

**Before the Commissioners appointed by Canterbury
Regional Council**

IN THE MATTER OF The Resource Management Act
1991

AND

IN THE MATTER OF Applications by the Central Plains
Water Trust and Central Plains
Water Ltd. to Take and Use Water
for Irrigation in the Central Plains
area.

Section 42A Officer's Report

Date of Hearing: 25 February 2008

Supplementary report of DAVID MICHAEL SCOTT

1. My full name is David Michael Scott. Details of my qualifications and experience have been documented in my contribution to the Section 42A Report.
2. This supplementary report provides comment on a number of matters raised in Mr Julian Weirs response to the Section 42A Report.

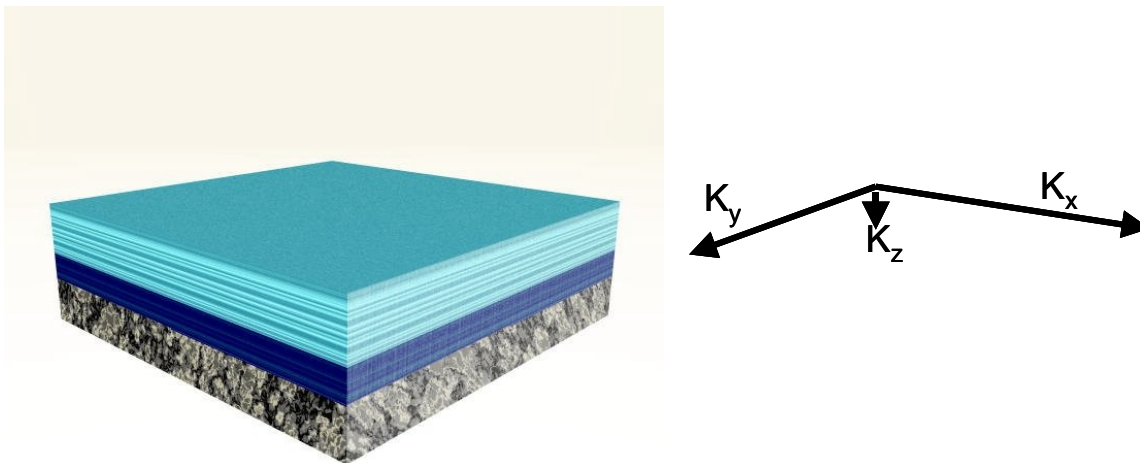
Model conceptualization

3. In para. 20 of my report I state that “*the aquifer/aquitard layered sequence may simply be a convenient mathematical device to represent the effects of vertical anisotropy on a regional scale*”. Mr Weir responds (in his para. 15) that the anisotropy ratios were established in the process of model calibration. I would like to add a couple of points of clarification:

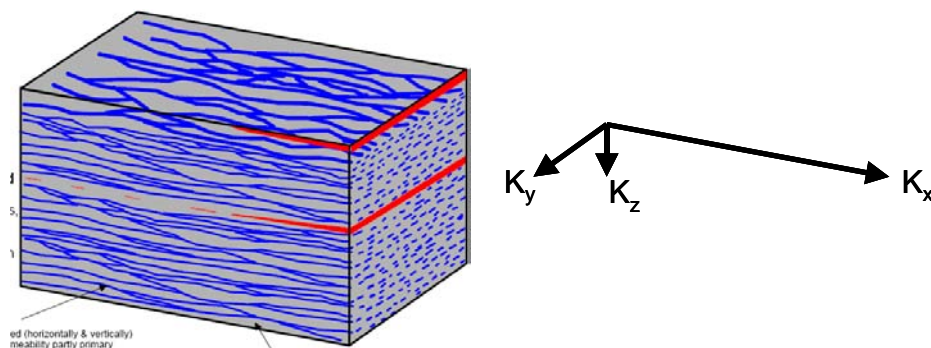
- I understood that the ratios were established through model calibration. The point I was attempting to make was that the vertical hydraulic conductivities that result from that calibration process are extremely low. This, in my opinion, begs a question about the validity of the conceptual model upon which they are based. Mr Jon Williamson independently reviewed the model in relation to its use in the Valetta and Ashburton River Groundwater Allocation Zones and commented that aquitard vertical hydraulic conductivities “*are equivalent to that expected for concrete and sedimentary hardrock*” (Williamson 2008).

- The other point is a little more complex and made more obscure by my typographic error. My comment should have read “*the aquifer/aquitard layered sequence may simply be a convenient mathematical device to represent the effects **of horizontal** anisotropy on a regional scale*” (correction in bold type). Figure 1 is intended to clarify this point. In modelling groundwater flow in typical sedimentary deposits it is common practice to assume that hydraulic conductivities are isotropic in the horizontal plane (i.e. $K_x = K_y$) but anisotropic vertically (i.e. $K_z \ll K_x$). This configuration of hydraulic conductivity is illustrated in Figure 1a and is easily represented in conventional multi-layer groundwater models. In alluvial-fan systems, such as in the Canterbury Plains, it appears that the configuration illustrated in Figure 1b may be more appropriate to describe the high hydraulic conductivity that can occur within discrete inter-connected flow channels. If this sort of structure is hydrologically significant then representing it with a model that ignores that characteristic may result in physically unrealistic parameter values.

4. In para. 18 of his response Mr Weir refers to the long model run time and explains why he has rejected Dr Merrick’s recommendation that it should be significantly reduced. Mr Williamson’s review also raised concerns about the model run time. Mr Weir’s comment that he is “*not willing to reduce the performance of the model by reducing run times*” appears to miss the point made by Dr Merrick and Mr Williamson that the model run time currently limits the utility of the model.



(a) Conventional structure – horizontal anisotropy



(b) Alluvial fan structure – vertical anisotropy¹

Figure 1: Alternative representations of hydraulic conductivity.

Calibration to observed groundwater levels

5. In his para. 19 Mr Weir acknowledges the model's underestimation of groundwater levels in extended wet periods and in paras. 20 to 23 suggests two possible explanations. Dr Bidwell has responded to the first suggestion that unaccounted for recharge may be a factor by referring to the comparatively successful Eigenmodel approach.
6. Mr Weir's second suggestion regarding the model's underestimation of lack of response (in his paras. 22 and 23) is that it may be "*due to under representation of the rate of vertical water movement from shallow to deep aquifers during these extended wet periods*". Given the extremely low aquitard hydraulic conductivities referred to above I agree that this is likely. However I do not accept Mr Weir's conclusion that, if this is the explanation, the model will provide conservative assessment of groundwater mounding - this flies in the face of the clear evidence that the model has underestimated the observed response in extended wet periods. I suspect that the real consequence of model under-estimation of vertical flow will be to over-estimate horizontal flow – possibly laterally to surface water features as suggested by the high simulated baseflow in the Selwyn River in the late 1970s.

¹ Schematic from Davey (2006)

7. I accept Mr Weir's point (in his para. 24) that shallow groundwater levels are better matched in other areas of the model. However, if this better match has been achieved by an unrealistic mechanism of diverting shallow groundwater to surface water features, it leaves considerable uncertainty about the reliability of the simulated results.

Prediction of groundwater mounding

8. As mentioned above I have used a modified version of Dr Bidwell's Eigenmodel to provide an alternative estimate of the nature of groundwater mounding that could be expected as a result of the CPW scheme. The modifications, undertaken by Dr Bidwell, allow the representation of additional land surface recharge within four zones between the coast and the inland boundary of the plains. I have used this modified version of the model using the following assumptions:
- irrigation from CPW scheme results in additional recharge of 300 mm/year compared to dryland farming (from para. 27 of Dr Bright's evidence²)
 - this additional recharge is uniformly distributed over the six month period from Oct to March
 - the area commanded by the CPW scheme occupies the inland 50% of the model domain
 - 60% of that area is supplied by the scheme³.
9. Figure 2 provides a comparison of the simulated groundwater levels at well L36/0092 for the case without CPW (Base Case) and for this additional recharge (CPWES). The Base Case is the same result described by Dr Bidwell and the close match to observed levels demonstrates the strong relationship between land surface recharge and groundwater levels. The CPWES scenario suggests that a new dynamic equilibrium develops over 6 to 8 years with groundwater levels elevated by approximately 8 metres compared to the Base Case. These figures are similar to some of the results described by Mr Weir. The critical difference is that the Eigenmodel shows that, with the CPW scheme in operation, groundwater levels at well L36/0092 would likely be 8 metres higher than the observed levels – not 5 metres lower as predicted by Mr Weir⁴. This suggests that the model may be under-estimating groundwater level by about 13 metres at that particular location.
10. I should acknowledge that this analysis has been done on the assumption that the additional recharge resulting from irrigation is the same from one year to the next. This has been done to simplify the analysis but it is a reasonable approach given that demand for irrigation water is not particularly dependent on the prior winter recharge as demonstrated by Dr Bright's estimates of seasonal water use. Figure 5 in Dr Bright's evidence shows high demand for the year ending 31 May 1978 despite that being in a period with higher than average dryland recharge **and** groundwater levels.

² The average annual drainage from irrigated land was estimated to be 543 mm and from un-irrigated land it was estimated to be 200 mm.

³ 60% represents 60,000 ha of a total command area of 102,000 ha.

⁴ Figure 7 of Dr Bidwell's report shows that the model simulation of the CPWES scenario predicts a maximum groundwater level at L36/0092 in 1978 of about 87 m – 5 m lower than the observed water level.

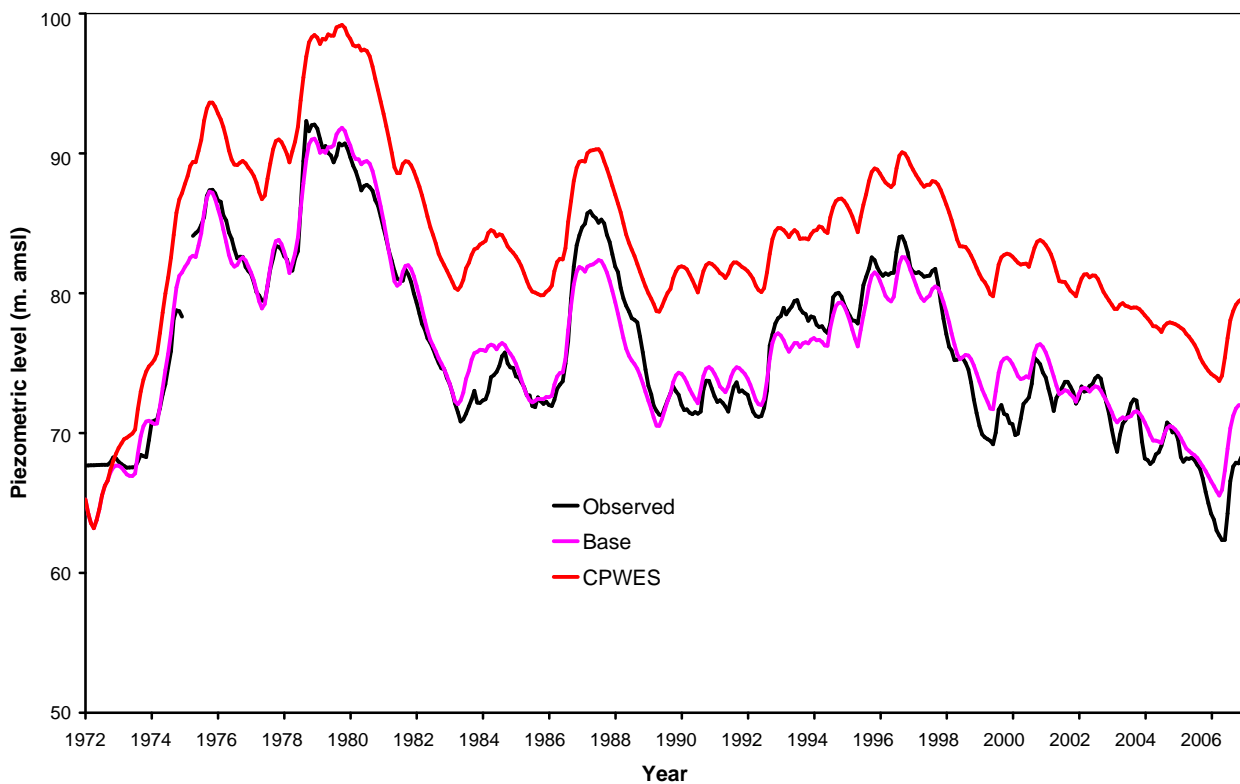


Figure 2: Simulated piezometric level at well L36/0092 for Base Case (without CPW) and CPWES scenarios.

11. This brings me to another point where I take issue with Mr Weir. In para. 46 of his response he states that *“The use of historical climate patterns is the best method currently available to consider a worst-case scenario..”* The historic climate pattern illustrates only one possible sequence of climate conditions. A reliable worst-case assessment would consider a range of climate projections and, given the emerging consensus about climate change effects, should incorporate an allowance for the range of anticipated changes⁵. Simulation of groundwater levels for that range of climate projections would provide a much more realistic picture of possible future effects. In my opinion it is not sufficient to simply speculate, as Mr Weir does, that *“this is unlikely to result in groundwater levels higher than the wet period considered”*. Having to resort to speculation when it would clearly be desirable to simulate alternative scenarios is presumably another consequence of the extended model run time.
12. In para. 49 of his response Mr Weir agrees with my comment that it will be difficult in the future to clearly distinguish CPW scheme induced effects from climate driven ones but then goes on to misconstrue the point I was attempting to make – i.e. significant CPW scheme effects may be masked by climate. In my opinion this is a very important issue and I would like to illustrate my point by referring to the simulated groundwater levels for well M35/1000 shown in Figure 3 which has been adapted from Mr Weir’s evidence (Appendix E). Let us assume, by way of example, that a hypothetical farmer’s ability to cultivate and/or harvest crops would be

⁵ Ministry for the Environment (2008) guidelines on climate variability and change state that “councils and communities do need to consider and plan for climate change. Of particular importance are infrastructure and developments with a long lifetime, which will need to cope with climate conditions in 50-100 years’ time. Examples include...planning for irrigation schemes...”

compromised in years when shallow groundwater levels rose above 75 metres (depicted by the dashed red line). For the Status Quo case that critical condition would have occurred in 10 of the 40 years simulated (indicated by the blue diamonds). For the CPWES scenario the critical condition would occur in 28 of the 40 years – an almost three-fold increase which would be likely to have a significant effect. Nevertheless, despite this increased frequency being caused by the CPW scheme, it would be very difficult for the affected farmer to demonstrate that the adverse effects are as a direct consequence of the scheme. Mr Callander, in para 4.10 of his evidence for Christchurch City Council, makes the same point and I agree with his opinion that it would be unreasonable to place the burden of proof on the affected party.

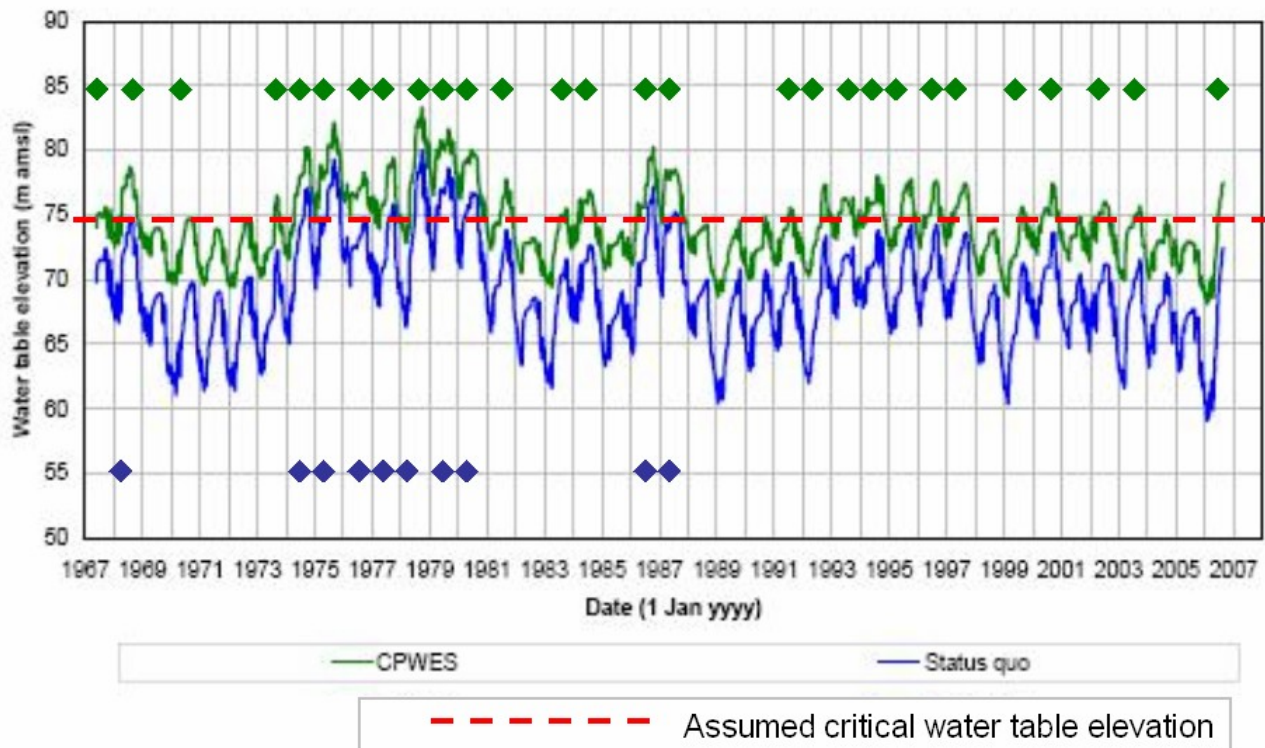


Figure 3: Simulated groundwater levels for well M35/1000 in relation to an assumed critical level.

REFERENCES CITED

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