IN THE MATTER OF	The Environment Canterbury (Temporary Commissioners and Improved Water Management) Act 2010 and the Resource Management Act 1991.
AND	
IN THE MATTER OF	The hearing of submissions on the Proposed Canterbury Land and Water Regional Plan.

STATEMENT OF EVIDENCE OF BRUCE McCABE

Dated: 4 February 2013

1. INTRODUCTION

1.1. My full name is Bruce McCabe. I am an Environmental Scientist and hold the degrees of MSc (Hons) and PhD (Chemistry) from the University of Waikato. I am currently employed by Babbage Consultants Limited as Environmental Services Manager. My previous employment includes 25 years as an independent environmental consultant, 3 years involved in fertiliser research and development with Ballance Agri-nutrients, and as Principal Scientist, MWH New Zealand Ltd.

1.2. I have 35 years' experience as an environmental scientist and environmental manager involved in assessing and managing the effects of activities on soil, groundwater and surface water quality. This experience has been gained during my PhD research into lake eutrophication and during project involvement in a wide range of industries, including mining, municipal landfilling, municipal

potable water supply, municipal and industrial wastewater management, industrial processing, dairy farming and dairy milk processing.

1.3. I have during my work for both industrial and local authority clients reviewed numerous District and Regional plans and have provided expert advice on science-based aspects of these plans, including the analysis of and presentation of submissions on proposed Regional Policy Statements and Proposed Regional Plans.

1.4. Notwithstanding that this is a Regional Council hearing, I have read the Environment Court's Code of Conduct for Expert Witnesses and agree to abide by its provisions. I confirm that I have complied with these rules in preparing my evidence, that this evidence is within my sphere of expertise and that I have not omitted to consider material facts known to me that might alter or detract from my expressed opinions.

1.5. I am authorised to give this evidence on behalf of Synlait Milk Ltd and Synlait Farms Ltd ("Synlait").

2. SCOPE OF EVIDENCE

2.1. I will, in my evidence, comment and provide recommendations on the issues arising from the Objectives, Policies, Rules and Definitions contained in the Proposed Canterbury Land and Water Regional Plan ("the Proposed Plan") relating to water quality. In particular my submission relates to the following:

a) The definitions of "Nutrient Discharge" and "Reasonable Mixing Zone" contained in section 2.10 and Schedule 5 of the plan,
b) Objective 3.5,
c) Activity and Resource Policies 4.1 including numerical outcomes in tables 1(a), 1(b) and 1(c), 4.2, 4.29, 4.31, 4.32, 4.33, 4.34, 4.37 & 4.38,
d) Region-wide Rules 5.39, 5.42, 5.43, 5.4 & 5.45.

2.2. It is acknowledged that the Proposed Plan is a default plan for any sub-regional zone up to a sub-regional zone plan becoming operative and a reserve plan in the case of failure of any sub-regional zone plan to cover every eventuality.

2.3. It is similarly acknowledged that a ZIP will be shortly presented in respect of the Selwyn-Waihora sub-region. To the extent the Selwyn-Waihora sub-region is a

water short area, where water quality outcomes have not been met, the issues in this zone will demonstrate more keenly the effects of the Proposed Plan as a default and a reserve plan.

2.4. My evidence will address the science used to derive the above Objectives, Policies and Rules and whether, based on the state of scientific knowledge within the Selwyn-Waihora sub-region, the requirements of the Resource Management Act, the Canterbury Water Management Strategy (CWMS) and the National Policy Statement on Freshwater Management (NPS FM) have been met when setting the above Objectives, Policies, Rules and Definitions contained in the Proposed Plan. I will also examine the relevance of the National Environmental Standards for Sources of Human Drinking Water (NES DW) and the Drinking-water Standards for New Zealand 2005 (DWSNZ) when setting nitrogen levels in shallow groundwater in Table 1c.

2.5. My evidence refers to groundwater quality data generated by Synlait as part of their site groundwater quality monitoring programme. These monitoring data are attached to my evidence and referred to when discussing specific issues.

2.6. The proposed controls over farming and industrial activity appear to be underpinned by the required outcomes for lakes, rivers and aquifers contained in Tables 1(a), (b) and (c) in Section 4 of the proposed plan. In my evidence I shall:

a) Discuss the required aquifer nitrate-nitrogen concentration outcomes with particular reference to actual groundwater data from the Selwyn-Waihora Zone and make recommendations regarding the groundwater nitrate-N concentration policy requirements contained in Table 1c and the rules proposed in this plan to implement this policy;
b) Discuss the required maximum Trophic Level Index (TLI) score of 6 for Te Waihora, the coastal lake at the coastal fringe of the Selwyn-Waihora Zone, and make recommendations regarding the proposed default groundwater nitrate-N concentration policy requirements contained in Table 1c and the rules proposed in this plan to implement this policy; and
c) Discuss alternative means of achieving water quality objectives by employing a best practicable option approach that satisfies the requirements of Objective A2 and Policy A3(b) of the NPS FM (reproduced in Attachment 1).

3. Statutory and Legal Imperatives

The NPS FM

3.1 The NPS FM requires that *"the overall quality of fresh water within a Region is maintained or improved while:*

"… (c) improving the quality of fresh water in water bodies that have been degraded by human activities to the point of being over-allocated" (Objective A2).

3.2 My evidence addresses the requirements of NPS FM Policy B71(b). It is acknowledged that this provision is mandatory prior to the Review of a Plan, but its provisions, in my opinion, are essential to the effective management of resources at any time.

3.3 The provision states:

"1. When considering any application the consent authority must have regard to the following matters:

a) the extent to which the change would adversely affect safe-guarding the life-supporting capacity of fresh water and of any associated ecosystem and

b) ***the extent to which it is feasible and dependable that*** *any adverse effect on the life-supporting capacity of fresh water and of any associated ecosystem resulting from the change would be avoided*."

3.4 Policy B71(b) above requires a scientific assessment as to whether it is almost certain that the objective, policy or rule will lead to the claimed outcome and avoid the harm that the plan requirement addresses.

The CWMS

3.5 The Commissioners of ECan are required to have "particular regard to the vision and principles of the CWMS" under s63 of the Environment Canterbury (Temporary Commissioners and Improved Water Management) Act 2010. The vision is:

a) To enable present and future generations to gain the greatest social, economic, recreational and cultural benefits from our water resources within an environmentally sustainable framework.

4. TABLE 1c CANTERBURY AQUIFER NITRATE-NITROGEN OUTCOMES

4.1. The default outcomes for Canterbury aquifers contained in Table 1c require that:

b) the concentration of nitrate-N in coastal confined and deep aquifers not increase above the average concentration recorded or reasonably deduced in the three years prior to 1 November 2010, and

c) the maximum and average nitrate-N concentrations in shallow groundwater are less than 11.3 mg/L and not greater than 5.6 mg/L respectively.

4.2. I have provided below my professional opinion of the achievability and appropriateness of the above outcomes based on the consideration of published groundwater data for the Selwyn-Waihora Zone together with resource consent groundwater monitoring data for the Synlait dairy processing factory.

4.3. The following factors all need consideration to determine whether the above outcomes are achievable and hence more than aspirational:

a) temporal variability of groundwater nitrate concentration,

b) spatial variability in groundwater nitrate concentration,

c) depth-related variability of groundwater nitrate concentration,

d) the age and travel time of groundwater through the aquifer,

e) historical, present and likely future activities within the catchment, and

f) the source(s) of aquifer recharge.

4.4. In shallow groundwater predominantly recharged by soil drainage, both annual and longer duration changes in groundwater nitrate concentrations are well documented. By way of example I refer to the Nitrate-N monitoring data for a number of groundwater wells near the Synlait site together with a site plan which shows the locations of these wells and direction of shallow groundwater flow (less than 50 mbgl), contained in Attachment 2 of this submission.

4.5. Well L36/1321. This well is located in an intensively farmed area, is screened at approximately 30 m below ground level and, based on the available data, is unaffected by Synlait factory wastewater disposal. These data show peaks in groundwater nitrate concentration in September/October which I interpret to be associated with Autumn/Winter soil drainage from land up-gradient of the well. It is evident from these data that the mean nitrate-N concentration prior to 1 November 2010 of 11.6 mg/L is greater than the maximum groundwater

nitrate-N concentration allowed by Table 1c and that the groundwater nitrate-N concentration at this location and depth in the aquifer has been increasing at an average rate of 1 mg/L/yr since 2008, effectively precluding attainment of the groundwater nitrate-N outcomes at this depth and location in the aquifer.

4.6. At well L36/2099 located 400 m to the northwest of well L36/1321, where groundwater is drawn from 60 mbgl, monitoring data show that prior to 1 November 2010 the groundwater nitrate-N concentration was 4.1 mg/L at this depth and has been increasing at an average rate of 0.3 mg/L/yr since 2008. As no distinct seasonal variations are observed in nitrate concentration at this depth, I conclude that the observed trend of steadily increasing nitrate concentration is attributable to the dispersion in the aquifer of nitrate derived from soil drainage from land some considerable distance up-gradient of the well.

4.7. At well L36/2247 located on the up-groundwater gradient SH1 boundary of the Synlait site, the average groundwater nitrate-N concentration at a depth of 33 mbgl, prior to 1 November 2010, is calculated to be 8.2 mg/L. Once again no seasonal variation in the nitrate-N concentration is observed at this depth and I conclude that the observed trend of steadily increasing nitrate concentration at this depth and location in the aquifer is attributable to the dispersion of nitrate in soil drainage from land some considerable distance up-gradient of the well.

4.8. Groundwater is abstracted from a depth of 60 to 70 mbgl from Well L36/1533 at the Synlait site and used for factory processing water. Groundwater monitoring data for this well show that prior to the 2010 earthquake the average groundwater nitrate-N concentration was 6.9 mg/L and was, in 2010, increasing at a rate of about 3.8 mg/L/yr. Immediately following the earthquake ground settlement resulted in deeper water rising in the aquifer and a reduction in groundwater nitrate concentration at this depth. Subsequently groundwater nitrate concentration has increased.

4.9. The age and source of groundwater near the Synlait site has recently been determined using hydrochemical tracer studies and are presented in Environment Canterbury Technical Report № U02/30 entitled "*Age and Source of Canterbury Plains Groundwater*". The results of this study for the Selwyn-Waihora sub-region are reproduced in Attachment 3; these data show that shallow groundwater near the Synlait site is derived primarily from soil drainage or from the Selwyn River and ranges in age from 20 to 40 years. This means

that the nitrate currently present in groundwater at a depth of ~30 mbgl near the Synlait site originates from farming up-gradient of the site up to 40 years ago. During this period land use has changed from predominantly dryland farming and limited irrigated cropping using water from the Rakaia, to today's irrigated intensive dairy and cropping activities, and intensive pig farming.

4.10. It is not possible, using the available groundwater data, to determine the source of or the length of time that nitrate has been in groundwater near the Synlait site. These data do however confirm that groundwater nitrate concentration near the middle of the catchment shows considerable temporal, spatial and depth variability and is not at a steady state concentration which reflects the current up-gradient land use. This means that further increases in groundwater nitrate concentration can be expected without any further nitrogen inputs from present day cropping, dairy farming and industrial activities.

4.11. Shallow groundwater, recharged by rainwater or the Selwyn River, near Te Waihora, is shown in Technical Report № U02/30 to have an age range of 30 to 80 years, this being approximately twice the age of shallow groundwater from this source near the Synlait site near the middle of the catchment. Given that shallow groundwater nitrate concentration near the Synlait site is not yet at a steady state concentration that reflects the current land use, I conclude that the concentration of nitrate in shallow groundwater in the lower catchment cannot be at a steady state concentration and that further increases in shallow groundwater nitrate concentration can be expected as groundwater moves through the aquifer towards the coast.

4.12. This means that notwithstanding any reductions in nitrate leakage that may be able to be achieved through changes to contemporary farming practice, any reductions in nitrate concentration are unlikely to be achieved for decades in shallow groundwater in the lower catchment. This time lag needs to be taken into account when considering options and time frames for achieving improvement in water quality. Policy E of the NPS FM provides for a staged approach in dealing with these decadal time lags, with a maximum achievement date of 2030.

4.13. As a consequence of the combined effects of historical changes to land use in the catchment and the time lag for groundwater movement through the aquifer, achievement of the outcomes for coastal confined aquifers, in Table 1c, i.e. the maintenance of water quality at least in the state recorded or reasonably

deduced in the three years prior to 1 November 2010, will, more likely than not, be unachievable and will not comply with the time-constrained requirement of the NPS FM.

4.14. The s42A report recommends that Policy 4.1 be altered by inclusion of a requirement to achieve outcomes in Table 1 by 2023 and for ZIPs "within the specified timeframes". Any lesser timeframe than 2030 required by the NPS FM further adds to the unachievability of these objectives.

4.15. The following default aquifer outcomes are proposed in Table 1c to ensure that groundwater is potable, without any need for treatment:

a) For the coastal confined aquifer and unconfined gravel aquifers, there is a default requirement that water quality is maintained at least in the state recorded or reasonably deduced in the three years prior to November 2010, and
b) For shallow groundwater predominantly recharged by soil drainage, the maximum groundwater nitrate-N concentration is less than 11.3 mg/L and the mean nitrate-N concentration is not greater than 5.6 mg/L.

4.16. The proposed numerical outcomes in Table 1c are based on the New Zealand drinking water standard and provide protection for this purpose. The proposed outcomes requiring stasis of groundwater nitrate concentration in the coastal confined and unconfined gravel aquifers are a redundancy and do not provide any protection to groundwater users not already provided by the shallow groundwater objectives. In this regard then, the proposed default groundwater nitrate stasis outcomes require a more restrictive control of land use than is required to protect groundwater for potable use. Therefore these default outcomes are neither efficient nor effective as intended by the CWMS and NPS FM.

4.17. The default ecological outcomes for Canterbury lakes are provided in Table 1b. With regard to Te Waihora, the largest and most eutrophic of the Canterbury lakes, a detailed consideration of the factors that limit primary productivity and hence the trophic state of this lake is required to determine whether the proposed stasis of groundwater nitrate concentration is required to achieve the proposed lake water quality/ecological outcomes or whether in fact these can be realistically achieved in this lake within the timeframe specified in the NPS FM Policy E1. This subject has been the subject of much research and I

shall discuss this issue in detail in Section 5 of my evidence. To paraphrase the outcome of my analysis, it is highly unlikely that the proposed stasis on groundwater nitrate concentration will have any material effect on the water quality/ecological outcomes in the lake. In this regard, although I would in no way advocate land use practices that would in effect be a race to the environmental bottom, I conclude that with respect to Te Waihora, there is currently no sound basis in fact for the inclusion of the groundwater stasis objectives contained in Table 1c of the proposed plan.

4.18. The default ecological outcomes for Canterbury Rivers are provided in Table 1a. I concur with and reiterate the statements made in the evidence of Shirley Haward for Fonterra regarding the applicability of set numerical criteria for a broad range of rivers and lakes, particularly where variations in geophysical characteristics can be expected to results in variations in the natural state of these water bodies.

4.19. It is my opinion that the inclusion of unachievable default outcomes in the plan is not appropriate on the basis that they are not feasible or dependable as provided by Policy B7 of the NPS FM. On this basis, I recommend that the outcomes in Tables 1a, b and c, be altered so that these outcomes are feasible and that the time frame associated with this objective be revised to the maximum permissible under the NPS FM.

4.20. The proposed LWRP does not define “shallow groundwater” other than it is “groundwater that is predominantly recharged by soil drainage”. This is, in my opinion, a significant oversight that needs to be addressed as this definition does not provide a systematic framework for determining compliance with the drinking water quality outcomes in Table 1c.

4.21. Groundwater nitrate concentration is generally inversely proportional to depth in the aquifer, being higher close to the surface where soil drainage with elevated nitrate enters groundwater, diminishing with depth as soil drainage water mixes with deeper river-derived water with a lower nitrate concentration. A defined depth is required to provide a systematic means of determining compliance with this objective.

4.22. The nitrate-N MAV for drinking water contained in the New Zealand Drinking Water Standards (2005) has been used to set nitrate outcomes for shallow groundwater. Firstly the nitrate-N MAV has been used to set the maximum

concentration objective and ½ MAV has been used to set a mean objective, with the intention of ensuring that the MAV is not exceeded. It should be noted that the nitrate-N MAV is set to protect young bottle-fed infants from "blue baby syndrome". This use of the drinking water nitrate-N MAV for this purpose in groundwater is defensible but recent scientific research indicates that high nitrate levels alone are not the cause of nitrate-related health problems; it is most often in combination with high levels of disease-causing micro-organisms.

4.23. Council has indicated that the intention of implementing these outcomes is to enable potable consumption of groundwater without the need for further treatment.

4.24. In my opinion then, if a drinking water quality-based standard is to be applied to shallow groundwater with this end in mind, it is necessary to specify a depth to allow a consistent approach to determining compliance. It would for instance be inappropriate to specify a compliance depth where groundwater may be unsuitable for potable use without further treatment because of the possible presence of disease-causing micro-organisms for instance.

4.25. In the Canterbury Region, groundwater down to a depth of 50 mbgl more often than not contains disease-causing micro-organisms and it is not until a depth of greater than 50 mbgl that groundwater is generally clear of pathogens and may not require treatment for potable consumption[1]. On this basis, I recommend that a compliance depth of 60 mbgl be adopted for determining compliance with the aquifer water quality objectives, this depth being consistent with the observed very low risk of pathogens being present in groundwater and hence the requirement for treatment of water prior to potable consumption.

4.26. If such a compliance depth is adopted to protect groundwater for potable consumption, then this, in my opinion, will obviate the need for the mean water quality outcome contained in Table 1c. At this depth, 50 to 60 mbgl, variations in groundwater nitrate concentration can be expected to be very small and setting a mean nitrate-N value of ½ MAV is not necessary to ensure that the MAV is not exceeded. By way of example I refer to the following groundwater nitrate-N monitoring data for wells near the Synlait site:

[1] Hanson C, Abraham P and Z Smith, August 2006; Bacteria Contamination in Canterbury Groundwater. Environment Canterbury Technical Report №. R06/31.

L36/2247 – the mean, 99%ile and maximum nitrate-N concentrations determined for groundwater 33 mbgl since June 2009 being 8.3, 9.5 and 9.7 mg/L respectively. Although the mean nitrate-N concentration of 8.3 mg/L is greater than ½ MAV, the groundwater nitrate concentration at this depth is less than the MAV and clearly complies with the NZ Drinking water standard.

L36/1553 - the mean, 99%ile and maximum nitrate-N concentrations determined for groundwater 60 mbgl from August 2007 until the earthquakes in 2010 being 6.4, 7.4, and 7.5 mg/L respectively. Once again, although the mean nitrate-N concentration of 6.4 mg/L is greater than ½ MAV, the groundwater nitrate concentration at this depth is less than MAV and clearly complies with the NZ Drinking water standard.

4.27. Based on these data, I conclude that at a compliance depth of 50 to 60 mbgl seasonal variations in groundwater nitrate concentration can be expected to be no more than minor and that the nitrate-N ½ MAV objective is not required to ensure that the nitrate-N MAV objective is achieved. And further, the imposition of the nitrate-N ½ MAV objective would effectively impose a default groundwater nitrate quality objective considerably lower than the MAV. Such an objective is not required to protect groundwater for potable use.

5. TABLE 1b CANTERBURY LAKE TROPHIC LEVEL INDEX OUTCOMES

5.1. Te Waihora is an expansive, shallow, turbid, brackish, hyper-eutrophic lowland lake with a Trophic Level Index (TLI) of about 6.7. Both the catchment and lake are in a highly modified state; much of the catchment being used for intensive agriculture and the lake level being artificially controlled by regularly cutting a channel through the gravel bar that separates the lake from the sea. Lake history, constructed from sedimentary records[2], indicates that the lake has a diverse history:

a) The lake formed as a freshwater lake some 7,500 years ago on the landward side of Kaitorete 'Spit' following its fusion with Banks Peninsular.
b) The lake then went through a series of brackish phases when the Waimakariri River flowed through the lake to the Sea.

[2] S G Kitto, 2010; The Environmental History of Te Waihora – Lake Ellesmere. MSc Thesis, University of Canterbury.

c) A nutrient rich, freshwater lake then formed following the avulsion (rapid migration) of the Waimakariri River to a discharge point the north of Banks Peninsular.

d) Subsequent development in the Lake Catchment, a reduction in the lake level and regular opening to the sea have resulted in the formation of a hypereutrophic, shallow, brackish lake.

e) Although available records indicate that macrophyte cover has waxed and waned since 1904, the lake has not returned to a macrophyte-dominated system since the macrophyte beds were destroyed during the Wahine Storm in 1968.

f) The failure of the macrophyte beds to re-establish following their destruction in 1968, the resultant internal recycling of nutrients from re-suspended lake sediment and the increased nutrient load, together with saltwater intrusion are recognised as being largely responsible for the present day condition of the lake.

5.2. The ratio of the water column total nitrogen to total phosphorus concentration (TN:TP) is used internationally to identify whether phytoplankton production is likely to be phosphorus or nitrogen limited. This information is used to identify the most effective and efficient means of reducing phytoplankton production:

a) where phosphorous is limiting, reduction of the phosphorus concentration is most effective,

b) where nitrogen is limiting, reduction of the nitrogen concentration is most effective, and

c) where phosphorous and nitrogen are co-limiting (i.e. there are optimal amounts of both of these elements available for phytoplankton growth) reduction of either element will be effective.

5.3. The results of the recent review of New Zealand lake nutrient data[3] indicate that the majority of New Zealand lakes (52.9%) have a mean ratio of total nitrogen to total phosphorus concentration indicative of potential P-limitation whereas only 14% of lakes have mean TN:TP indicative of potential N-limitation. It is my understanding that Te Waihora is no exception to this finding and that lake phytoplankton productivity may be effectively controlled by reducing the lake phosphorus load (both internal and external) and that a reduction in phosphorus

[3] Abell J, Ozkundakci D & D P Hamilton, 2010; Nitrogen and Phosphorus limitation of phytoplankton growth in New Zealand Lakes: Implications for eutrophication control. *Ecosystems* DOI: 10.1007/s10021-010-9367-9

availability within this lake will be critical to achieving any meaningful improvement in the lake trophic level index (TLI).

5.4. The default or reserve outcomes proposed in Table 1b of the proposed plan will require both the establishment of a moderate macrophyte cover over the lake (as measured by the Submerged plant indicator or SPI) and a reduction in the trophic state of the lake from a current TLI of about 6.7 to 6.0. The attainment of these two objectives will require as a pre-cursor a very significant and effective intervention in the internal recycling of phosphorous within the lake. This will require the establishment of good macrophyte cover over the lake. It is by no means certain that this can be achieved and in this regard, the current consensus of scientific thinking on Te Waihora is that a TLI of 6.0 will not be achievable without a socially unacceptable change in catchment economic activity.

5.5. The establishment of good macrophyte cover over the lake will require an increase in the lake euphotic depth (currently 0.1 m) to allow the establishment and growth of submerged macrophytes from the surface of the lake bed. This will in turn require stabilisation of lake sediment and a substantial reduction in phytoplankton growth rate. In my opinion, the only realistic means of achieving the necessary increase in euphotic depth is through in-lake alum dosing to reduce water turbidity and phytoplankton growth, combined with the rapid establishment of macrophyte beds.

5.6. In my opinion, the converse is also relevant; if it is not possible to establish good macrophyte coverage in the lake, it will not be possible to achieve any significant improvement in lake water quality or trophic state and the proposed restrictions on nitrogen leakage from farming in the catchment will be pointless.

5.7. The use of alum dosing to establish macrophyte beds in the lake will render phytoplankton growth in the lake phosphorus limited. This means that the proposed controls on nitrogen loads entering the lake from the catchment will largely be ineffective and emphasis would be better placed on controlling the phosphorous load to the lake rather than the nitrogen load in order to improve the lake trophic state.

5.8. It is argued that control of the nitrogen load to Te Waihora is also required to limit the lake water nitrate concentration because of potential nitrate toxicity to

fishes and micro-invertebrates that may live in this lake. In this regard, the results of a recent review of nitrate toxicity to freshwater aquatic species[4] are referred to – chronic guideline trigger values of 1.0, 1.7, 2.4 & 3.6 mg NO_3-N/L for 99%, 95%, 90% & 80% level protection. A review of the guideline setting process confirms that these chronic guideline values were derived using a very limited data set and the numerical values derived are primarily determined by the nitrate sensitivities of trout and salmon, both very nitrate sensitive cold water fishes not resident in this lake. Given that the above nitrate guideline values referred to are not directly relevant to the fish in Te Waihora, it would be inappropriate to use these guideline values as the basis for imposing restrictions on the nitrogen load to this lake.

5.9. Within the maximum time constraints imposed by the NPS FM for achieving plan objectives, the proposed controls on nitrogen leakage from farming activity are of very little or no consequence and for this reason, emphasis needs to be placed on controlling the internal and external phosphorus loads to Te Waihora rather than the current emphasis on the external nitrogen load.

6. Definitions

6.1. Nutrient Discharge – is defined solely with reference to the modelled discharge of nutrients using Overseer TM. Overseer was designed primarily as a tool to assist farmers to optimise fertiliser use and has been subsequently adapted to provide an indication of nitrogen losses from the plant root zone to assist in this process. This definition of a nutrient discharge has serious limitations when estimating the nutrient discharge from industrial sources, particularly when industrial activities are overlaid on traditional farming practice. In such situations, the use of actual monitoring data alone or in combination with other model(s) should be allowed where it provides a better assessment of nutrient leakage to groundwater. The following amendment to the definition of Nutrient Discharge is recommended "Nutrient discharge *means the modelled discharge of nutrients using Overseer TM or actual water quality data or other appropriate models*".

6.2. Reasonable Mixing Zone – is defined through reference to the definition provided in Schedule 5 of the proposed plan which does not allow for a mixing zone for point source or diffuse discharges to groundwater. A zone of

[4] Hickey CW & ML Martin, June 2009; A review of nitrate toxicity to freshwater aquatic species. Environment Canterbury Report №. R09/57.

reasonable mixing is provided for and is required for point source discharge to groundwater before any compliance conditions are applied. The following definition is recommended for point source discharges to groundwater – "*groundwater up to 2 km down-groundwater-gradient of the discharge to a depth of 50 m below ground level over this area".*

6.3. Shallow Groundwater – Table 1c refers to "shallow groundwater predominantly recharged by soil drainage" but a working definition of this groundwater is not provided in the plan or the RMA. A definition of shallow groundwater is required when determining compliance with the proposed health indicators. The following definition is recommended for inclusion in the proposed plan – Shallow Groundwater means "*for the purpose of determining compliance with plan objectives, groundwater at a depth of between 50 and 60 m below ground level".*

7. Objectives

7.1. Objective 3.5 – *"Outstanding fresh water bodies and hapua and their margins are maintained in their existing state or restored where degraded"*. This is not required by the Water Conservation Order in respect of Te Waihora. The WCO defines the outstanding features of Te Waihora as (a) habitat for wildlife, indigenous wetland vegetation and fish; and (b) significance to Ngāi Tahu and customary fisheries.

7.2. I support the distinction between outstanding and other freshwater bodies and differences in management objectives for these respective types of water bodies. However, the expectation that "degraded" outstanding fresh water bodies be restored is, without qualification, aspirational and not consistent with the requirements of NPS FM. I recommend that the following qualification be added to this objective ……."*or restored to a defined ecological state if it can be established that such a state can be achieved within the timeframe specified in the NPS FM at a cost that is not unacceptable to the community*".

8. Activity and Resource Policies

8.1. Policies 4.1 and 4.2 – My evidence and the evidence presented by Shirley Hayward for Fonterra shows that the default numerically defined outcomes in Tables 1a, b and c are not necessarily achievable across all water bodies in the

Region. In the absence of sub-regional plans, the implementation of these default objectives may result in unjustified restrictions and costs to farming, industry and communities. For this reason, it is recommend that strategic policies 4.1 and 4.2 be replaced in their entirety by one policy that reads *"Water resources in each sub-region shall be maintained largely in their existing state until water quality outcomes are collaboratively established for that sub-region*".

8.2. Policy 4.29 – The imposition of good management practice, or in the absence of any such articulation, through the normal consent process, is supported as an interim means of minimising potential adverse environmental effects of nitrogen losses to water until the sub-regional plans are operative. My evidence and the evidence presented by Shirley Hayward for Fonterra shows that sub-region-specific data is required to firstly identify achievable water quality outcomes that are acceptable to the community and then to identify effective and efficient means of achieving these objectives within the maximum time allowed by the NPS FM. The data provided in support of the proposed plan does not support priority being given to setting nutrient (nitrogen) discharge allowances in areas shown in planning maps as not meeting regional water quality outcomes.

8.3. Policy 4.31 – This policy, as written, will be very difficult, costly and confusing to implement and it is suggested that emphasis be placed on achieving good practice to minimise nitrogen losses when changes are made to farming activities.

8.4. Policies 4.32, 4.33, & 4.34 – Require farming activities to obtain resource consent to minimise the risk of Policy 4.1, i.e. the outcomes in table 1a, b, & c, not being met. I refer to my above comments regarding the achievability of Policy 4.1 and conclude that it is both inappropriate and inefficient that such policies be implemented in the absence of sub-regional plans that are based on robust science and have been developed through a collaborative process that balances the communities' social, economic, cultural and environmental objectives as envisaged under the CWMS.

8.5. Policies 4.37 & 4.38 – Consideration could be given to including alternative collaboratively agreed mitigation measures where nutrient load limits are exceeded to achieve effective and efficient means of achieving water quality objectives contained in sub-regional plans. It should be noted that the consensus of scientific opinion is that legacy water quality issues will likely result in a further degradation in surface water quality before any net

improvement in water quality may be achieved. In this regard, the maximum time limitation imposed by the NPS FM to achieve objectives constrains the setting of objectives to those that are achievable within this timeframe and hence the management measures that may be employed to achieve these objectives.

8.6. Policy 5.39 – Overseer^{TM} is known to have limitations when estimating soil phosphorus and nitrogen losses over the range of farming activities in Canterbury (dairy, cattle, sheep, pig, cropping horticulture, viticulture and silviculture) and in certain environments; for this reason the ability to use other models and actual data where available would be beneficial if this policy is implemented.

8.7. Policy 5.42 – Implementation of this policy will require that all farming activities prepare an estimate of nitrogen losses for the two years from 1 July 2011 to 30 June 2013. For many farming activities this will not be possible as all of the information required for an Overseer^{TM} model run will not be available. In addition, as modifications are made to Overseer^{TM} to improve its performance, so systematic errors will be introduced requiring re-calculation of historic loads to enable a determination of whether a change in farming practice will require consent. The ability to use as the reference point estimates of nitrogen loss for the previous year or two using Overseer^{TM}, another appropriate model or actual data would assist in determining whether a proposed planned change in farming activity will in fact be a changed farming activity in terms of this plan.

8.8. Policies 5.43 to 5.45 – The spatial definition of nutrient zones and lake management zones in the proposed plan would benefit from revision following the preparation of sub-regional plans. Provision in the plan for such revision is recommended.

9. SECTION 42A REPORT

Policy 4.1 and Table 1

9.1. The Council officers' report confirms the intention of Policy 4.1 and Table 1 as being to "*have a single set of objectives, with sub-regional sections able to set policies specific to the sub-regions to achieve the objectives*". Such an approach implies that these objectives are to be adopted without change in all of the sub-regional plans.

9.2. The officers' report also acknowledges that the Table 1 "*water quality states are not achieved universally at present*" and accepts that an extended timeframe to comply with is policy is reasonable. It also appears that the report envisages that the Table 1 outcomes may be modified locally in the sub-regional plans. This creates a level of uncertainty regarding the ability of outcomes to be set in sub-regional plans that are based on robust science, that are achievable, and have been developed through a collaborative process that balances the communities' social, economic, cultural and environmental objectives as envisaged under the CWMS.

9.3. R4.1 of the s24A report recommends that policy 4.1 be amended as follows:

"*Lakes, rivers, wetlands and aquifers will meet the fresh water outcomes set in sections 6-15 within the specified timeframes. If outcomes have not been established for a catchment, then each type of lake, river or aquifer will meet he outcomes set out in Table 1 by 2023".*

9.4. In my evidence I have established through reference to ground and surface water quality data in the Selwyn-Waihora sub-region that it is not feasible for water quality throughout the Canterbury Region to satisfy the outcomes of Table 1, irrespective of the time available to meet these outcomes, and that it will be more effective and efficient to rely on the sub-regional planning process to set sub-regional objectives that are appropriate for the sub-region and to maintain the status quo until these plans progress through the planning process.

9.5. The technical advice provided by the Principal Water Quality Scientist during the s42A report preparation is that "*the Table(s) identify 'outcomes' for Canterbury rivers and lakes, which may at times be aspirational. They are not however, intended as output tables (such as water quality guidelines or standards) that set numerical limits at specific points as for consent compliance purposes".*

9.6. The advice of the Principal Water Quality Scientist appears to be at odds with the clear intent of Policy 4.2, which states:
"The management of lakes, rivers, wetlands and aquifers will take into account the cumulative effects of land uses, discharges and abstractions in order to meet the fresh water outcomes in accordance with Policy 4.1".

Policy 4.2 then, requires that when processing a consent application, that any adverse effects be assessed against the outcomes contained in Table 1.

9.7. The s42A report states that "*Table 1 ….. will also enable the development in the interim period of sub-regional sections which may modify the outcomes sought locally"* (page 101). It appears that Table 1 is being used for a purpose that it was not intended. For this reason alone incorporating Table 1 in the proposed plan is inappropriate.

10. SUMMARY

10.1. The development of freshwater quality objectives is supported on a catchment scale (i.e. a sub-regional scale) providing they are based on robust science, are achievable, and have been developed through a collaborative process that balances the communities' social, economic, cultural and environmental objectives as envisaged under the CWMS.

10.2. Consideration, by way of example, of scientific data and water quality issues for the Selwyn-Waihora sub-region, confirms that the default water quality objectives of the proposed plan (Table 1) are in some cases unachievable, inappropriate, will result in unjustified costs, or do not meet the efficiency and effectiveness requirements of CWMS and NPS FM, or the maximum time constraint imposed on the achievement of water quality objectives in the NPS FM. The s42A report also confirms that the water quality outcomes in Table 1 are at times aspirational.

10.3. The following changes are accordingly recommended to the proposed plan:

a) That the water quality outcomes contained in Tables 1a and 1b be removed from the Plan and Policies 4.1 and 4.2 be replaced by a Policy that requires that water resources in each sub-region are maintained largely in their existing state, taking into account changes to water quality that are likely to occur as a results of historical land-use, until water quality outcomes are collaboratively established for that sub-region, rather than imposing default objectives that may be inappropriate.

b) The New Zealand drinking water quality-based objectives in Table 1c be amended in the following manner:

a. For shallow groundwater predominantly recharged by soil drainage, the requirement for a mean groundwater nitrate-N concentration objective of not greater than 5.6 mg/L (½MAV) be removed.
b. For shallow groundwater predominantly recharged by soil drainage, a depth of 50 to 60 m below ground level be specified for achievement of the nitrate-N MAV objective.

c) The definition of "Nutrient Discharge" be amended to allow the use of actual monitoring data alone or in combination with other model(s) where it provides a better assessment of nutrient leakage to groundwater.
d) The inclusion of the following definition for a zone of reasonable mixing to point source discharges to groundwater – *"groundwater up to 2 km down-groundwater-gradient of a discharge to a depth of 50 m below ground level over this area"*.
e) The inclusion of the following definition for shallow groundwater – *"for the purpose of determining compliance with plan objectives, groundwater at a depth of between 50 and 60 m below ground level"*.
f) The incorporation of the following amendment to Objective 3.5 – *"…. or restored to a defined ecological state if it can be established that such a state can be achieved within the timeframe specified in the NPS FM at a cost that is not unacceptable to the community"*.
g) Emphasis being placed on achieving "good practice" in all policies relating to nutrient discharges from all activities in the Region.

Dr. Bruce McCabe

Attachment 1 – National Policy Statement for Freshwater Management 2011

A. Water quality

Objective A1

To safeguard the life-supporting capacity, ecosystem processes and indigenous species including their associated ecosystems of fresh water, in sustainably managing the use and development of land, and of discharges of contaminants.

Objective A2

The overall quality of fresh water within a region is maintained or improved while:

a. protecting the quality of outstanding freshwater bodies
b. protecting the significant values of wetlands and
c. improving the quality of fresh water in water bodies that have been degraded by human activities to the point of being over-allocated.

Policy A1

By every regional council making or changing regional plans to the extent needed to ensure the plans:

a. establish freshwater objectives and set freshwater quality limits for all bodies of fresh water in their regions to give effect to the objectives in this national policy statement, having regard to at least the following:
    i. the reasonably foreseeable impacts of climate change
    ii. the connection between water bodies
b. establish methods (including rules) to avoid over-allocation.

Policy A2

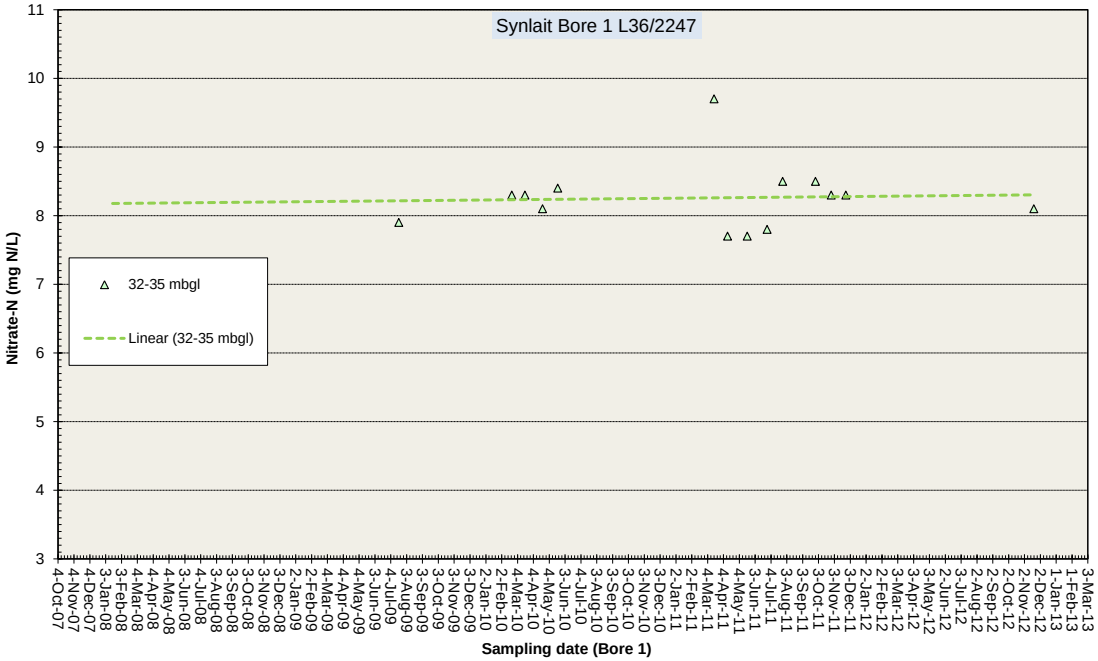
Where water bodies do not meet the freshwater objectives made pursuant to Policy A1, every regional council is to specify targets and implement methods (either or both regulatory and non-regulatory) to assist the improvement of water quality in the water bodies, to meet those targets, and within a defined timeframe.

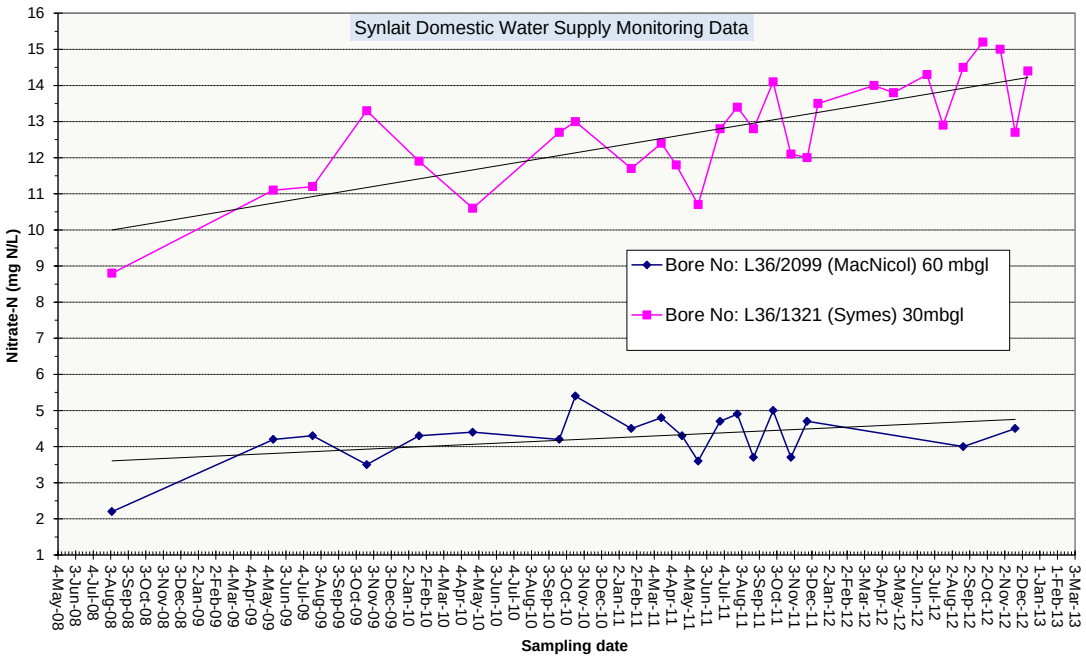
Policy A3

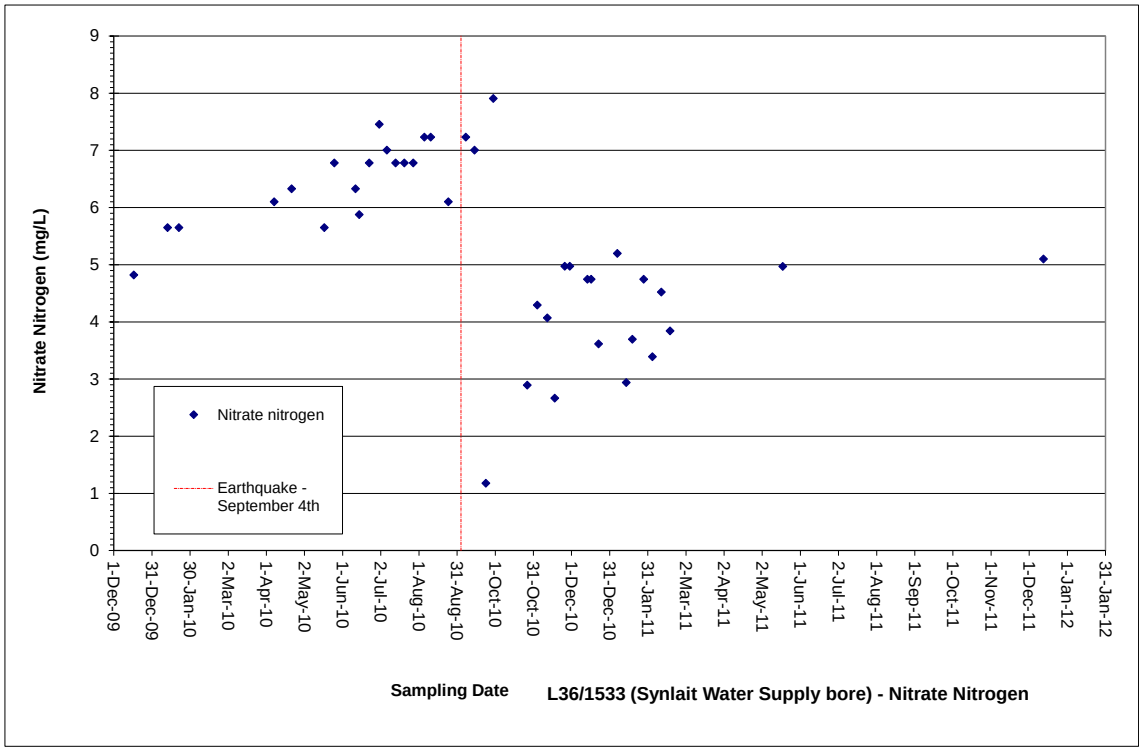
By regional councils:

a. imposing conditions on discharge permits to ensure the limits and targets specified pursuant to Policy A1 and Policy A2 can be met and
b. where permissible, making rules requiring the adoption of the best practicable option to prevent or minimise any actual or likely adverse effect on the environment of any discharge of a contaminant into fresh water, or onto or into land in circumstances that may result in that contaminant (or, as a result of any natural process from the discharge of that contaminant, any other contaminant) entering fresh water.

Attachment 2 – Synlait Milk Ltd, Dunsandel: Groundwater Flow and Monitoring Data




Synlait Domestic Water Supply Monitoring Data
Nitrate-N (mg N/L)
Sampling date
Bore No: L36/2099 (MacNicol) 60 mbgl
Bore No: L36/1321 (Symes) 30mbgl


Nitrate Nitrogen (mg/L)
Sampling Date
Nitrate nitrogen
Earthquake - September 4th
L36/1533 (Synlait Water Supply bore) - Nitrate Nitrogen

NOTES

1. BOUNDARIES EXTRACTED FROM LANDONLINE.
2. ALL LEVELS ARE IN TERMS OF LYTTLETON VERTICAL DATUM 1937. ORIGIN: U53#2 (B39Y), RL 102.492.
3. COORDINATE DATUM: MT PLEASANT CIRCUIT 2000.
4. LOCAL AUTHORITY: SELWYN DISTRICT COUNCIL.
5. AQUIFER No.1 WELLS < 40m DEEP. AQUIFER No.2 WELLS ~ 70m DEEP.
6. AQUIFER No.2 HAS BEEN ADJUSTED BY +1m FOR INCLUSION IN THE AQUIFER No.1 DATASET TO CREATE FLOWLINES.

KEY

- BORE 3 — SYNLAIT MONITORING BORE
- CADASTRAL BOUNDARY
- INFERRED AQUIFER FLOW LINE
- SYNLAIT PROPERTY BOUNDARY
- L36/0437 JG McDRURY — MEASURED WATERBORE OWNER
- L36/2099 MACNICOL — PRODUCTION WELL (MONITORED FOR WATER CHEMISTRY)

0 200 400 600 800 1000m
SCALE

OLD SOUTH RD
SHARLANDS RD
L36/0995 TERRACE FARMS LTD
L36/1796 SA HARRISON
L36/0840 RAY ADCOCK
HESLERTON RD
??
BORE 4
L36/1533 DUNSANDEL DAIRIES ONE LTD
MAIN SOUTH RD
OLD SOUTH RD
L36/2225 SA CAMERON
IRVINES RD
BORE 1
L36/2247 DUNSANDEL DAIRIES ONE LTD
L36/1626 GIFT FARMS LIMITED
L36/2216 DUNSANDEL DAIRIES ONE LTD
??
L36/2250 DUNSANDEL DAIRIES ONE LTD
L36/2015 DUNSANDEL DAIRIES ONE LTD
SHEATS RD
L36/0437 JG McDRURY
L36/2249 DUNSANDEL DAIRIES ONE LTD
L36/1727 DUNSANDEL DAIRIES ONE LTD
BORE 3
RAKAIA SELWYN RD
??
L36/1718 CAMDEN DAIRY FARMS
BORE 2
L36/2248 DUNSANDEL DAIRIES ONE LTD
BORE 5
L36/2430 DUNSANDEL DAIRIES ONE LTD
L36/2050 DUNSANDEL DAIRIES ONE LTD
HESLERTON RD
L36/0200 CG JANSON
L36/1101 CG JANSON
L36/1064 B FALKINGHAM
WAIKIMIHIA RD
L36/0472 RF SEEBECK
L36/0860 RF SEEBECK
L36/1981 RF SEEBECK
L36/2284 RF SEEBECK
L36/0246 LAMASEN HOLDINGS LIMITED
MAIN SOUTH RD
IRVINES RD
KNYVETTS RD
L36/1061 RC BRADLEY
L36/0898 CL TENNANT
BORE 6
L36/2431 DUNSANDEL DAIRIES ONE LTD
L36/1929 DUNSANDEL DAIRIES ONE LTD
L36/2099 MACNICOL
L36/1705 SHEUGH VENTURES
L36/1319 CJ WRIGHT
??
L36/0982 CJ WRIGHT
L36/1010 LAMASEN HOLDINGS LIMITED
FRASERS RD
L36/1337 BW O'CONNELL
L36/2368 R KEATS
L36/1321 SYMES
FRASERS RD
RAKAIA SELWYN RD
L36/1514

DRAWING REVISIONS

REV	DATE	DESCRIPTION
A	28.08.2012	WELL NAMES UPDATED
B	04.02.2013	WELLS L36/1321 & L36/2066 ADDED & KEY AMENDED

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CLIENT / PROJECT

SYNLAIT MILK LTD.

SYNLAIT STAGE TWO DUNSANDEL, CANTERBURY

DRAWING TITLE

GROUNDWATER FLOW AND BORE LOCATION PLAN

	DATE	INITIAL
SURVEYED	01.09.2011	LED
DRAWN	12.10.2011	MJD
SURVEY CHECK	03.10.2011	LED
DRAWING CHECK	12.10.2011	MJD
APPROVED	12.10.2011	BMc

SCALE
1:10000 @ A1
1:20000 @ A3

JOB NO. 43805 DRAWING NO. EM08 REVISION B

Attachment 3 – Age and Source of Canterbury Plains Groundwater

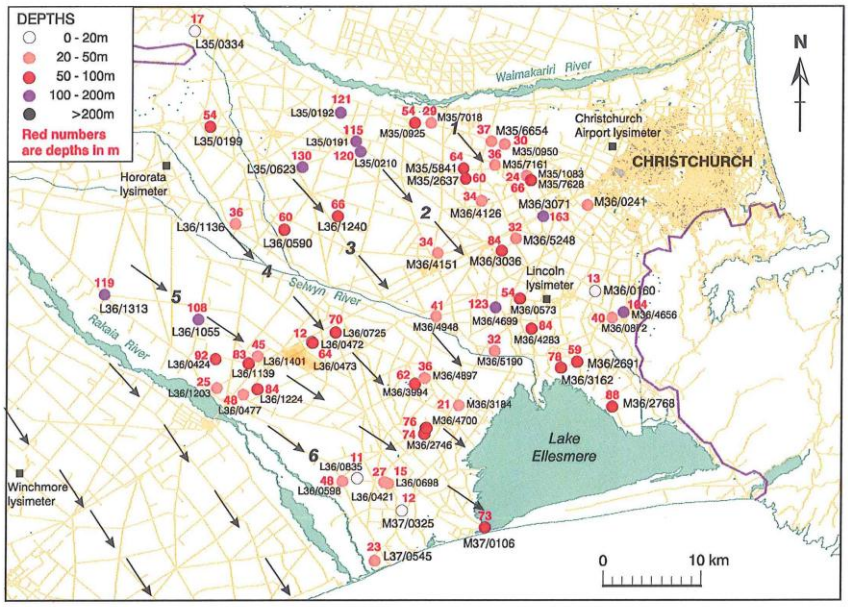

Figure 3.8 **Map of the Waimakariri-Rakaia (Central) Plans showing well locations and depths in metres.**
Arrows show flow directions in upper aquifers.

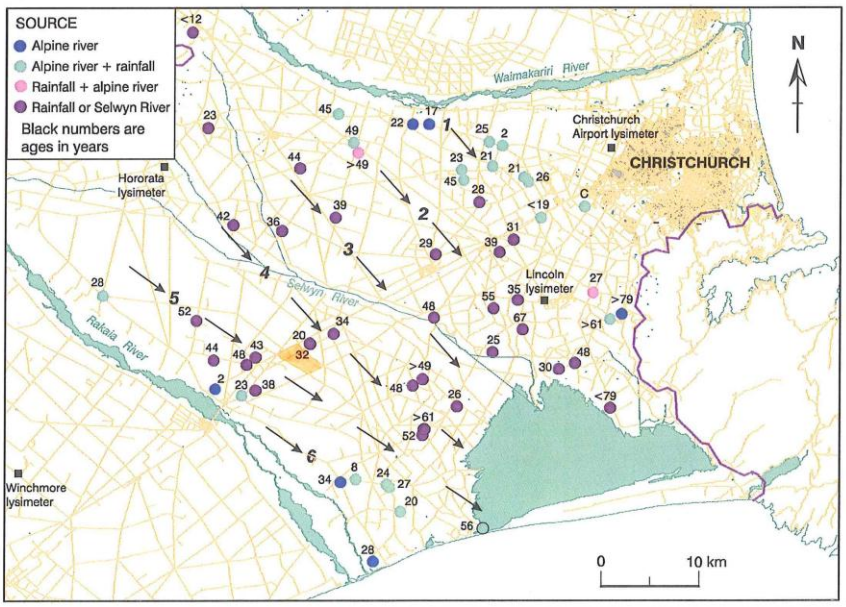

Figure 3.9 **Map of the Waimakariri-Rakaia (Central) Plains showing ages in years and sources of groundwaters, based on hydrochemical measurements.**
Lysimeter sites are marked. Arrows show flow directions in upper aquifers.