BEFORE THE HEARINGS PANEL

IN THE MATTER of hearings on submissions concerning the Proposed One Plan notified by the Manawatu-Wanganui Regional Council

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SECTION 42A REPORT OF MR PETER FRANCIS CALLANDER ON BEHALF OF HORIZONS REGIONAL COUNCIL CONCERNING MANAGEMENT OF GROUNDWATER

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1. INTRODUCTION

1. My name is Peter Francis Callander. I hold the qualifications of BSc (Geology) from the University of Auckland and MSc (Earth Sciences) from the University of Waterloo (Canada). Since 1991 I have been employed as a Senior Hydrogeologist with Pattle Delamore Partners Limited, an environmental consulting firm specialising in groundwater and surface water resources. In 1997 I was appointed as a Director of that firm.

2. Previously, I had been employed for eight years by the Canterbury Regional Council (CRC) and its predecessor the North Canterbury Catchment Board (NCCB). During this time I was involved with all the CRC and NCCB groundwater resource investigations and field trials. Between 1989 and 1991 I was in charge of the CRC groundwater section.

3. In the course of my work, I have been involved in the allocation and management of groundwater resources for Regional Councils, District Councils and water users for agricultural, industrial and public water supply purposes. This work has involved the analysis of numerous pumping tests, assessments of well yields and determining the effects of groundwater abstractions on other well users and the surrounding environment, at both local and regional scale. I have carried out numerical modelling exercises to quantify groundwater resources. Most of this work has been undertaken in the alluvial aquifers of Marlborough and Canterbury, which have similar characteristics to the productive aquifers in Horizons Region. I have undertaken groundwater management work with various regional councils – mostly Canterbury and Marlborough, and to a lesser extent with Bay of Plenty, Hawkes Bay and Horizons.

4. I have been an independent hearing commissioner on panels hearing consent applications for groundwater abstraction in Horizons' Region, which has included working on panels with Commissioners Rob van Voorthuysen and Annette Main. I have completed the MfE Commissioner Training Programme, and hold a current certificate from the Making Good Decisions Programme.

5. The evidence I will present to the Hearing Panel is within my area of expertise, except where I state that I am relying on information provided by another party. I am familiar with the Code of Conduct for Expert Witnesses and I agree to comply with this code.

My role in the Proposed One Plan

6. I was not involved in the original drafting of the notified version of the Proposed One Plan (POP). However, subsequent to its notification, I have been engaged to provide expert advice on the assessment and management of groundwater issues. This has included providing a general review of the regional groundwater report prepared by Mr Hisham Zarour, and on a draft report regarding guidelines for pumping tests on bores, as well as providing advice on the content of the Policies and Rules related to groundwater in the publicly notified version of the POP. The proposed changes to content of the groundwater sections of the POP that I will discuss have been developed in consultation with other experts on Horizons' POP team, particularly Mr Zarour, Dr Jon Roygard and Ms Helen Marr.

Scope of Evidence

7. The scope of my evidence is to provide a general overview of the groundwater resource and the management issues that arise from its use. I will then provide specific comments on the groundwater policies in Chapter 6 of the POP and the associated Rules, namely:
   i. Policy 6-21 – Overall Approach for Bore Management and Groundwater Allocation.
   ii. Policy 6-22 – Bore Development and Management.
   iii. Policy 6-23 – Groundwater Management Zones.
   iv. Policy 6-24 – Effects of Groundwater Takes on Other Groundwater Takes.
   v. Policy 6-25 – Effects of Groundwater Takes on Surface Water Bodies;
   vi. Policy 6-26 – Saltwater Intrusion.
   vii. Policy 6-6 – Maintenance of Groundwater Quality.

8. I will also comment on the Pumping Test Guidelines that are being prepared to assist with the implementation of the policies.

2. EXECUTIVE SUMMARY OF EVIDENCE

9. The geology of Horizons' Region comprises greywacke basement rock that has been uplifted to form the Ruahine Ranges and Tararua Ranges. Away from the ranges, this basement rock is overlain by a thick marine sedimentary sequence, and this in turn is overlain by more recent alluvial deposits that have been formed from the erosion of the inland ranges and increase in thickness towards the coast.

10. The presence of gravelly strata within the alluvial deposits, and some limestone and shell beds in the marine sediments, are sufficiently permeable that they comprise a productive groundwater resource that is accessed by water supply bores to provide drinking water for people and animals as well as irrigation, and commercial and industrial water supplies throughout the Region. In many parts of the Region, this groundwater represents a highly productive and good quality water resource that is utilised from an estimated 9,500 bores across the Region.

11. Groundwater within the Region also provides a contribution of water to many surface water features, including rivers, streams, lakes and wetlands; this groundwater seepage contributes to the values that are attached to those surface water bodies.

12. Access to the water resource is obtained by drilling bores. Abstraction of groundwater from a bore results in a lowering of groundwater levels. It is important that these activities occur within a management framework of Policies and Rules that enable the use of groundwater to take place in a manner that avoids the adverse effects that can arise if bores are poorly constructed or if excessive amounts of abstraction were to occur.

13. The notified version of the Proposed One Plan (POP) has Policies and Rules that address the key groundwater management issues; however, in my opinion, some of the wording of those Policies and Rules in the notified POP are of a general nature and could be further refined to aid in their implementation. The key policies are:

    i. Policy 6-22 Bore Construction and Management

    ii. This defines criteria for creating a “properly constructed bore”, which is a bore that is located and constructed so as to minimise the risk of adverse effects on neighbouring bores, provides an efficient means of abstracting groundwater, and does not provide a pathway for contamination to enter the groundwater system.

    iii. Policy 6-23 Groundwater Management Zones

    iv. The Region has been split into 10 Groundwater Management Zones and the POP specifies an annual volume that can be abstracted from each zone. These annual volumetric limits are a means of managing the widespread cumulative effects of groundwater abstractions. At present, the estimated quantity of groundwater abstraction is relatively low, so a conservative annual volume limit can be set. The proposed limit is based on 5% of the annual average rainfall within each zone. The numbers in the notified POP are in error due to a miscalculation. That error has now been corrected, as described in the evidence of Mr Zarour.

    v. Policy 6-24 Effects of Groundwater Takes on Other Groundwater Takes

vi. When groundwater abstraction occurs, it lowers groundwater levels in the surrounding area, and this can affect the performance of neighbouring bores. This policy requires pumping tests to be carried out to assess this effect and provides criteria to manage the effect so as to protect the reliability of supply for existing properly constructed bores.

vii. Policy 6-25 Effects of Groundwater Takes on Surface Water Bodies

viii. Abstraction of groundwater can cause depletion of surface water bodies that are connected to groundwater, such as rivers, streams, lakes, and wetlands. This policy proposes a classification system to determine the significance of the effect of the proposed groundwater abstraction on surface water bodies and to determine whether the groundwater abstraction should be subject to surface water management criteria in addition to groundwater management criteria. There is insufficient information to gauge the impact of this classification approach on existing users, therefore it may be that it is best not to apply to existing consent holders but only to new abstractions.

ix. Policy 6-26 Seawater Intrusion

x. Groundwater abstractions near the sea coast can lower groundwater levels to such an extent that seawater can move in a landwards direction through the strata and contaminate the groundwater. Therefore, this Policy specifies testing and monitoring criteria to preserve groundwater conditions at the coast that prevent this contamination occurring.

14. Rules related to groundwater quantity are specified in the POP to support the policies, with abstractions classified as Permitted or Discretionary. The drilling of bores is a Restricted Discretionary Activity in the notified POP, although the staff submission suggests it should be Permitted. In my opinion, some form of site-specific consent is required to adequately control bore drilling and I suggest this could be achieved as a Controlled Activity.

15. Many of the groundwater quantity policies require pumping tests to be carried out on bores. These tests are an important means of quantifying the effects of groundwater abstractions and an improved standard of pumping tests is needed in the Region to properly assess groundwater abstraction issues. Horizons is preparing a pumping test guideline document and it is important that this is promoted to drillers and consultants who carry out this work. However, there are so many site-specific variables that affect how a pumping test should be carried out that it is not practical to have the pumping test guidelines as part of the One Plan. Therefore, the best approach is for the One Plan policies to describe what the pumping tests must achieve and for Horizons technical

staff to work with groundwater users and their advisers to achieve a high standard of pumping tests; this process will be aided by the publication of the pumping test guideline document.

16. An important aspect of the POP is to implement a management framework that protects groundwater from contamination. Most groundwater contamination risks arise from land use activities that are set out in policies that describe general land use and specific discharge activities. However, there is one policy, Policy 6-6, which deals specifically with groundwater quality. In my view, the wording of this Policy should seek to ensure the groundwater quality is monitored and activities are controlled at a level that preserves the existing and future uses and values of the groundwater resource.

3. BACKGROUND INFORMATION

17. To set the scene for my evidence, I will briefly summarise my understanding of the groundwater resources of Horizons' Region that are to be managed by the POP. Information on this topic is provided in much greater detail in the evidence of Mr Zarour.

18. In very broad terms, the geology of the Region has been formed in three main sequences:

i. The geological basement is predominantly comprised of extremely low permeability and heavily inundated greywacke strata that have been uplifted by tectonic forces to form the Ruahine Ranges and Tararua Ranges. These rocks also occur at depth and underlie the younger geologic strata of the Region at variable depths.

ii. The basement rocks are typically overlain by fine-grained marine sediments, often appearing as a low permeability siltstone described in driller's logs as "papa". This strata does not generally support groundwater abstraction wells, although some coarser ground permeable shell beds and limestone layers are present at discrete locations such as those forming the Nukumaru Aquifer in Wanganui;

iii. In more recent geologic time (over the last 360,000 years), there has been the creation of alluvial deposits formed by the erosion of the greywacke ranges, a process that is continuing today. These alluvial deposits are highly variable but often contain zones where permeable gravelly strata predominate, forming high-yielding, productive aquifers. These productive water-bearing strata tend to be thinner close to the inland high country and thicken towards the coast. In the Tararua District, these deposits fill valleys and flood plains and can extend up to 30 metres thick. In the western parts of the Region (particularly in the lower

Manawatu and Rangitikei catchments) their thickness can extend up to several hundred metres.

19. These main types of strata and depositional environments and their subsequent uplift by tectonic forces form four broad categories of the Region's landforms that are mapped in Figure 1 (Appendix A), which covers the western deposits of the Region. The deposits mapped in Figure 1 are:

i. Axial ranges (Ruahine and Tararua) formed from the uplifted greywacke basement rocks.

ii. Dissected uplands formed from the uplifted marine sediments, which have been eroded by river processes.

iii. Coastal lowlands. These lowlands are built up by alluvial deposits formed by erosion of the more centrally located elevated sediments. In addition, shallow marine sediments that were deposited during inter-glacial times are inter-bedded into the alluvial strata at some locations. All of these sediments can often be mantled by fine-grained wind-blown deposits of fine silt (loess);

iv. The plains occur across the western coastal margin of the Region, extending further inland in the catchments of the Rangitikei River and Manawatu River. They comprise alluvial deposits throughout most of their area and younger coastal sand dunes along the western coastal margin.

20. Within these different types of strata, it is the younger alluvial deposits that have the greatest potential to form permeable and high-yielding aquifers. They are heterogeneous deposits, but when dominated by coarse sand and gravel and in hydraulic connection to a reliable source of recharge, they represent productive aquifers that are used for groundwater abstraction by approximately 350 consent holders, within a much larger number (estimated to be approximately 9,500) of smaller abstractions.

21. The variability within the strata is such that it appears that both laterally and vertically there are localised zones of permeable and less permeable strata. However, groundwater is able to move through these zones such that they do not form extensive and distinct aquifer and aquitard layers. Therefore, the entire vertical extent of alluvial deposits that includes permeable gravelly zones are best managed as a single heterogeneous, anisotropic and hydraulically interconnected sequence of strata. However, on a regional scale, it is possible to laterally define boundaries across the Region and these have been used to form separate Groundwater Management Zones. In many cases, these zone boundaries are related to the folding and faulting of the strata.

22. The groundwater receives its recharge from rainfall that occurs directly over the top of the aquifers and then infiltrates downwards through the soil into the groundwater, and from losses from rivers and lakes as subsurface seepages where they cross the alluvial deposits.

23. Discharge from the groundwater system occurs via the movement of groundwater offshore into the sea, via seepage into surface water bodies, lakes and wetlands, and via groundwater abstraction bores. In areas of shallow water tables, the evapotranspiration of plants and trees can also cause an abstraction of groundwater.

24. Mapping of groundwater levels from a large number of bores across the Region provides an indication of regional groundwater flow directions. A map of groundwater level contours is presented in Figure 2. The direction of groundwater movement is perpendicular to the contour lines. Figure 2 shows the general pattern of groundwater movement from the elevated parts of the Region down to the Tasman Sea, which is consistent with the structural pattern of folding and faulting and the surface water drainage pattern, all of which are inter-related. There are zones where the groundwater discharges into the major rivers and coastal lakes, such as Lake Horowhenua.

25. Long-term monitoring of groundwater levels in bores provides a measure of the balance between the recharge and discharge components of the groundwater system. Figure 3 shows the network of regularly monitored bores within the Region. The distribution of these bores is indicative of the main areas of groundwater usage. The records from these bores typically show a seasonal fluctuation but a generally stable long-term trend. Seasonally, water levels are lower during summer and early autumn (due to less rainfall recharge and increased groundwater abstraction), and higher during winter and early spring (due to more rainfall recharge and less groundwater abstraction). Figure 4 shows an example of this type of generally stable water level record.

26. This pattern of generally stable groundwater levels in the long term indicates that at the present time, the level of groundwater abstraction is in balance with the amount of recharge entering the aquifer system. As a result, the groundwater resource is available to be used for a wide range of water supply purposes.

27. Access to the groundwater resource is obtained by drilling bores and abstraction of groundwater requires a lowering of groundwater levels in the bore, which causes a lowering of groundwater levels that extend out into the strata surrounding the bore. This

creates a drawdown cone of lowered groundwater levels, as shown schematically in Figure 5.

28. This lowering of groundwater levels can have effects on neighbouring bores and on surface water bodies (eg. streams, lakes and wetlands) that are hydraulically connected to the groundwater table. The change in groundwater levels caused by abstraction can also induce the movement of areas of poor quality water into a productive water-bearing strata, causing water supplies to become contaminated, eg. the movement of seawater into a coastal aquifer.

29. Therefore, while the groundwater resource is sufficiently plentiful such that its use should be encouraged, the means by which it is abstracted has the potential to create adverse effects. These adverse effects are related to:

i. The way in which bores are constructed to abstract groundwater.
ii. The overall quantity of groundwater that is abstracted.
iii. Effects that arise from the lowering of groundwater levels when a bore is pumped, which can adversely impact on other bores and surface water bodies, or create an inflow of poor quality water.

This situation requires that water management policies are put in place to ensure that groundwater abstraction can occur in a way that minimises the risk of adverse effects occurring on a more than minor scale. The notified POP includes policies and rules that address these issues, which I comment on in Section 5 and Section 6 of my evidence.

30. As an overview comment on how groundwater issues are addressed in Plans, it is important to recognise that our ability to predict and quantify groundwater effects is not particularly precise. This is because groundwater is a water resource that is largely unseen, and has a large degree of natural variability but is only observed from measurements at randomly spaced discrete points where bores have been drilled and monitored. Therefore, it is often difficult to write policies and rules that precisely quantify the exact nature of how groundwater effects will be managed. Instead, the policies and rules can often do no more than describe in general terms the outcome that is to be achieved, and the specifics of how that will be interpreted in any particular situation will require the judgement of resource users, Council staff and decision-making bodies.

31. The notified POP has policies that cover all the relevant groundwater management issues. However, in my opinion, some of the wording is a bit too general and my suggested changes are intended to provide resource users and decision-makers with greater clarity regarding what the policies should achieve. I recognise that even with my

suggested wording changes, some judgement will still be required to implement the policies and rules, but such a situation is unavoidable when dealing with groundwater issues.

Key messages

1. Horizons' Region contains an extensive groundwater resource that is utilised by a large number of bores.
2. Monitoring indicates that the current level of groundwater abstraction is not causing any widespread adverse effects.
3. Potential adverse effects can arise from groundwater abstractions at a localised scale, due to the way in which bores are constructed and due to drawdown effects. More widespread problems can arise if too much groundwater is abstracted.
4. The policies and rules of the POP are required to manage these groundwater abstraction issues.

4. THE OBJECTIVES RELATED TO GROUNDWATER QUANTITY

32. Objective 6.3 of the POP deals with water quantity and allocation for both surface water and groundwater. It is an enabling objective which states that water is to be managed to enable people, industry and agriculture to take and use water to meet their reasonable needs. Given the current monitoring data on the Region's groundwater resources, I consider that objective appropriately indicates there is more water available to be used and that use should be enabled.

33. Objective 6.3 goes on to say that for groundwater, the enabling of its use must occur in a way that ensures that:

i. Takes do not cause a significant effect on the long-term groundwater yield.
ii. Groundwater takes that are hydrologically connected to rivers, lakes or wetlands are managed within the minimum flow and allocation regimes established for those water bodies, or to protect their life supporting capacity.
iii. The effects of a groundwater take on other groundwater takes are managed.
iv. Saltwater intrusion into coastal aquifers, induced by groundwater takes, is avoided.

34. Objective 6.3 also requires that water is used efficiently.

35. This Objective recognises that groundwater contributes to the Values identified in Table 6.2 of the POP and that access to, and abstraction from, the groundwater resource must be managed to minimise the risk of compromising those Values.

36. I consider that Objective 6.3 is an appropriate objective for the groundwater quantity aspects of the POP and that it provides an adequate focus for the development of policies to achieve that Objective.

5. COMMENTS ON GROUNDWATER QUANTITY POLICIES IN THE POP

37. Section 6.4.3.3 of the POP sets out Policies for Bores and Groundwater. It includes six policies (6-21 to 6-26) which deal with the management of effects related to groundwater quantity issues. My comments on each of these policies follow.

Policy 6-21 – Overall Approach for Bore Management and Groundwater Allocation

38. This Policy serves as a general reference for all other groundwater abstraction policies, and ensures that all policies in this section must be complied with. I consider this to be appropriate and have only one minor suggested wording change, that the reference to "saltwater intrusion" should be changed to "seawater intrusion", because Policy 6-26 refers specifically to issues at the sea coast, whereas salty groundwater can occur in other settings, such as in very low permeability sediments.

Policy 6-22 Bore Development and Management

39. Groundwater bores are the means by which people gain access to the groundwater resource so that water can be abstracted and/or so that the resource can be monitored. However, if bores are not constructed and maintained to a sufficiently high standard, they can lead to inefficient abstraction systems, wastage of water and/or the creation of a contamination pathway into the aquifer. Therefore, it is important to have a policy that deals with the construction and management of bores.

40. Within the bore drilling industry, the term "bore development" refers to a specific process where the screened section of a bore is cleaned out during drilling, therefore the title of the Policy should be altered to refer to "Bore Construction and Management".

41. The notified policy in the POP makes reference to NZS 4411:2001 Environmental Standard for Drilling of Soil and Rock, which is the only New Zealand Standard for drilling and maintaining bores, including the decommissioning of unused bores.

Therefore, it is appropriate for this Policy to make reference to this standard. However, the Policy also includes some generalised wording related to ensuring "adequate separation" from existing bores, avoiding an "over-concentration of bores" and ensuring a "high degree of efficiency", without indicating how those situations will be defined.

42. Groundwater conditions across the Region are so variable that it is not possible to define these terms with absolute precision; however, in my opinion some re-wording of the policy to provide a description of some criteria against which these terms can be judged would be beneficial. For example:

i. Adequate separation from existing bores is a separation distance that avoids or mitigates effects on the reliability of supply of properly constructed existing bores.

ii. Properly constructed existing bores are bores that are constructed in accordance with Policy 6-22 and are recorded on Horizons' groundwater database.

iii. A high degree of efficiency for bore construction is achieved, where:

   a. the bore is screened at a depth to make best use of the water bearing strata;

   b. the bore is adequately maintained;

   c. the bore can be pumped to make best use of the available drawdown;

   d. wherever possible, measurements of bore yield and drawdown will be used to assess this efficiency.

43. This extra wording should help to provide a better understanding of how bores can be constructed and managed in a way that avoids adverse effects.

44. Other aspects of Policy 6-22 require bores to be constructed and operated in a manner that prevents contamination or wastage of water, and that decommissioning of bores shall be done in a manner that is consistent with the New Zealand Standard NZS 4411:2001. I consider these to be appropriate and necessary components of a robust bore construction and management policy.

Policy 6-23 Groundwater Management Zones

45. While specific policies are proposed for the direct drawdown effects caused by abstraction bores, there are more widespread effects of groundwater abstraction that are of such a small scale for each individual abstraction that they are difficult to quantify; however, the cumulative effects of these abstractions can be of a large and adverse nature. This problem of cumulative effects over a very large scale can be managed by

defining annual allocation volumes from within specifically defined Groundwater Management Zones (GMZs).

46. Mr Zarour's evidence has described the boundaries of the GMZs that are shown in Figure 6. The division of the Region into these zones is reasonable, based on our understanding of the hydrogeologic structure of the aquifers. Policy 6-23 defines those zones and refers to Schedule C, which lists the volumes that can be abstracted from them (with numbers that have been changed, as per Mr Zarour's evidence).

47. I suggest altering the wording of the Policy's aim to make it clear that Schedule C lists an annual volume within each zone that is available for allocation, and that those volumes are not to be exceeded throughout the term of this Plan, although they can obviously be altered by implementing a Plan Change process. I also suggest that the Policy should clearly state that groundwater abstraction consents should include conditions that define an annual volume, so it is clear what quantity of water each consent contributes to the annual total for each zone. Groundwater consent conditions should also define the peak abstraction rate and the maximum daily abstraction rate.

48. The annual allocatable volume numbers in the modified version of Schedule C are based on 5% of the average annual rainfall within each zone. A ballpark indication of aquifer recharge would estimate that approximately 30% of rainfall reaches the groundwater. In addition, the aquifers receive additional recharge from seepage losses from some sections of surface water bodies. Therefore, a GMZ allocation limit of 5% of average annual rainfall is approximately 10-15% of the average annual groundwater recharge.

49. Current estimates of groundwater abstraction indicate that 0.04-1.6% of average rainfall is currently allocated within each zone (Zarour, 2008). Figure 7 provides a graph showing the current estimated groundwater abstraction and the estimated allocation limits of 3% or 5% of rainfall recharge. Not surprisingly, this low rate of current groundwater usage is not showing any sign of causing large-scale effects on the groundwater resources, as indicated by the generally stable groundwater levels referred to in Paragraph 3.9 of this evidence, with Figure 4 as an example of that pattern.

50. An increase in abstraction up to 5% of average rainfall is a significant change from the current abstraction situation, but is considered to be a reasonable limit to set for the current Plan based on the following guidelines:

i. A Ministry for the Environment (MfE) report entitled Groundwater Resource Management: Information Gaps Analysis (September 2001) recommends that a conservative allocation of sustainable groundwater abstraction could be 20% of annual rainfall. The proposed limit of 5% in the POP is well below this criteria.

ii. The Proposed National Environmental Standard on Ecological Flows and Water Levels identifies criteria for the potential degree of hydrological alteration from groundwater allocation. Their criteria are:

   a. Low – up to 10% of recharge.

   b. Medium – 11-25% of recharge.

   c. High – over 25% of recharge.

As noted in Paragraph 5.12, the allocation limit of 5% of average annual rainfall is estimated to be about 10-15% of average annual recharge, placing it in the low-medium classification of the proposed NES. The supporting document for the NES suggests its guidelines are conservative.

51. Based on that information, I am of the view that annual allocation limits of anything from 3% (which corresponds to around 6-9% of average annual recharge) to 5% of the average annual rainfall within each GMZ is a suitable balance between allowing a reasonable level of increase above the currently abstracted quantities, while ensuring that no large-scale adverse cumulative effects occur.

52. An alternative approach that could be considered would be to set the limit at a proportional increase of the current estimated usage, such as a doubling or trebling of the current usage as a limit for the life of this Plan.

53. While there are various options on which to base the annual allocation limit, the available guidelines indicate that a limit of up to 5% of average annual volume should not cause adverse effects that are more than minor over a large scale; it also sends a positive message that the groundwater resource is available for future allocation, provided that the localised potential adverse effects can be avoided, remedied or mitigated. Such an approach would seem consistent with the enabling concept of Objective 6.3

Policy 6-24 Effects of Groundwater Takes on Other Groundwater Takes

54. When groundwater abstractions occur, they create a localised drawdown in the groundwater levels in the surrounding area. This drop in groundwater levels can adversely affect the ability of neighbouring bores to operate effectively. The adverse

effect can arise either from the drawdown effects of a single bore (Figure 5a), or due to the cumulative drawdown effects of several bores. Therefore, a policy is required to manage this potential adverse effect.

55. The current wording of the notified Policy 6-24 provides a good description of what is to be achieved, but some more specific guidance would improve the Policy.

56. Clause (a) refers to a general requirement for consent applicants to carry out pumping tests. This is appropriate and could be made more specific by stating that the purpose of such tests is to define aquifer conditions and hydraulic parameters, provide information on bore efficiency, and enable modelling and assessment of potential drawdown interference between bores.

57. Clause (b) notes that restrictions on consented abstraction rates may be required to avoid significant drawdown impacts. This is also appropriate; however, it is not clear as to what the term "significant drawdown" actually means. That part of the Policy could be re-worded to define a specific magnitude of drawdown effects that needs to be considered. The suggested criteria is 0.5 m of drawdown with a 100-day pumping period (as may occur during a dry summer period). This is also a period of sufficient duration that most drawdown effects will have reached a relatively stable level. A second limiting criteria is proposed such that the assessment of those direct drawdown effects need only consider abstractions within a distance of 3 km, which is a distance over which most drawdown effects of any significance should occur. The 0.5 m drawdown and 3 km distance are filtering criteria to ensure that the assessments of effects focus on the major contributors to drawdown interference. However, they do not necessarily represent an adverse effect. The overall criteria should be that restrictions should only be imposed if those bores that are likely to create the largest drawdown effects (ie. located within 3 km and more than 0.5 m over 100 days) create a more than minor reduction in the reliability of supply for neighbouring bores.

58. I do not think it is feasible to define the term "a more than minor reduction in the reliability of supply" with any more precision, because the meaning will be quite difficult for public water supplies, irrigators and commercial and industrial water users, and will also depend on each individual system and its alternative or reserve supply capacity. This is a matter that will need to be judged on a case-by-case basis.

59. The notified POP uses the term "good quality bore"; however, in my opinion, it would be better to use the term "properly constructed bore". The notified version of clause (b)

also defined criteria for what a properly constructed bore is; however, Policy 6-22 may be more appropriate location for those criteria.

60. Clause (c) allows for a time delay on the full implementation of new abstractions so as to allow existing users who may be adversely affected to upgrade their bores. This is appropriate, but similar refinements in the wording of clause (c) are required to be consistent with the comments I have made regarding clause (b).

61. Clause (d) encourages consent applicants to consider providing an alternative water supply to affected parties as a reasonable mitigation option to address the issues raised in clauses (b) and (c). I consider this to be an appropriate part of this Policy.

62. I have considered alternative wording options for Policy 6.24 that would be more clear-cut in their implementation with regard to the definition of reliability limits or acceptable magnitudes of drawdown interference. For example, rather than use the term "a more than minor reduction in reliability of supply", the Policy could say "to ensure water is reliably available every nine years out of 10". However, whether or not that is an acceptable level of reliability will vary considerably between different groundwater users. It might be acceptable for some irrigators, but not for a public water supply or industrial user.

63. Similarly, the acceptable magnitude of drawdown interference between bores could be defined. For example, the Policy could state that the cumulative drawdown interference between bores should not exceed 20% of the available drawdown via properly constructed bores (with the remaining 80% of drawdown available for the bore's own operational requirement). However, whether or not an allowance of 20% drawdown interference represents an adverse drawdown interference effect will be completely variable between different groundwater users. Therefore, in my opinion, any precise definitions or these criteria should not be absolute, and I prefer the more descriptive approach that can be applied on a case-by-case basis.

Policy 6-25 Effects of Groundwater Takes on Surface Water Bodies

64. The drawdown effect caused by groundwater abstractions can impact on surface water bodies in the vicinity, including rivers, streams, lakes, and wetlands, as shown schematically in Figure 5b. Therefore, it is necessary to have a policy that deals with this direct interaction between groundwater and surface water.

65. For those situations where groundwater abstractions affect surface waterways, there is typically a gradational impact, depending on the degree of hydraulic connection between the bore and the surface waterway. A particularly useful reference for quantifying those effects is Guidelines for the Assessment of Groundwater Abstraction Effects on Stream Flow (Environment Canterbury report R00/11, ISBN 1-86937-387-1, First Edition, June 2000) and could be referenced in a revised wording of clause (a) of this Policy, or similar quantitative methods.

66. While the terminology in many of the documents on this topic refers to "stream depletion" or effects on "stream flow", the calculations that are carried out can be used to define the proportion of water from the bore that is drawn from a surface water body. By reporting the effect in this way, as a proportion of the bore abstraction rate, the assessment and criteria in this Policy can also be relevant for groundwater abstraction effects on all surface water bodies, including lakes and wetlands. However, those effects are likely to require numerical modelling assessments if there is a need to determine the proportion of water that is drawn from the surface water bodies as a result of groundwater abstraction.

67. Therefore, the classification of surface water depletion effects is best achieved by quantifying the loss of surface flow that is estimated to occur as a proportion of the groundwater pumping rate, over a fixed time period for comparative purposes.

68. It is suggested that the following five classifications could be utilised within Policy 6-25.

Table 1. Classification of Surface Water Depletion Effects

Classification of Ground-water Effects on Surface Waters	Magnitude of Potential Effect on Surface Water	Management Approach
Class 1: Riparian	Any groundwater abstraction screened within the geologically recent river bed strata of a surface water body.	The groundwater abstraction is subject to the same restrictions as a surface water abstraction, unless there is clear hydrogeological evidence that demonstrates that the effect of pumping will not impact on the surface water body.
Class 2: High	The surface water depletion effect is greater than the "Negligible" classification and calculated as greater than or equal to 90% of the maximum consented groundwater pumping rate after seven days of pumping, or greater than or equal to 50% of the average groundwater pumping rate after 100 days of pumping.	The groundwater abstraction is subject to the same restrictions as a surface water abstraction.

Classification of Ground-water Effects on Surface Waters	Magnitude of Potential Effect on Surface Water	Management Approach
Class 3: Medium	The surface water depletion effect is greater than the "Negligible" classification and calculated as less than 50% and greater than or equal to 20% of the groundwater pumping rate after 100 days of pumping.	The calculated loss of surface water is included in the surface water allocation regime, but no specific low flow restrictions are imposed on the groundwater abstraction because the effect is not direct.
Class 4: Low	The surface water depletion effect is greater than the "Negligible" classification and calculated as less than 20% of the groundwater pumping rate after 100 days of pumping.	No surface water management rules required because the effect is small and delayed.
Class 5: Negligible	The effect is not classified as riparian and the calculated surface water depletion effect after 100 days pumping is less than either 1% of the minimum flow for the surface water body or 5 L/s (whichever is the smaller).	No surface water management rules required because the effect is small. This dispensation for small abstraction effects recognises the uncertainties associated with trying to quantify surface water depletion effects.

69. Both the seven-day and 100-day pumping periods are used for the assessment of "high" surface water depletion effects because they describe two different circumstances (short-term or long-term pumping) where groundwater pumping could affect surface water bodies. However, if the effect falls into the "medium" or "low" categories, then short-term pumping effects will not be significant and only the 100-day pumping effect needs to be considered for the classification of the effect.

70. The exact cut-off values to be used for these different surface water depletion management categories is a matter of judgement as to the most reasonable basis for implementing the different levels of management restrictions. Figure 8 shows an example of the different surface water depletion effects for the proposed high, medium and low categories, and the effects of a requirement for them to cease pumping after they had been operating for 100 days – which could be the situation if low-flow restrictions were imposed during February of an irrigation season that commenced with regular pumping in November. The plot demonstrates that no immediate benefit to the stream is achieved by turning off the "medium" and "low" abstractions.

71. It is important to recognise the potential implications of including groundwater abstractions in the surface water allocation regime. For example, if the surface water core allocation block is fully allocated, this Policy could end up preventing groundwater abstractions in some areas, or conversely it could cause a surface water core allocation

block to be fully allocated and prevent any further surface water abstractions. There is insufficient information available to reliably judge the implications of this policy on the existing water allocation situation within the Region. For that reason, it should be considered whether this management approach for surface water depletion by groundwater abstractions could only be applied to consent applications for new abstractions that are lodged after the date that Policy 6-25 becomes operative, and not be applied retrospectively to existing consent holders or to applications to replace consents that have previously been exercised.

72. The use of quantified surface water depletion effects within the policy criteria will require detailed assessments of surface water depletion effects for many groundwater abstraction consent applications. Such assessments are not always clear-cut and can result in different outcomes from the analysis of different experts. Such differences of opinion are not uncommon when it comes to quantifying groundwater effects. If two differing opinions appear to be equally credible, then a precautionary approach would suggest that the more conservative interpretation should be favoured.

73. For that reason, I have considered an alternative approach to assessing individual stream depletion effects that would be more straightforward and simpler to implement. This involves the specification of clearly defined zones around surface water bodies. For example:

a. All abstractions within a specified distance from a surface water body and less than a specified depth shall be managed as a surface water abstraction. This is the approach that is currently adopted in the Oroua Water Allocation Plan.
b. All abstractions between specified distances from a surface water body and less than a specified depth range shall be included in the surface water allocation block, but shall not be subject to low flow restrictions
c. A groundwater abstraction can be exempt from these surface water management requirements if there is a clear hydrogeological basis that demonstrates the effect of pumping will not cause a more than minor effect on the surface water body.

74. The definition of these zones is administratively much simpler, but technically less correct. Therefore, I prefer an approach which requires an assessment of the actual effects that arise from each groundwater abstraction.

Policy 6-26 Saltwater Intrusion

75. Under natural groundwater flow conditions, there is an interface between fresh groundwater (derived from inland recharge from rainfall and stream seepage) and saline groundwater (derived from the sea). Groundwater abstractions near the sea coast can lower groundwater levels to such an extent that seawater can move into an aquifer, as shown schematically in Figure 9. The movement of seawater into an aquifer can create a potentially serious, large-scale, long-term and possibly irreparable contamination problem. Bores that become affected by seawater contamination could become unuseable for abstraction purposes. Therefore, a policy is required to address this issue.

76. Policy 6-26 relates to intrusion of saline water from the sea and therefore might be better termed “Seawater Intrusion” to differentiate it from other possible sources of saline water, as might occur in some of the Region’s older strata.

77. The risk posed by seawater intrusion is difficult to define because, until signs of saline water are observed in monitored boreholes, it is unclear how great the risk is. For comparison, in the case of surface water depletion effects, which are covered in Policy 6-25, the location of the surface water bodies is known and, in some situations, the effects of pumping can be directly observed. In contrast, the location of the position of the seawater interface within the underground strata is not directly observed in most cases and its response to pumping cannot be directly monitored. Therefore, recognising this uncertainty, a balance needs to be struck between protecting the resource while not unreasonably restricting groundwater development, in recognition of the enabling approach of Objective 6.3.

78. This balance can be achieved by incorporating monitoring of groundwater levels and the electrical conductivity of groundwater along the coastal margin, as part of the management approach and setting guideline criteria related to the monitoring that is undertaken. The electrical conductivity of the water is a parameter that can be measured by a field meter. It can also be measured by laboratory analysis, and if the analysis was to include measurements of the concentrations of anions and cations, it can be used to provide a measure of the mixture of fresh groundwater and any components of more saline groundwater.

79. Clause (a) of Policy 2-26 defines a zone within 5 km of the coastline within which pumping tests must be undertaken to assess the level of drawdown at the coast, and to

help in the definition of aquifer characteristics in this coastal environment. The definition of a 5 km zone appears reasonable based on the extent of drawdown effects that can occur in some coastal aquifers with low storage coefficients. I suggest a slight adjustment to wording of this Policy so as to better describe the purpose of the investigation, which should be to determine the level of drawdown at the coast, and the contribution of that drawdown to increasing the risk of seawater intrusion. Such an assessment can also be used to define the "critical discharge" of a coastal abstraction well.

80. Clause (b) defines situations where consent applications could be declined; however, in my opinion the notified wording of clause (b) is somewhat ill-defined as to what the cases are "where salt water intrusion might occur". Alternative wording for clause (b), which is related to the risk of seawater intrusion, would better reflect the approach that should be taken to evaluate this issue.

81. Clause (c) describes monitoring requirements, which should include both groundwater levels and electrical conductivity.

82. I suggest adding a clause (d) to provide guidance on what water levels should be maintained along the coastal margin. This should be based on a well-known and conservative groundwater criteria, referred to as the Ghyben-Herzberg approximation, which indicates that when groundwater levels are at an elevation above mean sea level that is more than 1/40th of the elevation of the depth at which groundwater is used in the general area (defined in metres below mean sea level), then seawater intrusion should not occur. Where this criteria is not met, then there should be a requirement for more detailed monitoring.

Key messages

1. The objective of groundwater quantity management is to enable the use of this water resource in a manner that avoids the adverse effects that can arise from over-abstraction.
2. Policies have been prepared to manage potential adverse effects that are related to:
    a. Bore construction and management.
    b. The overall magnitude of groundwater abstraction.
    c. Localised abstraction effects related to:
        i. Drawdown interference between bores.
        ii. Depletion effects on surface water bodies.
        iii. Seawater intrusion risk.
3. The policies have been worded to provide a clear description of the management outcome that is to be achieved

5. COMMENTS ON GROUNDWATER QUANTITY RULES IN THE POP

83. Chapter 15 of the POP deals with Takes, Uses and Diversions of Water and Bores. It contains Policy 15-1 related to consent decision-making, and Rules related to water abstraction.

84. Policy 15-1 should apply to groundwater as well as surface water consent applications.

85. The rules for groundwater takes are:
    a. Rule 15-2: Minor takes and uses of groundwater – Permitted;
    b. Rule 15-4: Bore and groundwater testing – Permitted;
    c. Rule 15-8: All other groundwater takes – Discretionary.

    This is considered to be a reasonable classification system.

86. Rule 15-4 classifies pumping tests on bores as a Permitted Activity. The conditions, standards and terms for that Rule include requirements for the discharge of water during the test and, therefore, I suggest that a reference to the discharge of the water should appear in the description of the activity. Also, data from the testing of bores should be provided to the Regional Council in a useful electronic format.

87. Rules 15-13 and 15-14 relate to the drilling and construction of bores.

88. Rule 15-13 in the notified version of the POP makes the drilling and construction of the bore a "restricted discretionary activity". The Horizons staff submission recommends that this should become a "permitted activity" because the requirements of ensuring appropriate construction standards and ensuring that construction details are supplied to Horizons can be achieved as the conditions for a permitted activity rule. Whilst that is theoretically correct, my understanding is that not all the drilling records are currently being supplied to Horizons and drilling standards for many boreholes need to be improved to reach the outcomes sought by NZS4411:2001. These deficiencies could be lessened by requiring a consent for the drilling of a bore.

89. The siting of a borehole and the way in which it is constructed has the potential to create adverse effects in two ways:

i. the bore drilling process creates an above ground discharge of drill cuttings and water at the drilling site; and

ii. the construction method can create a preferential pathway for contaminants to spread vertically through a groundwater system.

The issuing of a consent would allow site specific conditions to be placed on a bore drilling permit and would enable regular interaction between Horizons staff, bore owners and drillers to ensure that a high standard was achieved for the siting of bores, the standard of bore construction and the recording of information during the bore construction process.

90. The requirement for a consent would create a paper trail documenting an application to site a bore and the issuing of a permit, a copy of which must be held by the driller on site to ensure they are aware of their obligations. This level of documentation and control is not possible with a permitted activity. The bore permit would include conditions related to the bore location, the intended diameter and screened depth of the bore and its testing requirements, along with other possible conditions that may be needed to ensure that bores fulfil the requirements of Policy 6-22. The purpose of these conditions is to ensure that bores are constructed at suitable locations and minimise the creation of pathways for contamination. Bore drilling is also an important opportunity to gather useful information regarding the groundwater resource and the best circumstances should be provided for Horizons to gain this data.

91. If a decision is made that all bores require consents, then that requirement could be added to the description of a "properly constructed bore" in Policy 6-22(a), for all bores that are constructed after the One Plan becomes operative.

92. I support the Horizons Planning staff desire to minimise unnecessary consenting requirements and acknowledge that there are conditions that could be placed on a permitted activity rule that would lessen the risk of adverse effects, such as specifying separation distances from point sources of contamination and requiring bores to be screened across a single water bearing unit of consistent pressure and quality. However, based on current experience, that would still create a less desirable situation for Horizons to obtain good quality bore information and there would still be some bores that would require consents, due to their location or method of construction, which would not meet the permitted activity conditions.

93. As an alternative approach, that could be consistently applied for all bore drilling activities, consideration could be given to classifying the drilling and construction of a bore as a "controlled activity". This ensures that a specific consent document is issued for each bore to provide a desirable paper trail, whilst minimising the time and extra costs associated with processing consent documents.

94. It seems to me that the judgement between whether the bore drilling activity is authorised by a consent or as a permitted activity comes down to a consideration of whether the potential adverse effects can be adequately controlled through a single set of rules or whether a more site specific judgement is required. An additional consideration is related to which authorisation process provides the best means of ensuring good quality information is provided to Horizons to aid in their understanding and management of the groundwater resource.

95. The staff submission also seeks to clarify that Rule 15-13 should only apply to the drilling of a bore. This is considered to be an appropriate change..

96. Rule 15-14 prohibits the occurrence of unsealed bores that allow contaminants from the land surface to enter the bore, or the wastage of water under artesian conditions. I consider that to be an appropriate rule.

6. PUMPING TEST GUIDELINES

97. Many of the policies and rules in the POP refer to the need to conduct pumping tests on bores in order to provide information on bore yields, aquifer conditions and hydraulic parameters, and to enable quantification of the drawdown effects on neighbouring bores and surface water bodies.

98. Undertaking a pumping test that provides the information required to properly implement the policies and rules in the POP is not a straightforward exercise. It requires careful planning to choose the correct pumping rate, the bores in which water levels are to be monitored, the discharge of the pumped water, and the timing and duration of the test, as well as many other factors.

99. Unfortunately, there are many examples of tests that have been conducted under poor operating conditions such that the information that is required to assess the effects of an abstraction have not been clearly determined. For example, a common problem seems to be the use of observation bores that are themselves being pumped during the testing period. The pumping that occurs within these observation bores is of such a scale that it masks the ability to observe any drawdown effect from the bore that is tested, thereby negating the gathering of useful information from the test.

100. As a result, there is clearly a need for Pumping Test Guidelines to be prepared, distributed and promoted throughout the Region. I am currently working with Horizons staff to prepare such a document.

101. One of the things that becomes apparent when preparing such a document is that it is not possible to prescribe exactly what should happen for every pumping test situation. There are simply so many variables that the planning and implementation of a pumping test must be determined on a case-by-case basis. For that reason, I am of the view that a Pumping Test Guidelines document is best left outside of the policies and rules of the POP document. The policies and rules of the POP can be worded to describe what the pumping tests should achieve, but the details of the pumping tests will need to be determined by consent users and Horizons staff on a case-by-case basis.

102. One aspect that the draft guideline document emphasises is the need for careful planning in advance of the pumping test, and the benefits of involving Horizons technical staff in that pre-test planning process. In my opinion, the best way to improve the standard of pumping tests in the Region is for Horizons technical staff to work with the local drillers and/or consultants who typically carry out such tests, to explain to them what is required on actual pumping test projects and to provide them with a detailed review of each of the test procedures once the test has been completed and the data analysed.

7. GROUNDWATER QUALITY

103. I have been asked by Horizons to provide comment on Policy 6-6, which deals with the maintenance of groundwater quality. Groundwater quality is determined by a combination of natural interaction between the water and the strata which it passes through, and additional inputs derived from land use activities within the recharge areas where water infiltrates downwards into the groundwater resource. From a water resources management perspective, only the inputs derived from land use activities can be managed to influence the quality of the groundwater, eg. septic tanks or landfills.

104. Most of the management approaches for avoiding adverse effects from land use activities on groundwater are covered by other policies, which are described in Section 6.4.2.3 of the Water Chapter. This section deals with Discharges and Land Use Activities Affecting Water Quality, and includes the following policies that relate to impacts on groundwater quality:

i. Policy 6-9 – Point Source Discharges to Land.
ii. Policy 6-10 – Options for Discharges to Surface Water and Land.
iii. Policy 6-11 - Human Sewage Discharges.

There are other aspects of the POP relating to more general land use activities that also impact on groundwater, and these are covered in Chapter 13 of the POP. All these topics are being covered in the evidence from other witnesses.

105. While those other policies cover specific activities that affect groundwater quality, it is still considered useful and appropriate to have a policy that relates specifically to the groundwater quality that is to be achieved.

106. Policy 6-6 links back to Objective 6-2 (b) and to the third bullet point listed in Section 6.1.1, which describes the Scope of the Water Chapter. In all these three places, reference is made to maintaining the existing groundwater quality. However, any development or intensification of land use has the potential to cause a deterioration in groundwater quality. For example, every dwelling with an on-site wastewater disposal system adds microbiological contaminants and nutrients to the groundwater around the disposal point. Increases in productive farm land lead to increased stock numbers and fertiliser application, and irrigation adds to the drainage of contaminants to groundwater. Subdivision developments create sewer and stormwater reticulation and discharges, which affect groundwater quality.

107. Therefore, in its strictest sense, a requirement to maintain existing groundwater quality can be linked to a requirement to prevent any intensification of land use, which I suspect is not an intended outcome of the POP.

108. In contrast, Policy 6-9 uses a slightly different wording where it states that discharges of contaminants onto or into land shall be managed in a manner which ensures that there is "no significant degradation" of the existing groundwater quality. It seems to me that Policy 6-9 allows a certain degree of groundwater degradation, which is an inevitable consequence of most point source and diffuse discharges to land; that is not consistent with the groundwater quality Objective (6-2(b)) and Policy 6-6 of maintaining existing groundwater quality.

109. It is typical for land-based contaminants derived from the ground surface to have their greatest impact on shallow groundwater quality near the point of discharge. However, as contaminants move through the groundwater system, their concentrations are reduced by a range of natural processes including:

i. Dilution – with other groundwater and recharge water.
ii. Dispersion – through the spatially variable groundwater velocities that occur within the highly heterogeneous alluvial strata.
iii. Filtration – through zones of sand and silt.
iv. Adsorption – onto the solid particles that form the aquifers and aquitards.
v. Decay – micro-biological contaminants all die off over time.
vi. Biological degradation – naturally occurring organisms within the subsurface environment degrade a range of contaminants.
vii. Chemical transformation – some contaminants transform into innocuous by-products within the subsurface environment.

110. Therefore, with increasing lateral distance and increasing depth from the source of the contamination, the concentration of contaminants in the groundwater decreases and may eventually become undetectable.

111. As a result, I suggest that Policy 6-6 can still retain its title, Maintenance of Groundwater Quality. However, it could be re-worded refer to managing effects on groundwater quality, instead of to maintaining the existing quality

112. This change in wording is based on the concept that the point at which we want to maintain groundwater quality is at the point where it is potentially contacted by people and the environment, ie. in bores and in seepages into surface water bodies. It also

indicates that it is acceptable for changes in the use of land to occur that may impact on the groundwater at the water table, provided these impacts are controlled and localised, and do not extend to the locations where groundwater affects people and the surface environment.

113. The changed wording I have proposed could be viewed as keeping the original intention in the notified POP, but changing the point of compliance from "all groundwater" to "groundwater at the point where it is utilised".

114. Similar changes to maintaining groundwater quality to preserve its existing and future uses and values could be made to the corresponding scope and objective.

Key messages

1. Land use intensification will impact on groundwater quality; however, this should be managed so that it does not adversely affect the uses and values of the groundwater resource at points where it is utilised by bores and in the areas where it contributes seepage to surface water features.

8. CONCLUSION

115. The policies of the POP currently define the main issues related to groundwater management in Horizons' Region. As described in this evidence, the policies can be refined further to provide greater detail as to how they can actually be implemented. The proposed policy structure can be summarised in the following chart.

Table 2. Management Summary of Groundwater Abstractions in Horizons' Region

Policy		What the Policy Seeks to Achieve	Criteria to Determine that the Goal is Achieved
Bore Construction (Policy 6.22)		Adequate separation distance between bores to manage drawdown interference.	No more than minor adverse impacts on reliability for existing properly constructed bores (ie. Policy 6.24).
		A good standard of bore construction.	Compliance with NZS 4411:2001.
		Efficient bore design and abstraction systems.	Comparison with yield and drawdown characteristics of neighbouring bores.
Annual Allocation Volumes (Policy 6.23)		Sustainable abstractions that do not exceed annual useable aquifer recharge.	Total of all abstractions within a Groundwater Management Zone not to exceed 5% of average annual rainfall.
Effects of Abstraction	Drawdown Interference Effects Between Bores (Policy 6.24)	Avoid more than minor impacts on reliability of supply for existing properly constructed bores.	a) Properly constructed bores defined by Policy 6.22 b) Reliability assessed from yield and drawdown requirements of neighbouring bores.
	Effects on Surface Water Bodies (Policy 6.25)	Groundwater abstractions that cause large and/or rapid effects on surface water bodies should be subject to surface water management rules.	Groundwater abstractions placed into five classes, defined as riparian, high, medium low or negligible, based on the quantification of the proportion of the bore abstraction rate that affects surface flow over a fixed period of time.
	Effects on Seawater Intrusion (Policy 6.26)	Avoid seawater intrusion into aquifers.	Monitoring of groundwater levels and electrical conductivity, and adaptive management to restrict abstractions if the risk of adverse effects increases.
Groundwater Quality (Policy 6.6)		Management of land use activities and monitoring of groundwater quality to preserve its existing and future uses and values.	Groundwater quality in bores and surface seepage is preserved so that the existing and future uses, and values of the groundwater resource and surface seepages can continue.

9. REFERENCES

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Peter Callander
August 2009

APPENDIX A

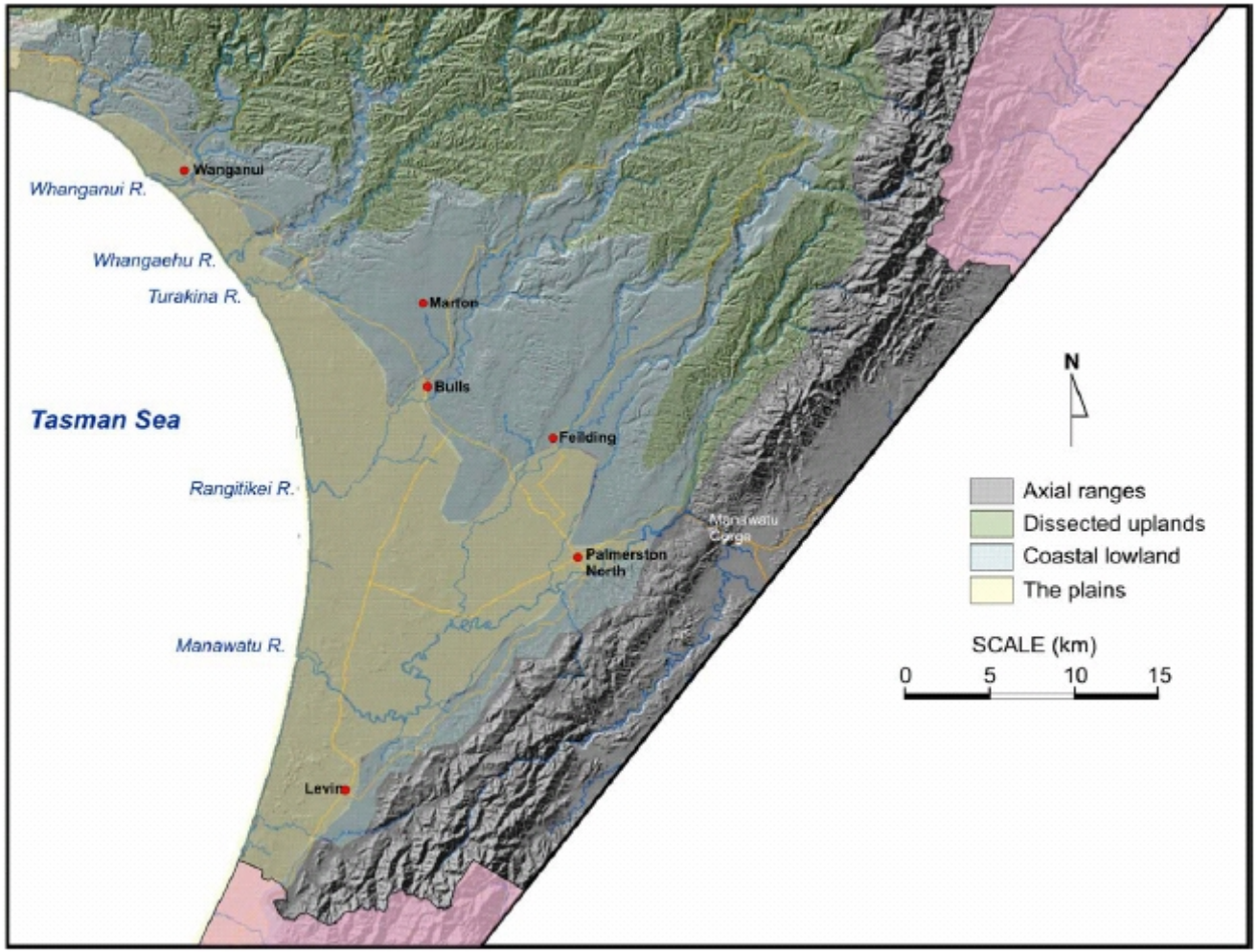

Figure 1: Physiology of the western subdivision of the Region
(Source: Begg, J.G., Palmer, A. and Gyopari, M., 2005.)

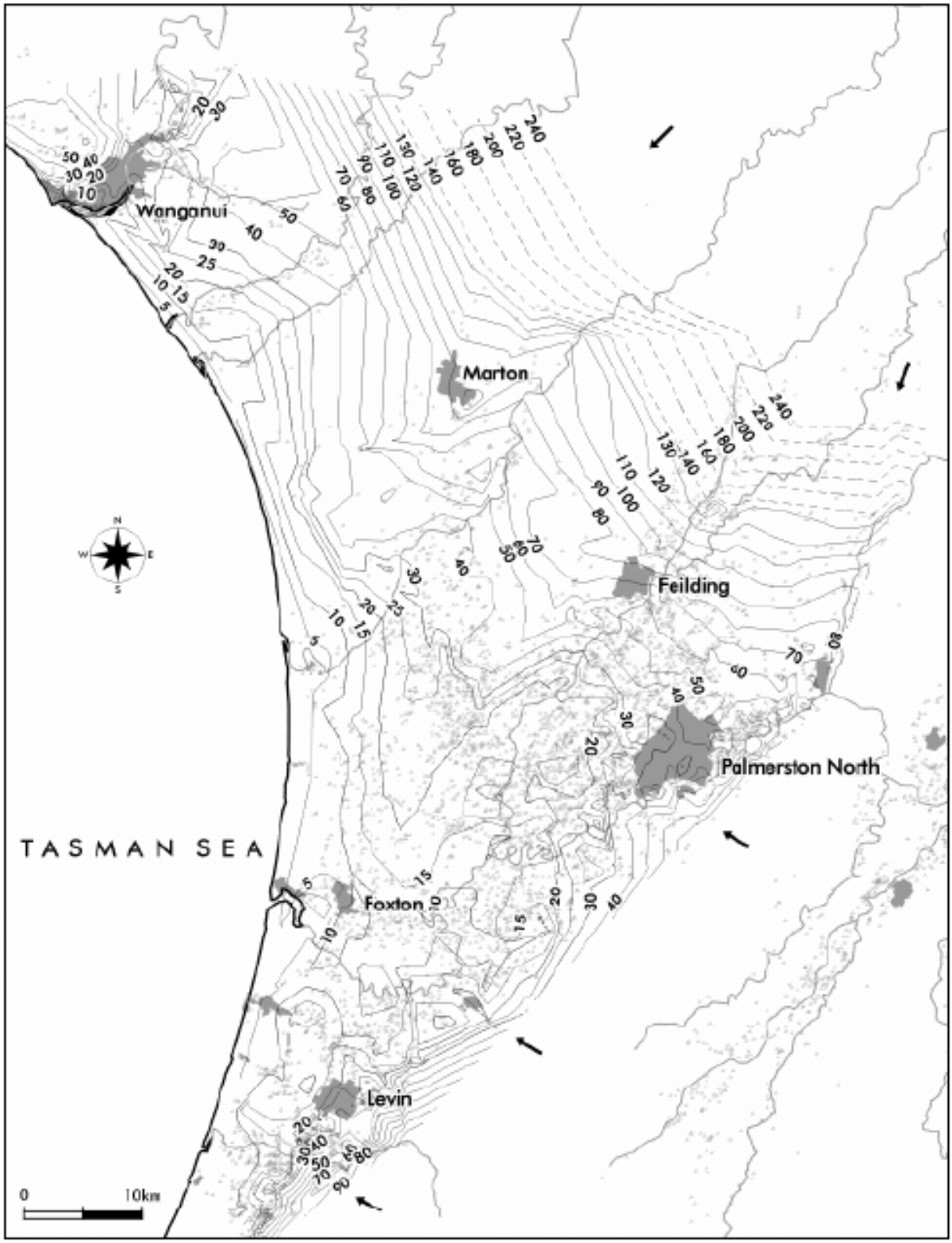

Figure 2: Groundwater level map for the Southwest Basin. Contours are in metres above mean sea level. Arrows indicate regional groundwater recharge and small dots represent observation sites.
(Source: Bekesi, G., 2001)

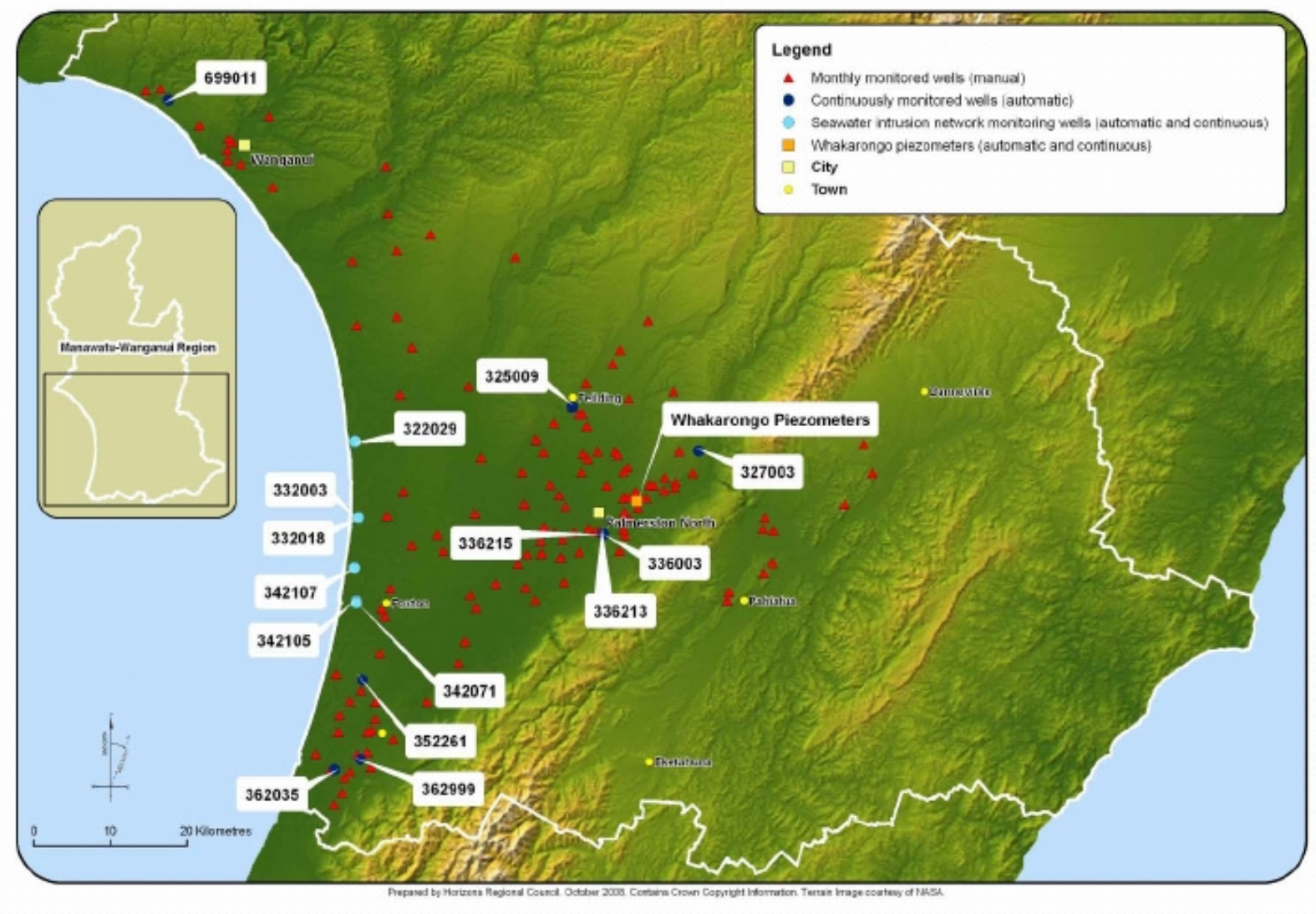

Figure 3: Groundwater level and salinity monitoring networks in the Manawatu-Wanganui Region. The legend shows different hydrogeological monitoring networks. (Source: Zarour, H. 2008.)

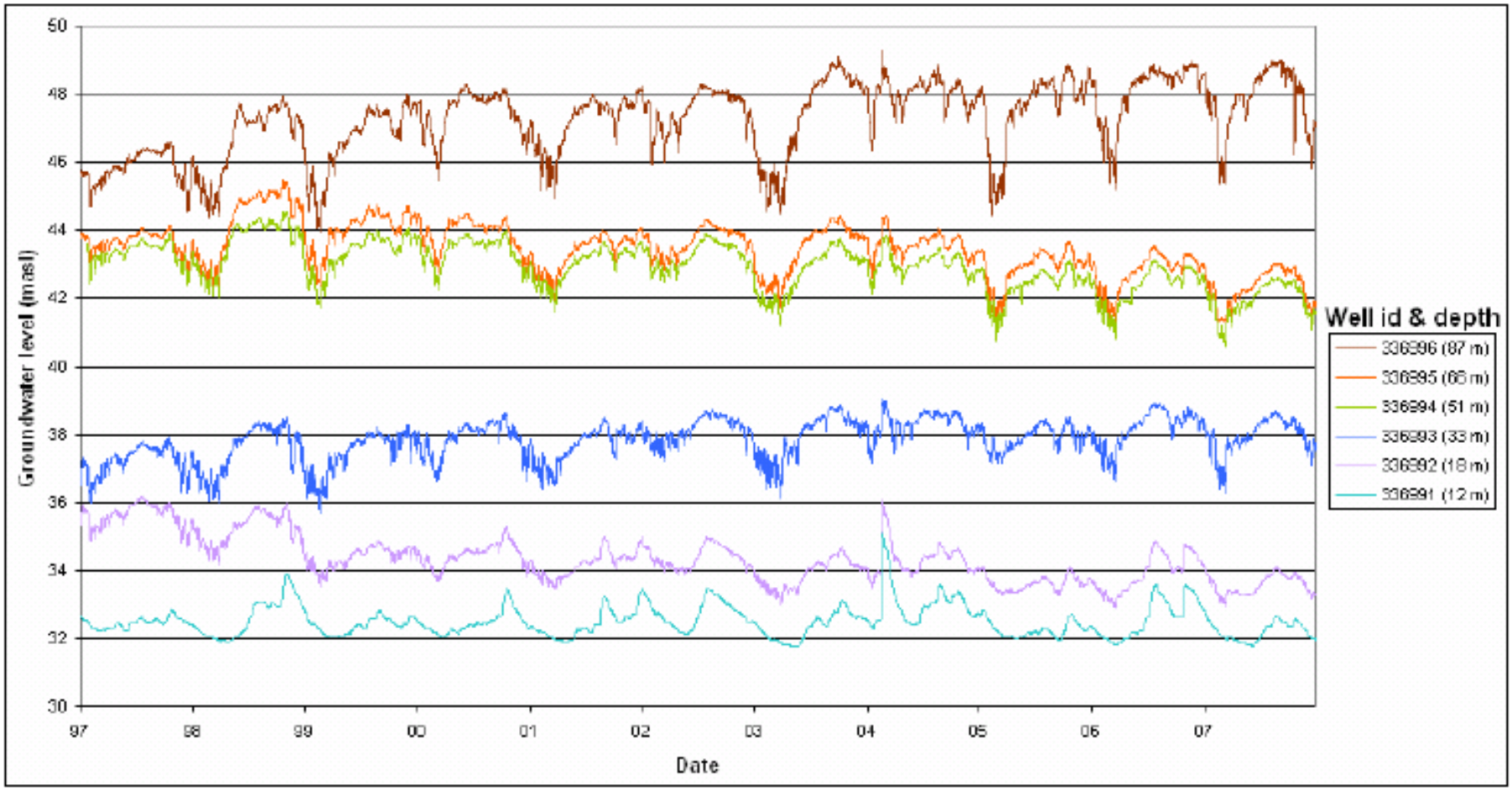

Figure 4: Daily average groundwater levels as monitored in the Whakarongo multi level piezometer system.
(Source: Zarour, H. 2008.)

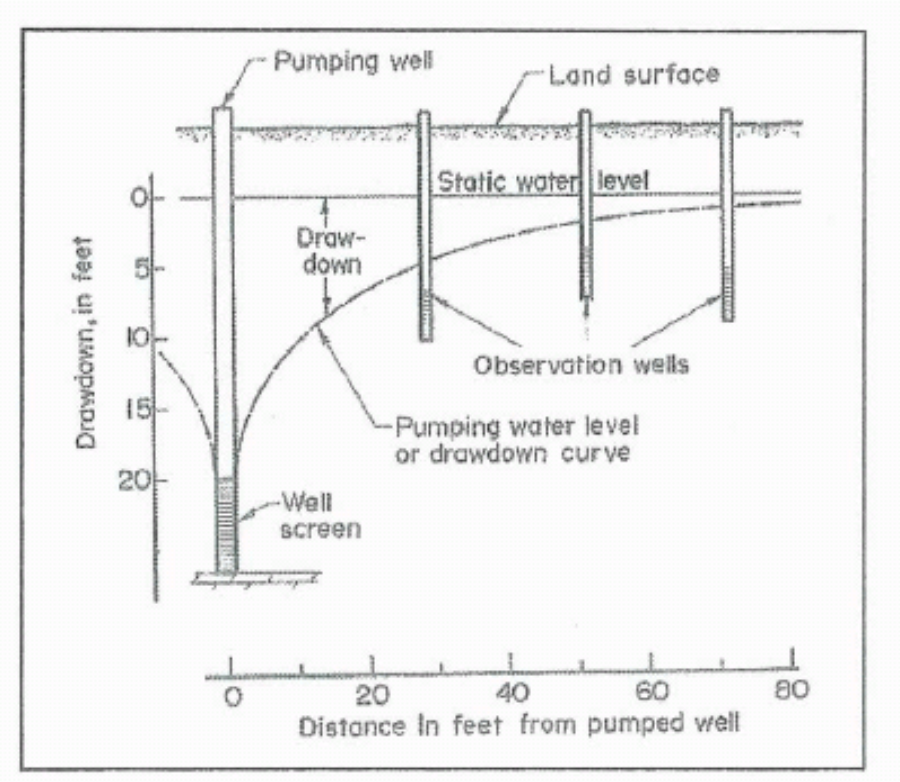

Figure 5a: Trace of half the cone of depression showing variation in drawdown with distance from the pumped well.
(Source: Johnston, 1966.)

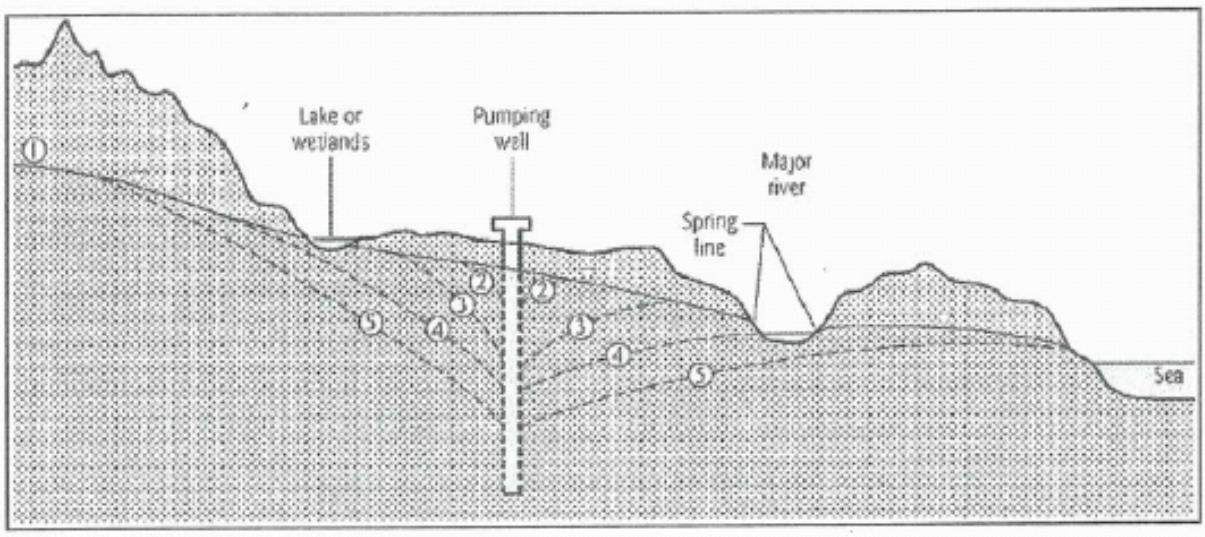

Figure 5b: Possible drawdown effect on surface water systems.
(Source: Younger, 2007.)

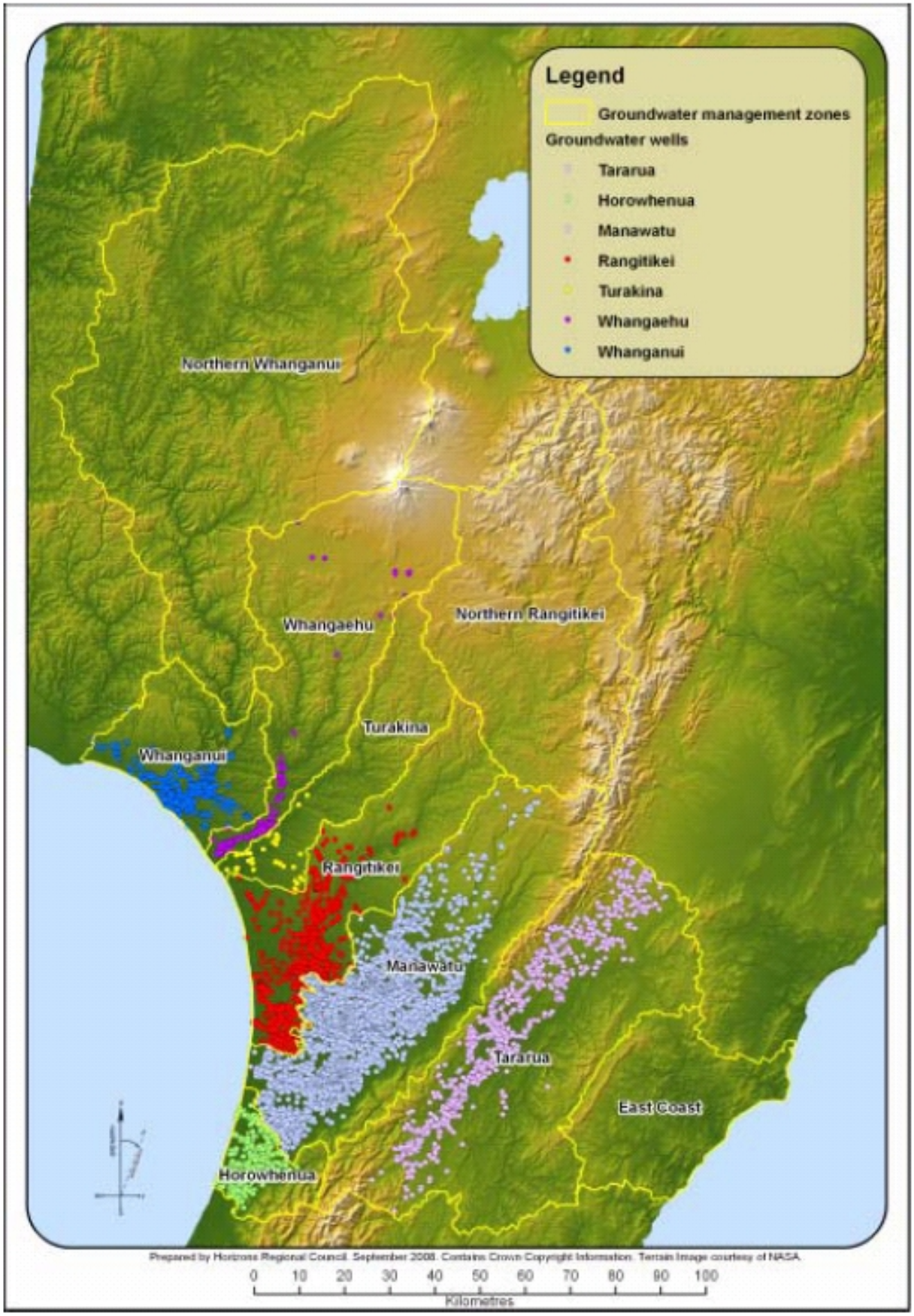

Figure 6: Groundwater management zones in the Manawatu-Wanganui Region and location of wells within each zone.
(Source: Zarour, H. 2008)

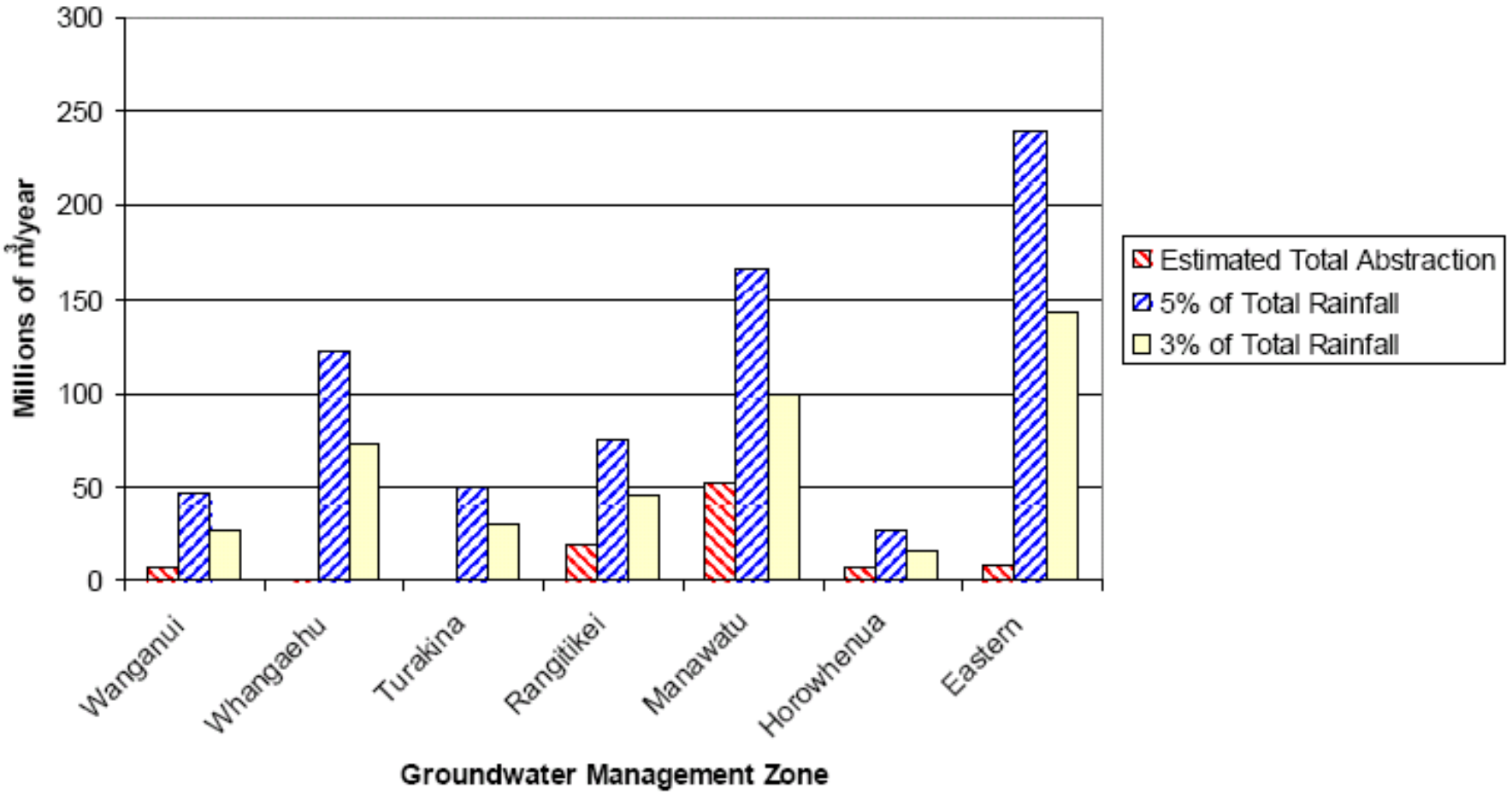

Figure 7: Estimates of Current Abstraction Rates and Annual Allocation Limits

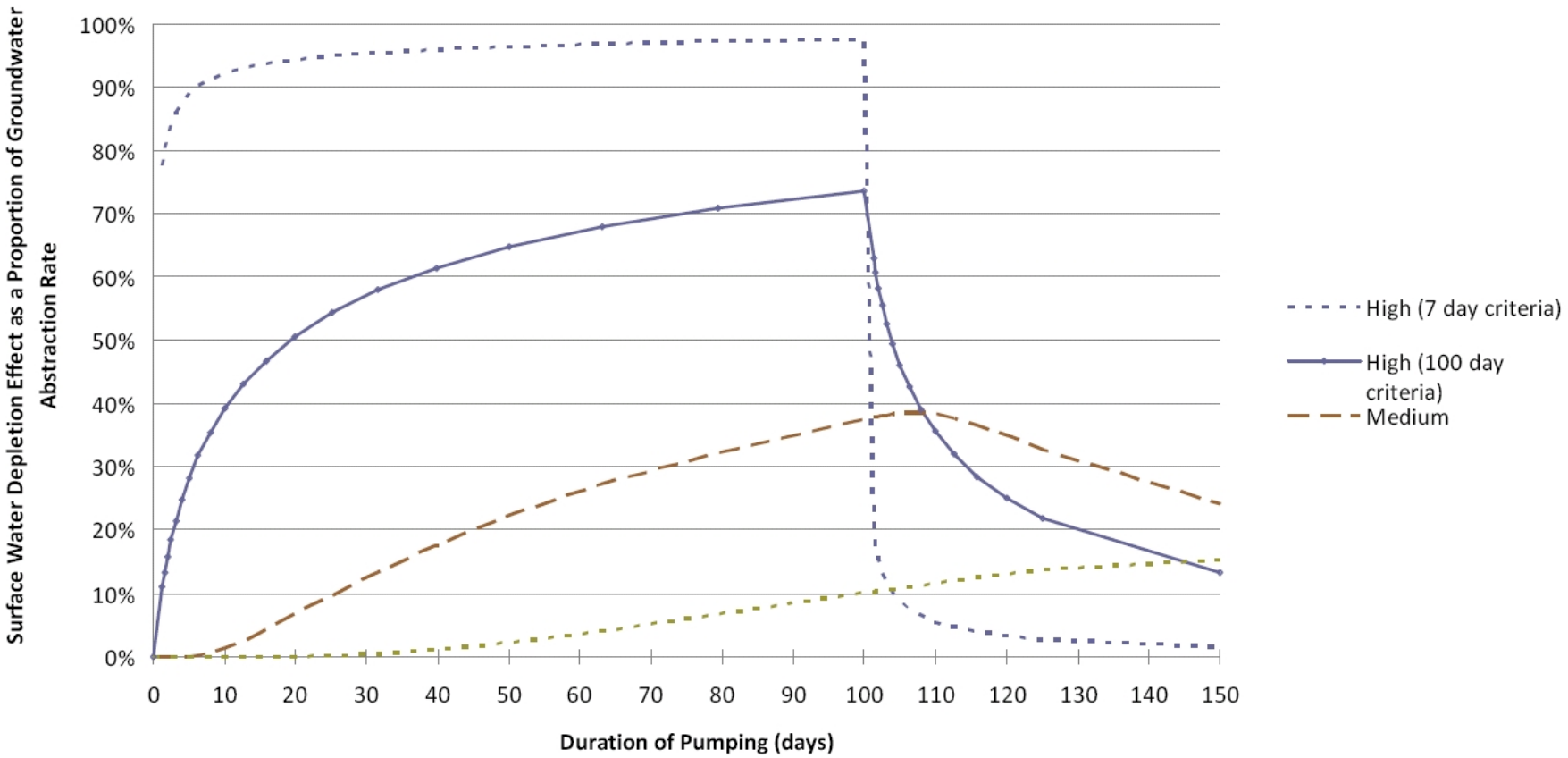

Figure 8: Example Classification of Surface Water Depletion Effects

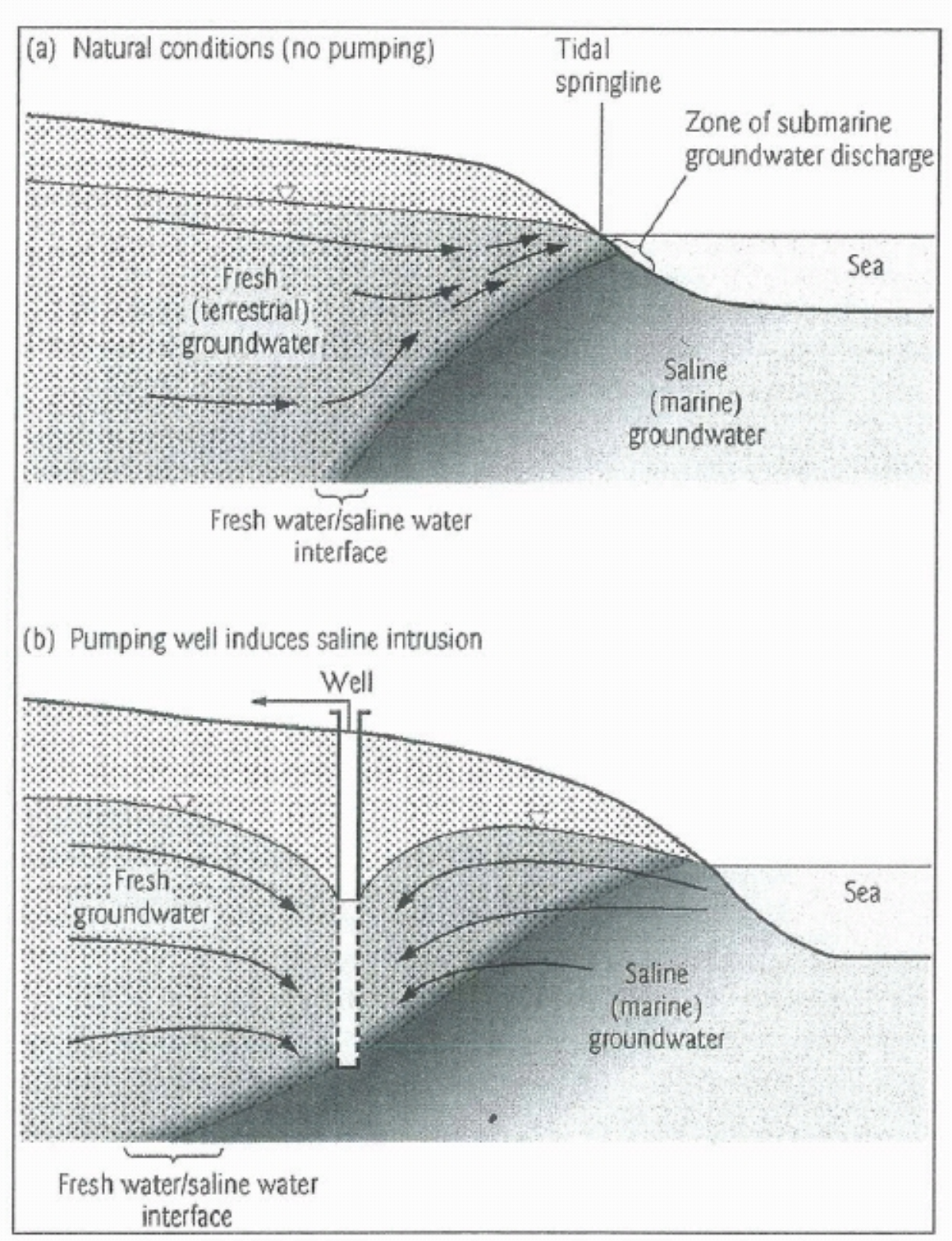

Figure 9: The seawater intrusion process.
(Source: Younger, 2007.)

APPENDIX B

SUGGESTED WORDING CHANGES TO GROUNDWATER QUANTITY POLICIES

6.4.3.3 **Policies for Bores and Groundwater**

Policy 6-21: Overall approach for bore management and groundwater allocation

(a) New bores* shall be constructed and managed in accordance with Policy 6-22.

(b) Total groundwater allocations shall comply with the annual allocable volumes for groundwater management zones set out in Policy 6-23.

(c) The measured and/or modelled effects of a proposed groundwater take on other groundwater users, surface waterbodies and ~~salt~~seawater intrusion shall be managed in accordance with Policies 6-24, 6-25 and 6-26.

Policy 6-22: Bore construction ~~development~~ and management

(a) ~~New b~~Bores* shall be sited to ensure adequate separation from existing bores*, ~~and to avoid an over concentration of bores* in a particular area,~~ wherever practicable, so as to avoid or mitigate effects on the reliability of supply of properly constructed existing bores*. A bore that is constructed in general accordance with clauses (a)-(d) of this Policy, and is recorded on Horizons groundwater database, shall be considered to be a properly constructed bore.

(b) ~~New b~~Bores* shall generally be constructed, and bore* logs and other records prepared, in accordance with the relevant standards at the time of drilling. The current standard is NZS 4411:2001 Environmental Standard for Drilling of Soil and Rock.

(c) ~~New b~~Bores* shall be designed to ensure a high degree of efficiency with respect to bore* development, bore* depth and diameter, and screen depth and length. A high degree of efficiency is achieved where:

- the bore adequately penetrates the aquifer from which water is being drawn at a depth sufficient to enable water to be drawn all year (i.e. the bore depth allows for the placement of a pump below the depth of seasonally low groundwater levels with sufficient allowance for drawdown requirements),
- the bore* is adequately maintained,
- the bore* is of sufficient diameter and the bore* has a pump capable of drawing water to the land surface

Wherever possible, measurements of the yield and drawdown characteristics of a bore should be used to indicate its efficiency.

(d) ~~New b~~Bores* shall be sited, constructed and used in a manner that prevents:

(i) contaminants from entering the bore* from the land surface
(ii) the wastage of water in artesian conditions.

(e) Bores* that are no longer required shall be decommissioned in general accordance with the relevant standards at the time of drilling. The current

standard is NZS 4411:2001 Environmental Standard for Drilling of Soil and Rock.

Policy 6-23: Groundwater Management Zones

The ~~total amount~~ annual allocated volume of groundwater taken from each groundwater management zone mapped in Schedule C shall not exceed ~~comply with~~ the annual allocable volume specified in Schedule C.

Consents to take groundwater from bores shall list a maximum annual abstraction value as one of the consent conditions, in addition to their peak abstraction rate and maximum daily abstraction rate.

Policy 6-24: Effects of groundwater takes on other groundwater takes

(a) Consent applicants wishing to take groundwater shall ~~generally~~ be required to undertake pumping tests and hydrogeological assessments in order to determine likely impact on existing groundwater takes in the vicinity. The purpose of the pumping tests is to provide information on bore performance, aquifer conditions and hydraulic parameters and to quantify the potential effects on existing bores.

(b) Consent conditions restricting the rate and/or duration of pumping shall be imposed on new takes of groundwater where this is necessary to avoid ~~significant~~ drawdown impacts that, in combination with other nearby abstractions, cause a more than minor reduction in the reliability of supply from any existing lawful groundwater take from a properly constructed bore that has been constructed in accordance with Policy 6-22 ~~on existing groundwater takes from good quality bores* in the vicinity. A groundwater take is considered to be from a good quality bore* in circumstances where the bore* penetrates the aquifer from which water is being drawn at a depth sufficient to enable water to be drawn all year (ie., the bore* depth is below the range of seasonal fluctuations in groundwater level), the bore* is adequately maintained, the bore* is of sufficient diameter and is screened to reasonably minimise drawdown, and the bore* has a pump capable of drawing water from its base to the land surface.~~ This relates to the control of localised drawdown effects that are more than minor and therefore shall only apply to effects from bores located no further than 3 kilometres from each other within the same hydrogeologic system that are estimated to cause more than 0.5 m of drawdown within a 100 day pumping period.

(c) Consent conditions specifying short-term restrictions on the rate and/or duration of pumping may also be imposed on new takes of groundwater where this is necessary to avoid ~~significant~~ drawdown impacts that cause a more than minor reduction in the reliability of supply of ~~on~~ existing bores* that are not ~~of a good quality~~ properly constructed, in order to allow sufficient time for such bores* to be upgraded or replaced.

(d) The Regional Council may encourage consent applicants to consider the option of providing water to neighbouring properties in circumstances where this would be more practical than meeting the requirements of subsections (b) or (c).

Policy 6-25: Effects of groundwater takes on surface waterbodies

The effects of groundwater takes on surface waterbodies, including wetlands, shall be managed in the following manner:

~~(a) An appropriate scientific method shall be used to calculate the likely degree of connection between the groundwater and surface water at the location of the groundwater take.~~

~~(b) To the extent justified by the calculation under subsection (a), the groundwater take shall be assessed and managed as if it were a surface take from the water management zone(s) to which it is connected.~~

(a) The effects of a groundwater abstraction on surface water shall be assessed according to the "Guidelines for the Assessment of Groundwater Abstraction Effects on Stream Flow" prepared by Environment Canterbury (Environment Canterbury Report R00/11, ISBN 1-86937-387-1, First Edition, June 2000) or similar quantitative methods approved by the Manawatu-Wanganui Regional Council.

(b) Consent applications for new groundwater abstractions (not including replacements of previously exercised consents), lodged after the date that this Policy becomes operative, shall have their surface water depletion effects classified and managed in the following way:

Classification of Groundwater Effecta on Surface Waters	Magnitude of Surface Water Depletion Effect	Management Approach
Class 1: Riparian	Any groundwater abstraction screened within the geologically Recent river bed strata of a surface waterway.	The groundwater abstraction is subject to the same restrictions as a surface water abstraction, unless there is clear hydrogeological evidence that demonstrates that the effect of pumping will not impact on the surface water way.
Class 2: High	The surface water depletion effect is greater than the "Negligible" classification and calculated as greater than or equal to 90% of the groundwater pumping rate after seven days of pumping, or greater than or equal to 50% of the average groundwater pumping rate after 100 days of pumping.	The groundwater abstraction is subject to the same restrictions as a surface water abstraction.
Class 3: Medium	The surface water depletion effect is greater than the "Negligible" classification and is calculated as less than 50% and greater than or equal to 20% of the groundwater pumping rate after 100 days of pumping.	The calculated loss of surface water is included in the surface water allocation regime, but no specific low flow restrictions are imposed on the groundwater abstraction because the effect is not direct.

Class 4: Low	The surface water depletion effect is greater than the "Negligible" classification and is calculated as less than 20% of the groundwater pumping rate after 100 days of pumping.	No surface water management rules required because the effect is small and delayed.
Class 5: Negligible	The effect is not classified as riparian and the calculated surface water depletion effect after 100 days pumping is less than either 1% of the minimum flow for the surface waterway or 5 L/s (whichever is the smaller).	No surface water management rules required because the effect is small. This dispensation for small abstraction effects recognises the uncertainties associated with trying to quantify surface water depletion effects.

Policy 6-26: ~~Saltwater~~ Seawater intrusion

~~Salt~~Seawater intrusion along the coastal margins of the Region arising from groundwater takes shall be managed by the following measures:

(a) Consent applicants wishing to take groundwater within 5 km of the coastal mean high water spring line shall be required to carry out pumping tests and hydrogeological assessments~~ in order~~ to determine the level of drawdown ~~at the coast~~ and the ~~likelihood of inducing salt~~ contribution of that drawdown to increasing the risk of seawater intrusion.

(b) ~~In cases where saltwater intrusion might occur, t~~ The consent application may be declined or the amount of water that can be taken shall be limited to an amount that ~~restricts~~ lessens the ~~likelihood~~ risk of ~~salt~~ seawater intrusion.

(c) In addition, consents to take groundwater within 5 km of the coast shall contain conditions relating to the monitoring of groundwater levels and electrical conductivity and the restriction or suspension of takes if specified electrical conductivity thresholds are reached or exceeded. These monitoring requirements and electrical conductivity thresholds will be determined on a case by case basis and may include requirements for regular chemical analyses.

(d) Wherever possible, groundwater abstractions shall be managed to avoid critical pumping rates that could draw seawater towards the pumping bore and to maintain groundwater pressures along the coastal margin that are above mean sea level by an amount that is one-fortieth (1/40) of the depth to which groundwater is used in the general area (as defined in metres below mean sea level) so as to avoid water quality problems in abstraction bores. Where this height of fresh water along the coastal margin is not maintained, then extra monitoring of groundwater levels and groundwater quality must be carried out at the coast.

6.1 Explanations and Principal Reasons

Groundwater

Groundwater quality and quantity is connected to that of surface water and this is recognised in this chapter, while providing for its management separately. Bores will be managed to ensure that they are ~~of good quality~~ properly constructed and do not lead to contamination of groundwater, wastage of water or unnecessary effects on other bores or surface waterbodies (Policy 6-22, 6-24, 6-25). Groundwater management zones have been established and sustainable allocations set. Groundwater takes will be managed within these allocations (6-23). Groundwater quality within the Region is good and is not declining, but maintaining this good quality will be a consideration when managing discharges (Policy 6-9).

SUGGESTED WORDING CHANGES TO GROUNDWATER QUANTITY RULES

15 Takes, Uses and Diversions of Water, and Bores

15.1 Policies

Policy 15-1: Consent decision-making for takes and uses of surface water and groundwater

When making decisions on resource consent applications, and setting consent conditions, for takes and uses of surface water and groundwater the Regional Council will:

(a) recognise and provide for the provisions of Chapter 6, in particular the Policies in Section 6.4.3

(b) seek to avoid any adverse effects on other lawful activities, particularly on other surface water takes and groundwater takes from properly constructed bores (as described in Policy 6-22 and 6-24).

(c) have regard to the objectives and policies of Chapters 2, 3 and 7 to the extent that they are relevant to the activity.

15.2 Rules – Takes and Uses of Water

Rule	Activity	Classification	Conditions/Standards/Terms	Control/Discretion Non-Notification
15-4 **Bore and groundwater testing**	The taking, ~~and~~ use and discharge of groundwater for bore or groundwater testing purposes pursuant to s 14(1) RMA, and any consequential discharge into water or onto land pursuant to s 15(1) RMA.	**Permitted**	(a) The Regional Council shall be notified in writing at least 5 working days prior to commencement of the test. (b) The rate of take shall not exceed 60 l/s. (c) The duration of any single test shall not exceed 7 days. (d) The activity shall be carried out in accordance with the NZS 4411:2001 Environmental Standard for Drilling of Soil and Rock. (e) The take shall not lower the water level in any wetland that is a rare or threatened habitat*. (f) Where the discharge is into water the discharge shall not: (i) change the receiving water temperature by more than 3°C	

Rule	Activity	Classification	Conditions/Standards/Terms	Control/Discretion Non-Notification
			after reasonable mixing (ii) cause erosion of the bed of the receiving waterbody (iii) alter the natural course of the receiving waterbody (iv) cause visibly noticeable iron flocculation in the receiving waterbody. (g) Where the discharge is onto land the discharge shall not increase land instability or the risk of erosion. (h) The discharge shall not cause or contribute to flooding on any other property*. (i) Following completion of the test the bore shall be covered and secured as soon as practicable. (j) Records of all pumping and recovery tests shall be kept by the owner, including the location of the pumped bore and any monitoring bores, the flow rate during pumping, the water level at the pumped bore and any monitoring bores, and the time at which all measurements are taken. These records shall be forwarded to the Regional Council, in an electronic format approved by the Regional Council, within 1 month of completion of the tests.	

15.4 Rules – Bore Drilling and Bore Sealing

Rule	Activity	Classification	Conditions/Standards/Terms	Control/Discretion Non-Notification
15-13 **Drilling and bore construction**	The drilling, construction or alteration of any bore* ~~or hole that extends below the seasonally highest groundwater level,~~ and any associated discharge of water or contaminants is a controlled activity if it meets the conditions of this rule. If these conditions are not met then the activity is classified as discretionary.	~~Restricted discretionary~~ Controlled	(a) The bore shall be constructed and maintained in general accordance with the relevant standards at the time of drilling. Th current standard is NZS 4411:2001 Environmental Standard for Drilling of Soil and Rock. (b) The bore shall be sited and constructed in a manner that minimises the risk of adverse environmental effects. (c) Consent conditions shall include details of the bore location, the intended diameter and screened depth, and any testing requirements. (d) A copy of the issued consent shall be held on-site by the bore driller whilst he/she is undertaking work on the construction of the bore. (e) Details of construction, bore logs, pumping tests and any other test results shall be lodged with Horizons Regional Council within 30 days of the completion of the bore construction.	~~Discretion is restricted to:~~ ~~(a) compliance with the NZS 4411:2001 Environmental Standard for Drilling of Soil and Rock~~ ~~(b) bore location, size and depth~~ ~~(c) bore screening~~ ~~(d) backflow prevention~~ ~~(e) information requirements including bore logs, piezometric levels, groundwater tests, and bore construction details~~ ~~(f) duration of consent~~ ~~(g) review of consent conditions~~ ~~(h) compliance monitoring.~~ ~~Resource consent applications under this rule will not be notified and written approval of affected persons will not be required (notice of applications need not be served on affected persons).~~

SUGGESTED WORDING CHANGES TO GROUNDWATER QUALITY POLICY

6.1.1 Scope

This chapter addresses the management of freshwater in the Manawatu-Wanganui Region. It covers:

- **Water management zones and values** – the establishment of water management zones* and associated water management values for each zone, for the purpose of managing water quality, water quantity and activities in river and lake beds.
- **Surface water quality** – the establishment of water quality standards for rivers and lakes, in order to give effect to the values, together with a policy regime of maintaining water quality in those water management zones* that meet their water quality standards, and improving water quality over time in those water management zones that do not.
- **Groundwater quality** – the maintenance of ~~existing~~ groundwater quality to preserve or enhance its existing and future uses and values.
- **Discharges and land-use activities affecting water quality** – the management of discharges into surface water, discharges onto or into land, and diffuse run-off and other land-use activities affecting surface water and groundwater quality.
- **Surface water quantity and allocation** – the establishment of minimum flows and allocation regimes for rivers, and the management of water takes and other activities affecting surface water quantity.
- **Groundwater quantity, ~~and~~ allocation, and bores** – the establishment of groundwater management zones (GMZ), identification of respective allocable volumes and the active management of the effects of groundwater takes on the environment and on users of the resource.
- **Beds of rivers and lakes** – the management of activities that disturb the beds of rivers and lakes, the management of existing and new structures in the beds of rivers and lakes and the establishment of sustainable gravel extraction limits for rivers.

The effects of hillcountry erosion on water quality are addressed in Chapter 5. The ecological impacts of takes, diversions, discharges and drainage on rare and threatened habitats* and at-risk habitats* are addressed in Chapter 7.

Objective 6-2: Water quality

(a) Surface water quality is managed to ensure that:

(i) water quality is maintained in those rivers where the existing water quality is sufficient to support the values of the river

(ii) water quality is enhanced in those rivers where the existing water quality is not sufficient to support the values of the river

(iii) accelerated eutrophication or sedimentation of lakes in the Region is prevented or minimised

(iv) the special values of rivers protected by water conservation orders and local water conservation notices are maintained.

(b) Groundwater quality is managed to ensure that ~~the existing~~ groundwater quality is maintained or enhanced to preserve its existing and future uses and values.

6.4.2.2 Groundwater Quality

Policy 6-6: Maintenance of groundwater quality

(a) Discharges and land-use activities shall be managed in a manner which maintains or enhances~~the existing~~ groundwater quality to preserve its existing and future uses and values.

(b) Groundwater takes in the vicinity of the coast shall be managed in a manner which avoids ~~salt~~seawater intrusion.