the A and B Blocks.
3 – Please refer to Table 2 for more details on the scenarios.

59 From Table 3, maximum drop in surface water level as a result of AHP and irrigation abstractions will range from 0.18 – 0.24 m depending on the scenario. This is primarily because with irrigation operating fully, the flow range in which the 50 m^3/s hydro take is operating is almost 20 m^3/s higher, and water levels change less with flow as the flow gets higher. This is also shown in Figure 7 of **Mr Jowett**'s evidence which shows that at the high flows (e.g. above approximately 40 m^3/s), the Q-H curve has a shallower slope than at lower flows.

60 The "no irrigation" scenario generates the largest water level change with flow (0.24 m) primarily because when the AHP takes 50 m^3/s

from a starting flow of 70.3 m^3/s the flow just below the intakes is the lowest river flow of the scenarios assessed at 20.3 m^3/s.

61 It should also be noted that the predicted changes in water levels with changes in flow are conservative. For example:

61.1 It has been assumed that abstractive flows will be taken at the full consented rates. Mr Woods' evidence discusses in more detail the irrigation demand profiles over a 12 month period. The maximum demand ranges from approximately 2% (in winter) - 85% (at peak) of the consented rates.

61.2 The model also assumes the proposed AHP take occurs constantly at the full 50 m^3/s abstraction and that flows are held at those given in Row 5 of Table 3 continuously, with no times of lesser take and no additional flow in the river.

Groundwater Levels

62 Shallow groundwater near the Amuri Plains reach of the Waiau River is very likely to be hydraulically connected to the Waiau River, which means the river will supply some of the recharge into this shallow groundwater. When the river water level is lowered, groundwater level may also drop close to the river. This drop diminishes further away from the river.

63 To understand the changes in groundwater levels as a result of the proposed AHP take, I worked with Spiire Limited to model the groundwater levels resulting from the changes in surface water levels presented in Table 3 above.

64 This was achieved by using a three dimensional numerical groundwater model constructed using MODFLOW (PMWIN5.3); widely used and widely accepted groundwater modelling software package.

65 The MODFLOW outputs provided an understanding of the rate and direction of movement of groundwater through the subsurface lithology and interactions with surface water.

66 The model was validated using measured groundwater levels in bores undertaken by ECan in April 2011 and data from a network of 18 monitoring bores that were installed between December 2011 and February 2012 along the Amuri Plains reach of the Waiau River.

67 I have appended more details on the modelling inputs and parameters in **Attachment D**.

68 I have summarised the results from the model in Table 4 below which is an expansion of Table 3. The last row in Table 4 shows the resulting maximum drop in groundwater levels in the immediate

proximity (within 50 m) of the Waiau River. This decreases further with distance from the river.

Table 4: Changes in Surface Water and Groundwater Levels as a Result of the Operation of the Proposed AHP and Full Irrigation (flows in m^3/s and depths in m)

Allocation	**Meridian's Preferred Regime - Irrigation Takes Operating** [1]	**Irrigation Takes <u>NOT</u> Operating**	**HWRRP Flow Regime - Irrigation Takes Operating** [2]
Flow Upstream of the Hydro Intake	89.5	70.3	91.5
Flow Below the AIS Intake If the proposed AHP is not Taking[3]	78.5	70.3	80.5
Flow Just Below the AIS Intake After the proposed AHP Takes 50 m^3/s[4]	28.5	20.3	30.5
Maximum Drop in River Levels As a Result of the Flow Changes (3 minus 4 above)	0.19	0.24	0.18
Maximum Drop in Groundwater Level within 50 m of the River	0.18	0.22	0.16

1 – Based on Meridian's proposed flow regime and with irrigation takes operating at maximum.
2 – Assumes flow regime in the Preferred Plan and includes the 2 m^3/s gap between the A and B Blocks.

69 In **Attachment E** I show the groundwater level contours as a result of change in the river flow from 70.3 to 20.3 m^3/s (Column 3 in Table 4).

70 I have plotted the contours down to the 0.1 m as I consider that a drop of less than 0.1 m is likely to have negligible effects on abstractive users. For example, in the Canterbury Natural Resources Regional Plan (NRRP) and the proposed Land and Water Regional Plan (Schedule 12) pumping from proposed groundwater takes that cause groundwater level changes of ≤ 0.1 m are considered to have *de minimus* effect on existing neighbouring takes and no assessment of effects on them is required.

71 In general:

71.1 Groundwater levels in the areas around the intake to the west and extending from the river north to the foothills at the western edge of the Emu Plains may fall by up to 0.22 m. A 0.22 m drop is also likely to be the maximum effect on the all year round abstractors such as the HDC and stockwater takes;

71.2 On the north bank, the effect is 0.10 – 0.22 m for most of the takes within the reach and reduces to less than 0.05 m near the foothills; and,

71.3 Further downstream of the intake (below Rotherham), on the south bank, the effects quickly reduce to 0.10 m within 300 – 500 m from the river.

71.4 The maximum effect likely on groundwater change is 0.18 m under Meridian's preferred flow regime and this includes the effects of the AIS take. This occurs when all abstractive users are taking (Column 3 in Tables 3 and 4).

71.5 Under the flow and allocation regime in the Proposed Plan, the maximum groundwater change will be 0.16 m, including the effects of the AIS take. This is when all abstractive users are taking water (Column 4 in Tables 3 and 4).

71.6 The differences in water level changes between Meridian's preferred flow regimes and the Proposed Plan flow regime is less than 0.01 m (0.19 m - 0.18 m from the second to last row in Table 4). This is not surprising given that the only difference is the 2 m^3/s "gap" between the "A" and "B" blocks in the Proposed Plan.

72 Flows and levels in the Waiau River are always changing, often quickly, and additional recharge through rainfall and seepage will cause these maximum possible groundwater reductions to reduce quickly or to be masked over time.

73 In reality, the drawdown of groundwater levels associated with the stage drops will be very slow and will progress to their full extent in days or months, assuming that the table flow regime remain constant.

EFFECTS OF FLOW AND ALLOCATION REGIME IN THE PROPOSED PLAN ON ABSTRACTIVE USERS

Effects on Surface Water Takes, Groundwater Takes, Unconsented Domestic and Stockwater Takes

74 I have discussed the maximum water level changes that will occur under the different flow regimes in Paragraph 71.

75 The changes in water levels associated with or effects on each take are detailed in **Attachment F**.

76 In theory, the potential effects of these flow regimes on abstractive users are:

76.1 Loss of head and insufficient water towards the surface water takes; and,

76.2 Insufficient water over the groundwater pumps or the suction points.

77 However, in reality, I expect the actual effects to be negligible as:

77.1 The magnitude of the estimated changes in water levels are small as the majority of the takes that I visited in February – April 2012 had at least 2 m of water above the pumps during pumping;

77.2 The Proposed Plan changes to the minimum flows is within the range of flows already experienced in the Waiau River, so it is expected that all existing abstractive infrastructure will be already set up to take water at (for those takes with minimum flows) or below (domestic and stockwater takes) the minimum flows proposed in HWRRP. They should therefore be able to operate even when the predicted maximum drops in water levels are experienced;

77.3 Further to this, as I explained in Paragraphs 59-61 and 72 - 73, the actual effects are likely to be less than calculated changes.

78 However, as **Mr Woods** explains in Section 6 of his evidence the operation of the proposed AHP will increase the length of time the river flows will be close to or at the minimum flow. This has the potential to lag into lower groundwater levels. Again, in reality, I do not expect these lags to be a common occurrence for the reasons given in Paragraphs 72 and 73 above.

Community Irrigation Schemes

79 The AIS is unlikely to be impacted by the changes in river levels under the different flow regimes I have discussed. The AIS intake is already designed to operate at or below the minimum flow in the proposed plan of 20 m^3/s. This is because the current minimum flow in the river is 15 m^3/s in February and March.

District Council Takes

80 The two HDC takes are close to the Waiau River and will, therefore, likely experience a maximum water level drop of up to 0.22 m when the proposed AHP is taking 50 m^3/s.

81 Given the likely depth of the wells and the water levels above the pumps, such a water level drop is unlikely to cause insufficient water over the pumps and will be within the range of water levels currently experienced.

HOW EFFECTS COULD BE MITIGATED, IF DEEMED NECESSARY

Effects on Surface Water Takes, Groundwater Takes, Unconsented Domestic and Stockwater Takes

82 As already stated I do not expect the abstractive infrastructure to be adversely affected by the proposed AHP.

83 In the unlikely event that the change in groundwater level adversely impacts the operation of the groundwater takes, possible mitigation measures include:

83.1 Lowering the pumps or suction pipes where the depth of the bore allows for this to be done and abstraction to occur unhindered;

83.2 Deepening the bores;

83.3 Installation of new pumps where the existing pumps will not be able to work either because of the increased pumping depth;

83.4 Upgrade of the existing pump electrics and/or transformer as necessary; and,

83.5 A combination of any or all of the above.

Community Irrigation Schemes

84 The intake of the proposed AHP could be designed and located so that there are no direct interference effects on the AIS. If any interference did occur, consideration of the detailed design, operation and monitoring could be undertaken.

District Council Takes

85 No mitigation or monitoring is generally necessary as I expect these takes to operate well under the flow regime in the Proposed Plan.

86 In the unlikely event that groundwater lag occurs causing a reduction in groundwater levels, the mitigation measures I have outlined in Paragraph 83 are relevant.

CONCLUSIONS

87 There is no significant difference on impact on abstractive users between Meridian's preferred flow regime and the flow regime in the Proposed Plan when abstractive users are taking water.

88 The surface water takes along the river are likely to experience a drop in water level of up to 0.19 m when the proposed AHP takes 50 m^3/s and abstractive users are operating.

89 A band of shallow groundwater close to the Waiau River running between the proposed intake and outfall of the hydro scheme could fall by up to 0.22 m under the worst case scenario i.e. the proposed AHP takes 50 m^3/s with 0.3 m^3/s being taken all year round and the irrigation users are not taking water. Surface water levels along the Amuri Plains reach are likely to drop by approximately 0.24 m under these conditions.

90 Some of the existing river intake points between the canal intake and outfall will be affected by a drop in water level for longer periods than currently experienced.

91 As the minimum flow will increase from 15 to 20 m^3/s in the key months of February and March, it is likely that existing abstractive users will still be able to operate. This is because existing infrastructure is already likely to be set up to abstract down to the existing minimum flow.

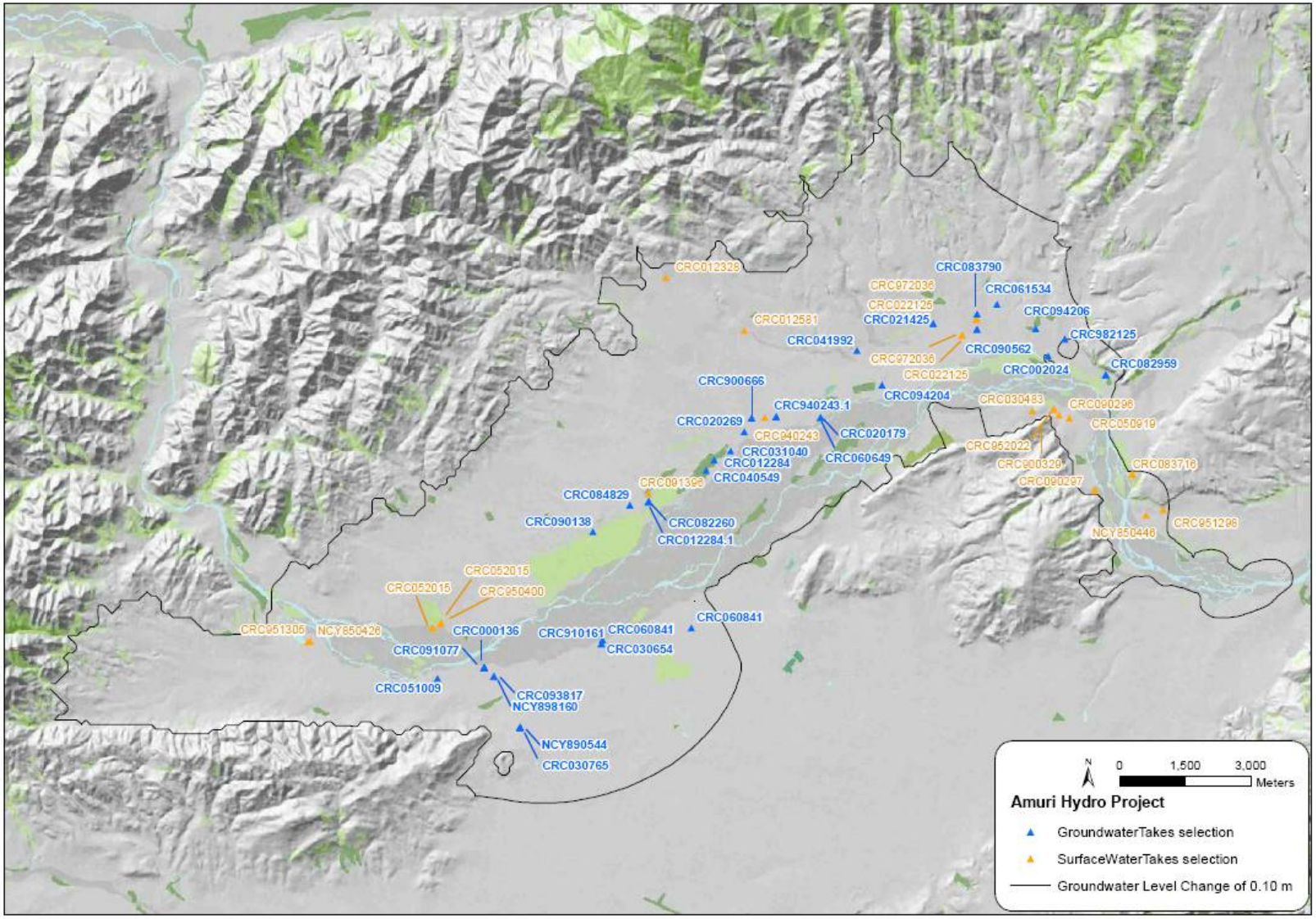
92 Should it be necessary, it is practical to implement mitigation measures to maintain ensures that the infrastructure continues to operate.

93 Overall, I am confident that the taking of water, by these takes, like the modelled proposal could occur while implementing the provisions in the proposed plan relating to community and stockwater drinking supplies and existing abstractive users.

Dated: 12 October 2012

Victor Mthamo

ATTACHMENT A – LOCATION OF SURFACE AND GROUNDWATER TAKES



ATTACHMENT B – DETAILS OF ABSTRACTIVE USERS

Table B1: Private Surface Water Takes

Consent No	Consent Holder	Peak Flow Rate (L/s)	Source Name	Use/Irrigation Method	Area (ha)
TOTAL SURFACE WATER TAKES		**1,944.5**			**2.718**
NORTH OF WAIAU RIVER					
CRC052015.1	Lancewood Trust	232.5	Waiau River	K-line	465
CRC950400.2	LH Dairy Limited	400	Waiau River	Border-dyke	650
CRC951490.1	Mr J C Rutherford	360	Waiau River	Spray (rotorainer)	500
CRC091396*	Mr J S Rutherford	104	Waiau River		159
CRC083716.1	Hauwai Farms Limited	57	Waiau River	Spray Irrigation	116
CRC940243.3	G & G Coats Limited	126		Spray Irrigation	243
CRC972036.2	Wansden Farms Limited	115	Home Stream or 3 Waterholes	Border Dyke	50
CRC022125.3	Mr M R & Mrs A J Gardner	115	Home Stream or 3 waterholes	Spray (Pivot)	202
Total Consented		**1,405.5**			**2,226**
Total in the Processing Queue		**104**			**159**
TOTAL CONSENTED AND QUEUED - NORTH		**1,509.5**			**2,385**
SOUTH OF WAIAU RIVER					
CRC020873.1	Mr S L & Mrs R L Anderson	20	Rotherham Stream	Spray	70
CRC012306	Mr S L Anderson	78	Un-named Tributary	Lateral sprinkler	100
CRC030483	Mr C M Shearer	30	Un-named Tributary	Spray Irrigation	50
CRC050919	Mr T Devine	23	Unnamed tributary of the Waiau River	Travelling gun	37
CRC090296*	Mr A W & Mrs G J Black	89	Waiau River		0
CRC090297*	Mr A W & Mrs G J Black	5	Waiau River		18
CRC090297*	Mr A W & Mrs G J Black	160	Waiau River		18
CRC952022	Messrs A T & A W Black	30	Cones Creek	Gun	40
Total Consented		**181**			**297**
Total in the Processing Queue		**254**			**36**
TOTAL CONSENTED AND QUEUED – SOUTH		**435**			**333**

*The following applications for consents were in the processing queue at the time this report was issued: *CRC090296, CRC090297, CRC091396*

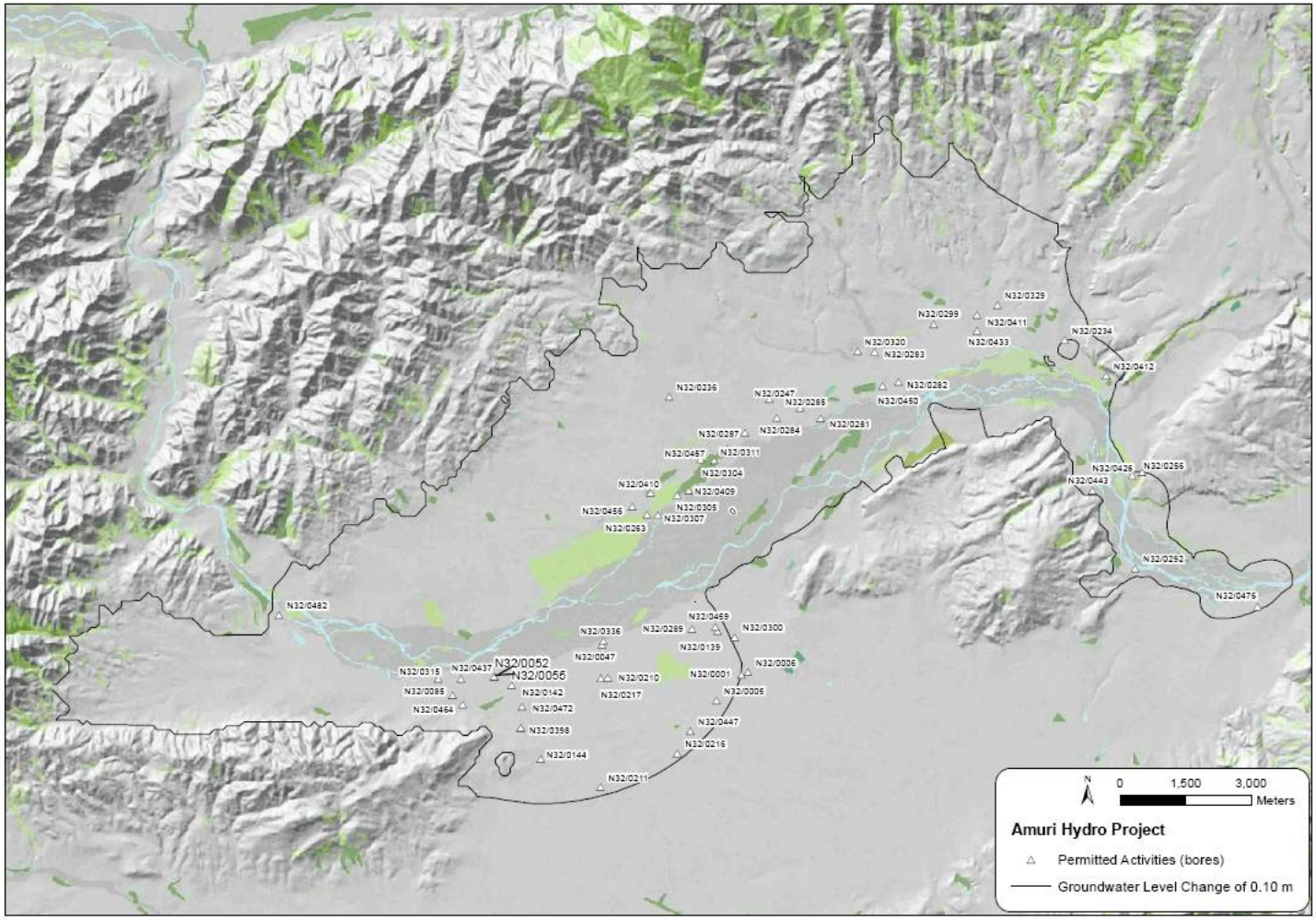
Table B2: Private Groundwater Takes

Consent No	Consent Holder	Peak Flow Rate (L/s)	Use/Irrigation Method	Area (ha)
TOTALGROUNDWATER TAKES		**2,812.7**		**4,979**

Consent No	Consent Holder	Peak Flow Rate (L/s)	Use/Irrigation Method	Area (ha)
NORTH OF WAIAU RIVER				
CRC020269	G & G Coats Limited	104	Spray (Pivot)	180
CRC021425.1	Wansden Farms Limited	62	Spray (Pivot)	115
CRC031040	Mr R A Florance	126	Spray (rotorainer)	280
CRC041992	Mr & Mr S E & D S M McLean	70	Spray (Pivot)	126
CRC060649	Mr & Mrs D D & D M Galletly	220	Spray (rotorainer)	400
CRC061534	Mr A J Galletly	60	Spray Irrigation	100
CRC082260.2	Mr J S Rutherford	241.9	Irrigation	570
CRC082959.1	The Bluffs Limited	140	Spray (Pivot)	243
CRC083790	Mr M R Gardner	5	Stockwater	0
CRC084829	Mr A I Gardner	232	Spray (Pivot)	402
CRC090138*	Mr J S Rutherford	126.5		219
CRC090562*	Mr M R & Mrs A J Gardner	5	Stockwater	0
CRC090562	Mr M R & Mrs A J Gardner	175	Irrigation	305
CRC094204	Mr & Mrs D D & D M Galletly	10	Stockwater	0
CRC094206*	Mr & Mrs D D & D M Galletly	65	Intensive Farming	111
CRC940243.3	G & G Coats Limited	174	Spray (Pivot)	260
CRC982125	Hillview Enterprises Limited	60	Spray Irrigation	120
Total Consented		**1,679.9**		**3,101**
Total in the Processing Queue		**196.5**		**330**
TOTAL CONSENTED AND QUEUED - NORTH		**1,876.4**		**3,431**
SOUTH OF WAIAU RIVER				
CRC000136.4	Mr G A Derrick	30	Lateral sprinklers	50
CRC012627	Haumuri Farm Limited	80	Spray (Pivot)	120
CRC012653.4	Reklaw Farms Limited	50		187
CRC012670	Mr S L Anderson	46	Spray (Pivot)	80
CRC020690.1	Bermar Holdings Limited	117	Spray (Pivot)	200
CRC021027	Mr G D S Grigg	96	Side roll	150
CRC070904	Cranford Downs Limited	21	Spray (Pivot)	35
CRC030654	Mr & Mrs T M & J E Roberts	26	K-line	42
CRC040701.1	Mr S L & Mrs R L Anderson	20		22
CRC042448.2	The New Zealand King Salmon Co Limited	50		0
CRC050573.2	The New Zealand King Salmon Co Limited	72		0
CRC051009	G M Williams Family Trust	28	Spray Irrigation	47
CRC060841	Mr & Mrs T M & J E Roberts	25	Spray (Pivot)	54
CRC060841	Mr & Mrs T M & J E Roberts	19	Spray (Pivot)	34
CRC072517	Mr P B & Mrs E J Chick	116		237
CRC091077*	Mr G A Derrick	30		50
CRC092643*	Reklaw Farms Limited	60		185
CRC900474.2	Waiau Salmon Limited	22.5		0
CRC970394.1	Bermar Holdings Limited	27.8	Travelling gun	55
Total Consented		**846.3**		**1,313**
Total in the Processing Queue		**90**		**235**
TOTAL CONSENTED AND QUEUED - SOUTH		**936.3**		**1,548**

*The following applications for consents were in the processing queue at the time this report was issued: *CRC090562, CRC094206, CRC090138, CRC91077, CRC92643*

ATTACHMENT C – MAP SHOWING THE UNCONSENTED DOMESTIC WATER TAKES



ATTACHMENT D – SUMMARY OF GROUNDWATER MODEL INPUTS AND ASSUMPTIONS

Modelling Methodology
The assessment work involved modelling the groundwater levels and this involved the following processes:

- Deciding on the numerical model to use to understand the groundwater flow processes and the interaction with surface water.
- Defining the scenarios to be modelled.
- Collecting all the necessary input data.
- Constructing a groundwater model to provide an understanding of the likely impact on groundwater levels in those areas which may be affected.
- Making assumptions and defining the limitations of the groundwater model.
- Collecting data from a groundwater monitoring network around the affected reach of the Waiau River and using the data to calibrate the model.
- Reporting the results from the model and finally using these to provide an understanding of the impact on abstractive users.

A three dimensional numerical groundwater model constructed using MODFLOW (PMWIN5.3); widely used and widely accepted groundwater modelling software package.

Model Inputs
River Stage and Flow Relationship
Key to the modelling work is understanding the flow/river stage height along the reach between the proposed intake and outlet of the proposed hydro scheme.

Q-H relationships by Duncan and Bind (2009)[4] and the work by Jowett (2012)[5] were considered For the Q-H relationships within the braided river, I adopted the more current and updated, results from Jowett (2012) and presented in **Mr Jowett's** evidence.

Other Model Inputs and Aquifer Parameters
The overall groundwater recharge of the Emu and Amuri Plains under spray irrigated land is typically around 280 mm/year. Groundwater recharge through irrigation is assumed to be declining considerably with the change from border dyke and therefore an average recharge rate was adopted.

The Waiau River is represented in the model as rectangular channel. The river is represented as a continuous body i.e. multiple braids are not included.

The river bed conductance is an important input to the model. Discharge from the river and from streams to groundwater right underneath the river or stream bed, is likely to be vertical and the vertical conductivity or conductance therefore governs the flux from surface water to groundwater.

The water depths in the river cells were estimated from both ECan (2011) and Jowett (2012). The streambed conductance was estimated at 200,000 m^2/day.

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[4] Duncan and Bind (2009). "Waiau River Instream Habitat Based on 2-D hydrodynamic Modelling". NIWA. Prepared for Environment Canterbury.

[5] Jowett, I. (2012). Instream habitat in the Waiau River. Jowett Consulting. Prepared for Meridian Energy.

A two layer aquifer system has been adopted based on PDP (2010)[6] and Armstrong (2000)[7]. The first layer is a surface unconfined aquifer the ground level (at 0 m) to an average of 40 m. This top aquifer is consists of the Burnham Formation and post-glacial deposits.

The actual depth of the top of the Kowai gravels has been derived from a selection of bore logs on the Amuri and Emu Plains. The bottom of the second aquifer (Kowai Gravels) has been set at a depth of 150 m below the bottom of the first aquifer.

The transmissivity of an aquifer equals the product of the (saturated) thickness (D) and the horizontal hydraulic conductivity (K_h). The aquifer depths I have described above were multiplied with the following hydraulic conductivity estimates estimated from the ECan database and from Aqualinc (2011)[8] who reported the results of step testing programme around Culverden:

- Layer 1 (Post-glacial gravels) - horizontal hydraulic conductivity (K_h) and vertical hydraulic conductivity (k_v) values adopted are 203 m/day and 0.06 m/day respectively
- Layer 1 (Burham gravels) - the K_h and k_v values adopted are 50 m/day and 0.06 m/day respectively
- Layer 2 (bottom of Quaternary gravels) - a single K_h and k_v value of 10 m/day was adopted.

The reason for introducing a vertical conductivity which is substantially smaller than the horizontal conductivity is the apparent presence of discriminating strata between the first uppermost aquifer and the aquifer below this (Armstrong, 2000).

It is assumed that irrigation groundwater takes do not occur during winter, whereas the other takes occur all year round.
Leakage from the Amuri Irrigation Scheme is assumed to contribute to the recharge of the aquifers and to buffer the effects that fluctuations in river flows have on groundwater levels around the Waiau River.

Model Calibration
Groundwater monitoring sites were established to collect data for calibrating the model and from ECan's groundwater network around the Culverden Basin.

The groundwater levels collected from most piezometers showed good correlation with the model estimates.

A sensitivity analysis was also carried out to determine the impact of other input parameters such as the horizontal hydraulic conductivity, transmissivity and river bed conductance. This showed that by and large the assumptions adopted were appropriate.

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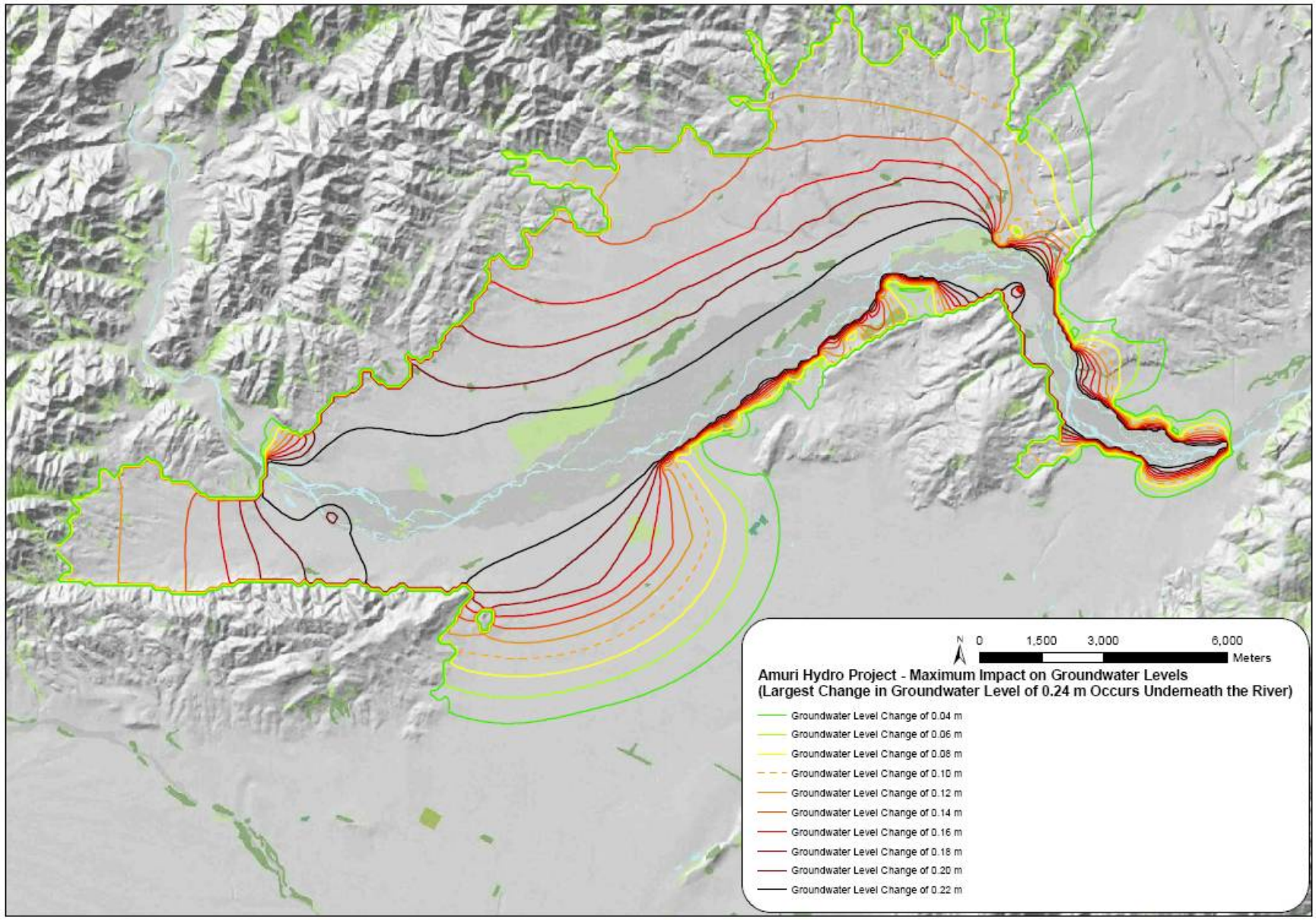
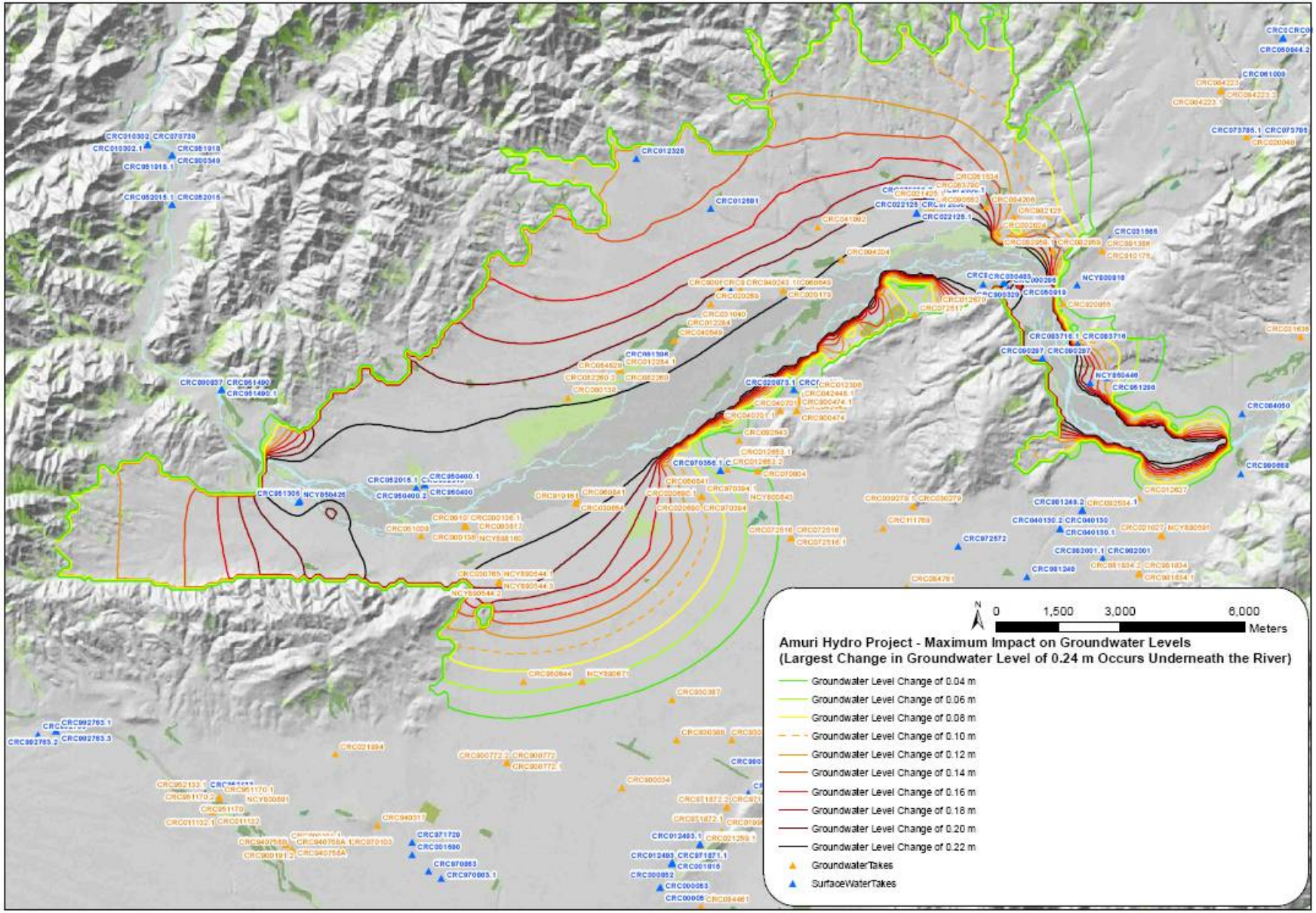
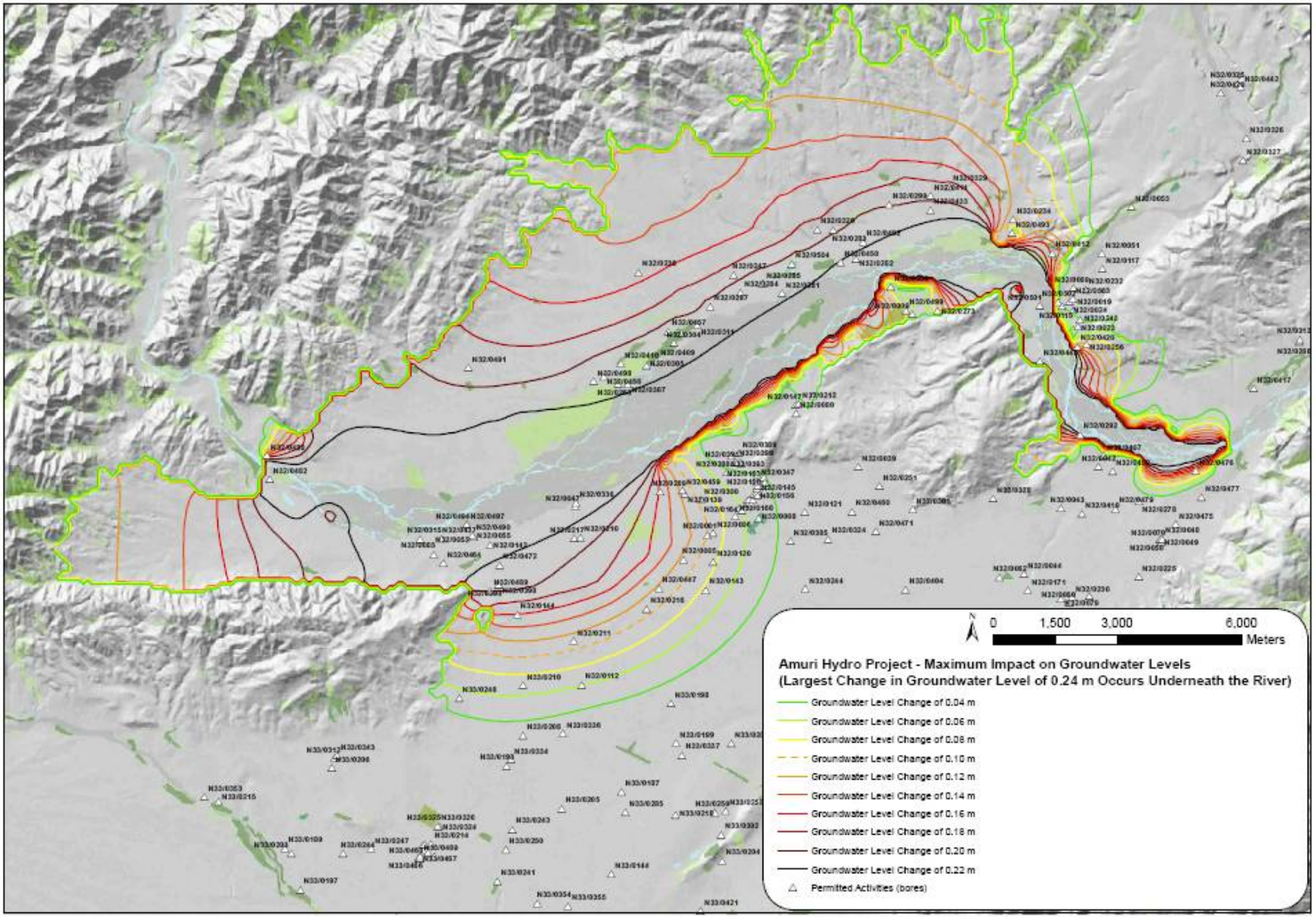
[6] *Pattle Delamore Partners Ltd, J. Sanson, 2010, Unpublished Letter titled Depth to Groundwater in the Culverden Basin, prepared for Raymond Ford of Environment Canterbury.*
[7] *Armstrong, M (2000) Geomorphological and geophysical investigation of the effects of active tectonic deformation on the hydrogeology of North Culverden Basin, North Canterbury. A thesis submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy, University of Canterbury, New Zealand.*
[8] *Aqualinc Research Limited, H. Rutter, 2011, Unpiblished Letter to David Poulsen of Environment Canterbury.*

ATTACHMENT E – GROUNDWATER LEVEL CHANGES FOR THE HYDRO ABSTRACTION IS 50 m^3/s




N
0
1,500
3,000
6,000
Meters
Amuri Hydro Project - Maximum Impact on Groundwater Levels
(Largest Change in Groundwater Level of 0.24 m Occurs Underneath the River)
Groundwater Level Change of 0.04 m
Groundwater Level Change of 0.06 m
Groundwater Level Change of 0.08 m
Groundwater Level Change of 0.10 m
Groundwater Level Change of 0.12 m
Groundwater Level Change of 0.14 m
Groundwater Level Change of 0.16 m
Groundwater Level Change of 0.18 m
Groundwater Level Change of 0.20 m
Groundwater Level Change of 0.22 m
GroundwaterTakes
SurfaceWaterTakes


0 1,500 3,000 6,000
Meters
Amuri Hydro Project - Maximum Impact on Groundwater Levels
(Largest Change in Groundwater Level of 0.24 m Occurs Underneath the River)
Groundwater Level Change of 0.04 m
Groundwater Level Change of 0.06 m
Groundwater Level Change of 0.08 m
Groundwater Level Change of 0.10 m
Groundwater Level Change of 0.12 m
Groundwater Level Change of 0.14 m
Groundwater Level Change of 0.16 m
Groundwater Level Change of 0.18 m
Groundwater Level Change of 0.20 m
Groundwater Level Change of 0.22 m
Permitted Activities (bores)

ATTACHMENT F – EFFECTS ON ABSTRACTIVE USERS

Table F1: Effects on Surface Water Takes

Consent No	Consent Holder	Predicted Effect
CRC052015.1	Lancewood Trust	Up to 0.19 m drop. No effect.
CRC950400.2	LH Dairy Limited	Up to 0.19 m drop. No effect.
CRC951490.1	Mr J C Rutherford	Above the proposed hydro intake. No effects.
CRC091396	Mr J S Rutherford	None – consent still in the processing queue
CRC083716.1	Hauwai Farms Limited	Up to 0.19 m drop.
CRC940243.3	G & G Coats Limited	Up to 0.18 m drop.
CRC972036.2	Wansden Farms Limited	At 900 m from the Waiau River - no effect.
CRC022125.3	Mr M R & Mrs A J Gardner	No effects at given the distance from the river.
CRC012328	Birch Topping Limited	Recharge from Blind Stream + distance from the Waiau River. Thus o effects are anticipated
CRC012581	Mr & Mrs PR & SL Harris	Recharge from Blind Stream + distance from the Waiau River. Thus o effects are anticipated
CRC020873.1	Mr S L & Mrs R L Anderson	Up to 0.19 m drop. No effect.
CRC012306	Mr S L Anderson	Up to 0.19 m drop. No effect
CRC030483	Mr C M Shearer	The take is on a tributary of the Waiau River which is supplied from springs further up catchment. No effects anticipated
CRC050919	Mr T Devine	Up to 0.19 m drop. No effect
CRC090296	Mr A W & Mrs G J Black	None – consent in the processing queue
CRC090297	Mr A W & Mrs G J Black	
CRC090297	Mr A W & Mrs G J Black	
CRC952022	Messrs A T & A W Black	No effects anticipated

The following consents were in the processing queue at the time this report was issued: CRC090296, CRC090297, CRC091396

Table F2: Groundwater Takes Effects

Consent No	Consent Holder	Predicted Effects
NORTH OF WAIAU RIVER		
CRC020269	G & G Coats Limited	No effects
CRC021425.1	Wansden Farms Limited	The bore is at least 1,100 m. Drop < than 0.1 m. No effect.
CRC031040	Mr R A Florance	At less than 100 m from the river. Drop ≤ 0.19 m
CRC041992	Mr & Mr S E & D S M McLean	1,300 m from the river. Drop < than 0.1 m. No effect.
CRC060649	Mr & Mrs D D & D M Galletly	The bores are less than 50 m from the river. Drop ≤ 0.19 m No effects
CRC061534	Mr A J Galletly	At 1,100 m from the river. Drop ≤ 0.10 m. No effect.
CRC082260.2	Mr J S Rutherford	The take is 500 m from the river. Drop ≤ 0.11 m
CRC082959.1	The Bluffs Limited	The take is 400 m from the river. Drop ≤ 0.12 m
CRC083790	Mr M R Gardner	Drop ≤ 0.19 m
CRC084829	Mr A I Gardner	The take is 600 m from the river. Drop ≤ 0.11 m
CRC090138	Mr J S Rutherford	Still in-process.
CRC090562	Mr M R & Mrs A J Gardner	Still in-process.
CRC094204	Mr & Mrs D D & D M Galletly	The take is 500 m from the river. Drop ≤ 0.11 m
CRC094206	Mr & Mrs D D & D M Galletly	Still in-process.
CRC940243.3	G & G Coats Limited	The take is 400 m from the river. Drop ≤ 0.11 m
CRC982125	Hillview Enterprises Limited	The take is 650 m from the river. Drop ≤ 0.10 m

Consent No	Consent Holder	Predicted Effects
SOUTH OF WAIAU RIVER		
CRC000136.4	Mr G A Derrick	Bore is close to the river. Drop ≤ 0.19 m
CRC012627	Haumuri Farm Limited	The take is 950 m from the river. Drop ≤ 0.10 m
CRC012653.4 and CRC092643	Reklaw Farms Limited	At 1,250 m or 650 m from the Waiau River is expected to be less than 0.1 m.
CRC012670	Mr S L Anderson	The effect on groundwater 650 m from the Waiau River is expected to be less than 0.1 m.
CRC020690.1 and CRC970394.1	Bermar Holdings Limited	The effect on groundwater 1,300 m and 500 m, respectively, from the Waiau River. Drop ≤ 0.10 m
CRC021027	Mr G D S Grigg	Close to the river. Drop ≤ 0.18 m
CRC070904	Cranford Downs Limited	Close to the river. Drop ≤ 0.18 m
CRC030654 and CRC060841	Mr & Mrs T M & J E Roberts	At 300 m from the river. Drop ≤ 0.13 m
CRC040701.1	Mr S L & Mrs R L Anderson	Drop ≤ 0.19 m. No effects.
CRC042448.2 and CRC050573.2	The New Zealand King Salmon Co Limited	At 600 m from the river. Drop ≤ 0.18 m.
CRC051009	G M Williams Family Trust	At 300 m from the river. Drop ≤ 0.12 m
CRC072517	Mr P B & Mrs E J Chick	At 800 m from the river. Drop ≤ 0.10 m
CRC091077	Mr G A Derrick	Still in-process. No effects
CRC900474.2	Waiau Salmon Limited	The take is 500 m from the river. Drop ≤ 0.11 m