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: 12 ï 16 September 2009

Further 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 Mr Julian Weir's supplementary evidence which describes his assessment of regional scale effects of the revised CPW scheme.

3. Mr Weir has used his numerical model to produce estimates of the effects of the revised scheme on groundwater mounding and stream discharge. Because of the limited time available to undertake these calculations this assessment has been limited to the 12 year period 1967 to 1979. Nevertheless, the results are sufficient to confirm the expectation that the revised scheme would have less effect on mounding and discharge than the original proposal.

4. Mr Weir has also provided estimates of effects using the Eigenmodel. Dr Bidwell described this method in his report to this hearing and I presented some preliminary results in my earlier supplementary report. Mr Weir has been able to calibrate the Eigenmodel to reproduce observed groundwater levels with a reported mean error of -0.03 m (less than 10% of the equivalent statistic achieved with the numerical model). It is notable that this was achieved using a single set of aquifer parameters – i.e. the model was not recalibrated for each observation well. Mr Weir's Table 4 reports a smaller Normalised RMS for the numerical model than for the Eigenmodel which is surprising given that numerical model was reported to have significantly higher mean error. In any case, when evaluating the effects of groundwater mounding the absolute error is the principal concern.

5. Mr Weir then used the calibrated Eigenmodel to compute groundwater mounding and stream flow changes for three scenarios – the Status Quo, the original proposal (CPWES) and the revised scheme (CPWES No Dam). For most of the statistics reported (maximum mounding, average mounding, maximum flow, average flow) the effects predicted by the Eigenmodel are greater than those predicted by the numerical model – in many cases to a significant extent.

6. In my opinion the predictions derived using the Eigenmodel are plausible and illustrate very effectively the inherent uncertainty involved in modelling natural systems. Mr Weir poses the question "Which is right?" and argues that the Eigenmodel predictions are less realistic than those gained using the numerical model. He goes on to suggest that the predictions may even exceed the likely upper bounds and lists a number of factors to support that point of view.

7. I take issue with Mr Weir's evaluation of the Eigenmodel method and predictions. Rather than ask "Which model is right?" a more appropriate question is "Which model is more reliable for the purpose at hand?" In this context a primary purpose is to predict the increase in groundwater levels that is likely to result from an increase in land-surface recharge. Perhaps the best test of a model's fitness for that particular purpose is to consider how well it is able to reproduce the observed increase in groundwater levels resulting from the higher than average rainfall recharge in the 1970s. Observations of groundwater levels in that period are available for 5 of the 8 wells used in Mr Weir's Eigenmodel analysis.

8. I have reproduced (in my Appendix A) the relevant plots from Mr Weir's Appendices F & G to show the Eigenmodel and numerical model results for each well on the same page and to an approximately equal vertical scale. For two of the wells (L36/0023 and L36/0092) the Eigenmodel provides a markedly better fit over the 1970s than the numerical model. The results for both models are roughly comparable for well L36/0142, though the numerical model does exaggerate the annual cycle. For well M35/1080 the numerical model somewhat overestimates the water level range over the 1970s but provides a fit that appears to be superior to the Eigenmodel. It is difficult to make a clear comparison for the remaining well (M37/0010) - the Eigenmodel provides a satisfactory fit but it is difficult to assess the numerical model performance because of the vertical scale used in the original plot. On the basis of this simple evaluation I believe that it is reasonable to regard the Eigenmodel mounding estimates as being more reliable in the inland section of the study area ï for the rest of the area it is not clear which method is likely to be more reliable.

9. In his paragraph 55 Mr Weir does acknowledge that the Eigenmodel calibration is equal to or better than the numerical model but then describes factors which, he believes, limit the reliability of the Eigenmodel results. In my opinion several of Mr Weirõs reservations are not soundly based for the reasons outlined below:

- *The assumption of constant recharge from alpine rivers*
  The relative success of the Eigenmodel in being able to explain observed groundwater level variation in terms of land-surface recharge demonstrates that the assumption of constant recharge from alpine rivers is a reasonable one. Field observations provide supporting evidence that river recharge rates may be relatively steady. Environment Canterburyõs monitoring of groundwater levels in an array of bores on the south side of the Waimakariri River has demonstrated that groundwater gradient away from the river has been remarkably steady over the last ten years (mean gradient 0.0022 m/m, standard deviation 0.0001 m/m) as shown in Figure 1. The simulated river recharge reported in Appendix N of Mr Weirõs original evidence shows larger fluctuations and it is possible that the numerical model may be exaggerating this effect.

- *The potential for non-uniqueness*
  Mr Weir suggests that the Eigenmodel has a greater potential for non-uniqueness than the numerical model. Non-uniqueness refers to the situation where alternative combinations of model parameters are able to produce equally good calibrations. It becomes an issue affecting model reliability when these alternative combinations result in conflicting predictions. The Eigenmodel, with effectively only three parameters, is significantly less likely to be affected by non-uniqueness than the numerical model which has in excess of 1,000 parameters (25 zones x 4 layers x 11 aquifer parameters per aquifer unit). The very short runtime and limited number of parameters of the Eigenmodel allows any non-uniqueness to be quickly and comprehensively assessed. An equivalent evaluation of the numerical model is effectively impossible given the large number of parameters and extended run time.

- *Location of boundaries not known*
  The Eigenmodel certainly uses a very simplified representation of aquifer geometry. However, the strategy of identifying effective location parameters (described in paragraph 40 of Mr Weirõs evidence) appears to have satisfactorily allowed for the complex real-world geometry.

- *Eigenmodel designed for a single purpose*
  I see this as a strength rather than a weakness since it limits the potential for any non-uniqueness to contribute to prediction uncertainty. Hence, predictive reliability for that single purpose is likely to be better than for a more complex, multi-purpose model.

10. In conclusion, I believe that Mr Weir's Eigenmodel based predictions of groundwater mounding and flow increases are sound and reliable. Those results illustrate the potential for a more extensive area affected by shallow groundwater than predicted by the numerical model. Planning of possible mitigation measures should consider the wider range of effects that have been identified through this additional analysis.

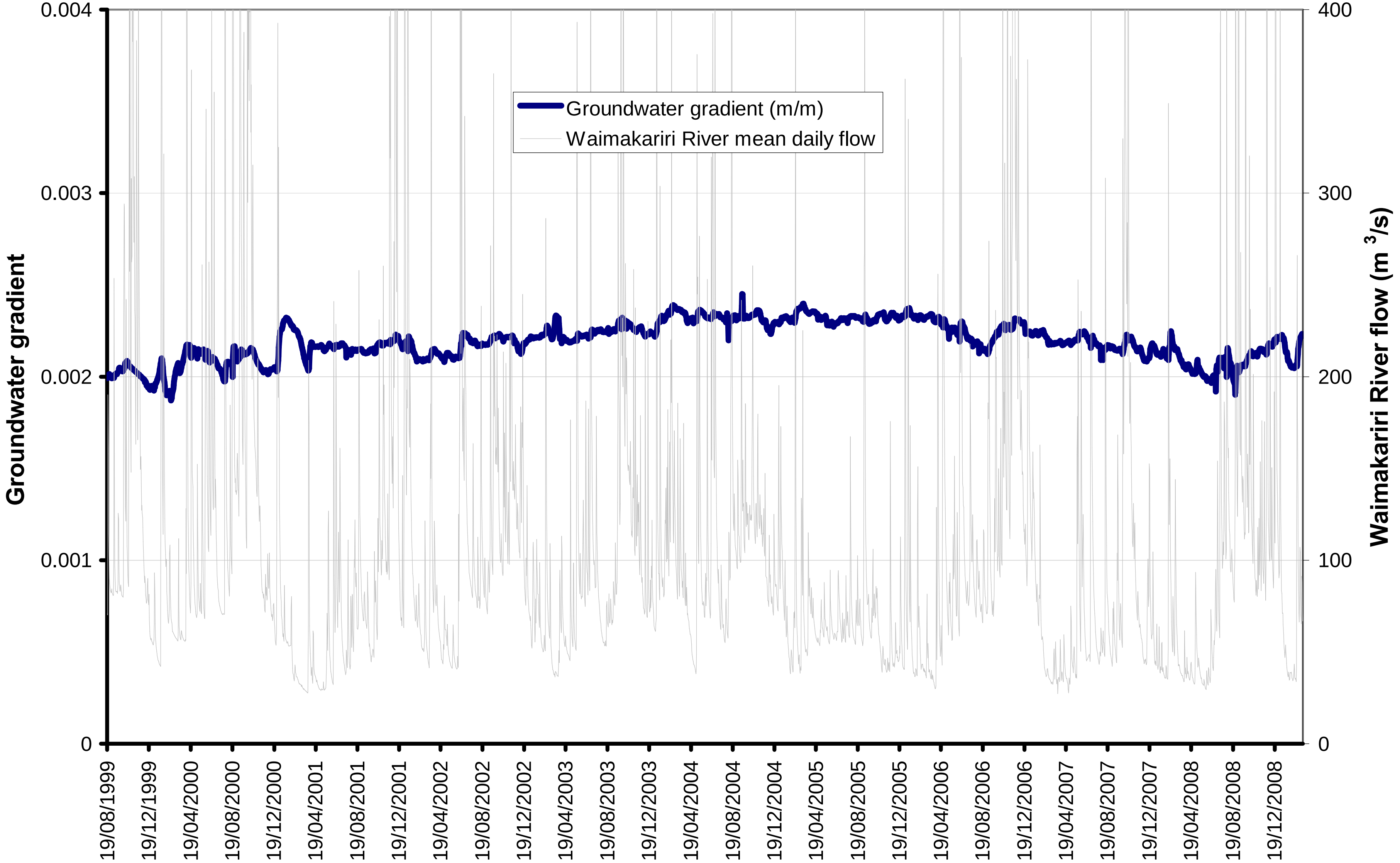
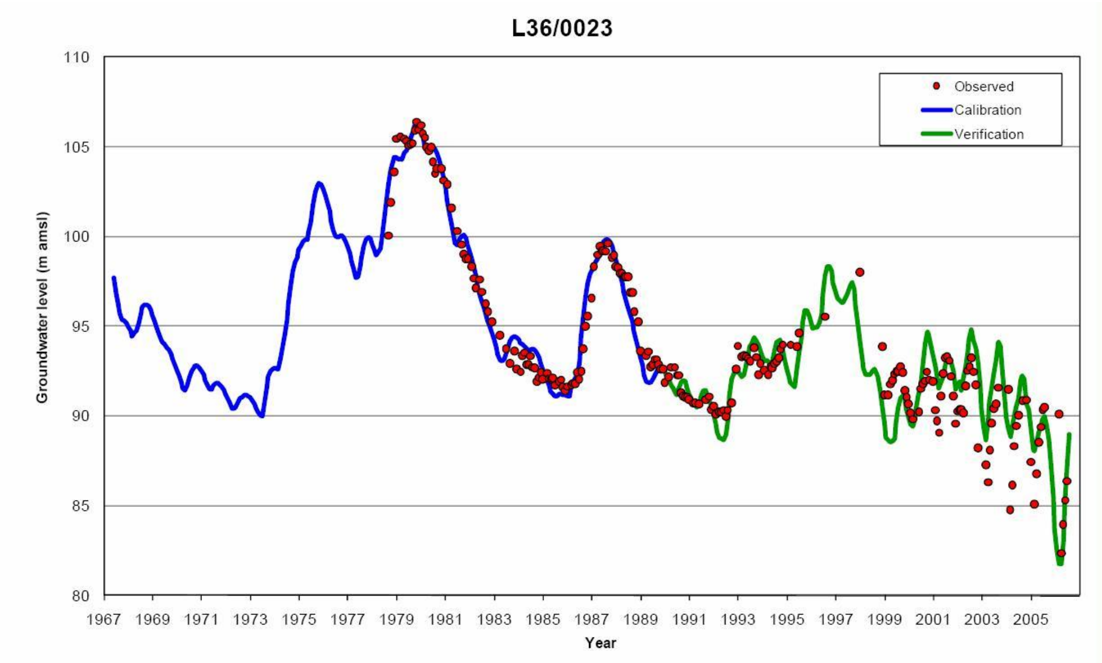
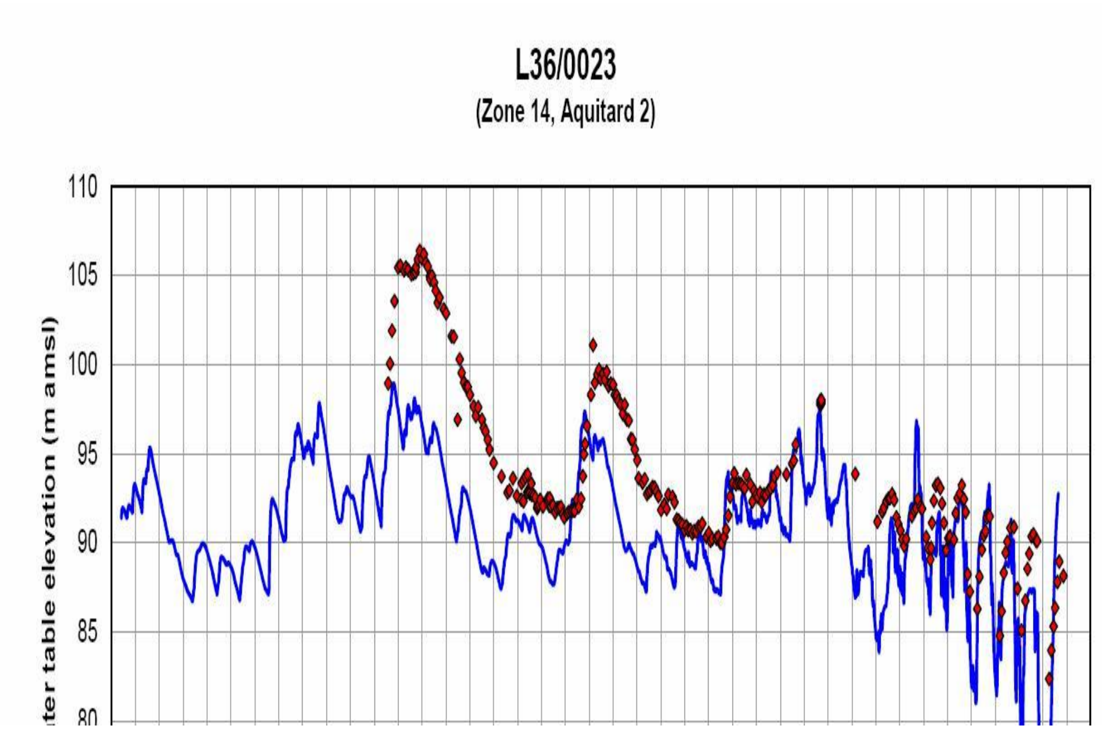


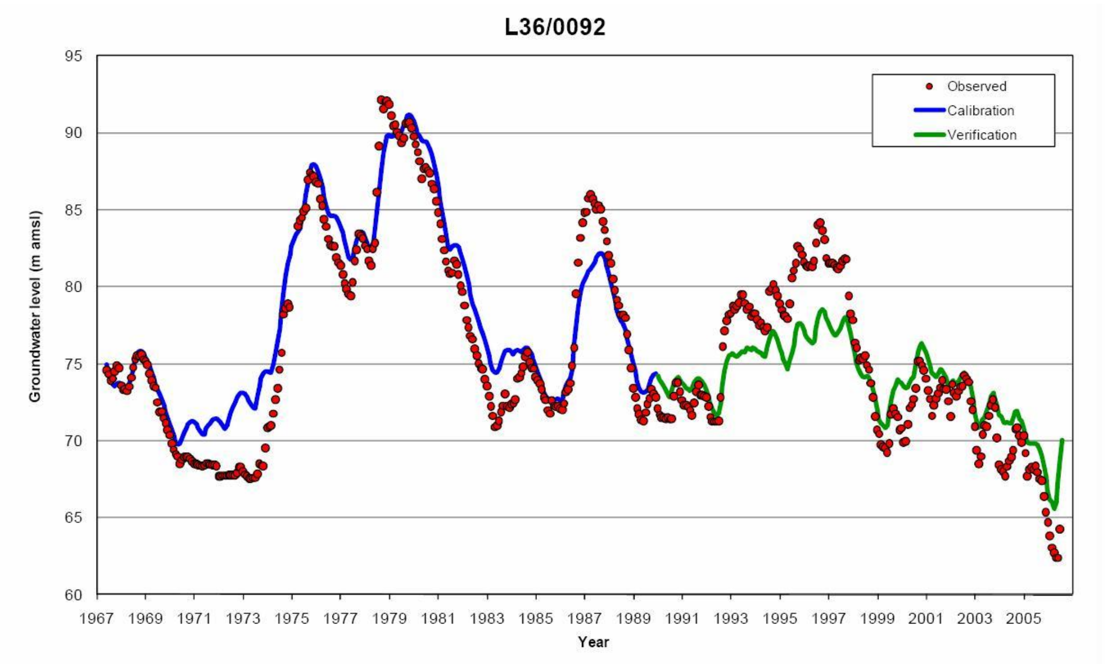
Figure 1: Groundwater gradient measured adjacent to Crossbank (south bank of the Waimakariri River in the vicinity of Christchurch airport) together with mean daily flow recorded at the State Highway 1 recorder site.

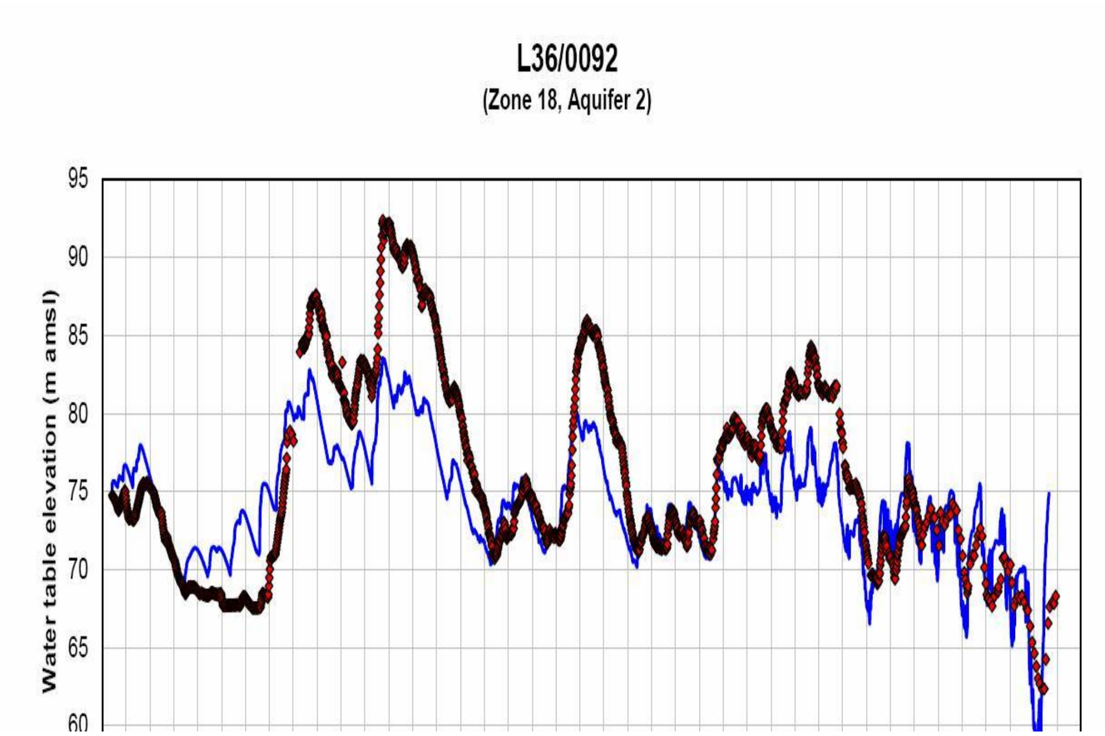
Appendix A

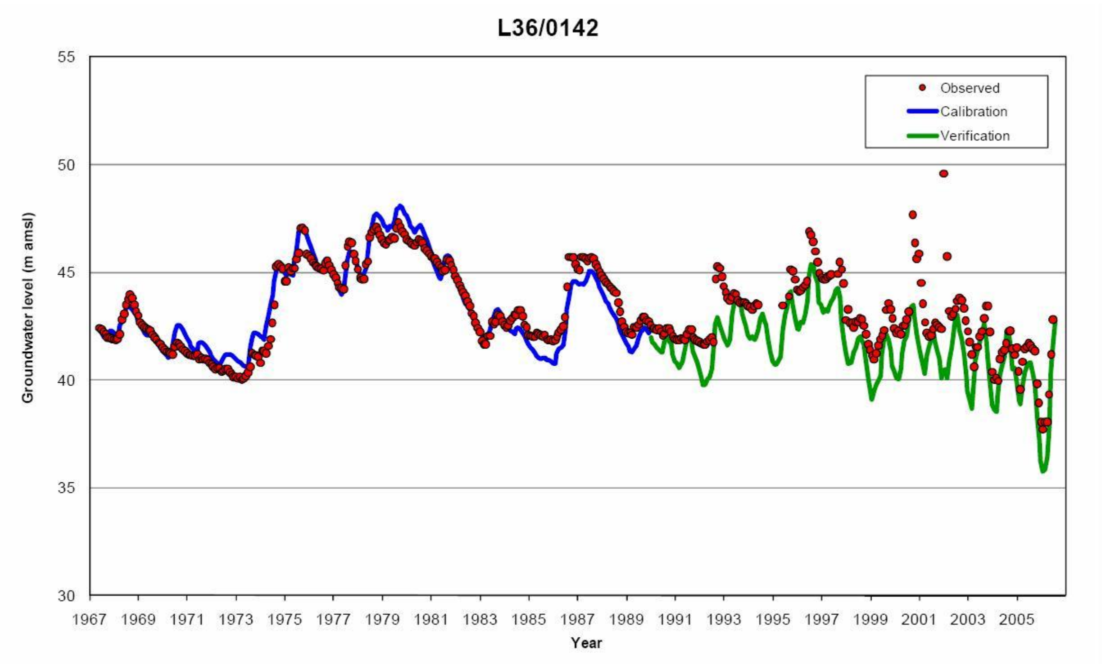
Groundwater level plots reproduced from Appendices F and G from Mr Julian Weir's supplementary evidence. In each case the upper plot shows the Eigenmodel results. The numerical model results are shown in the lower plots rescaled to approximately match the vertical axis of the Eigenmodel plot.

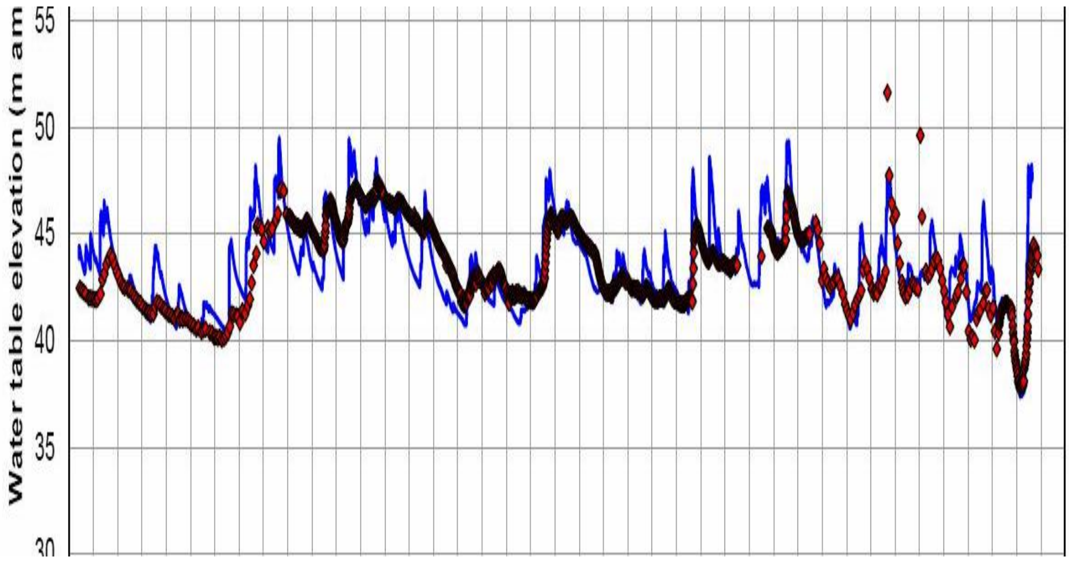


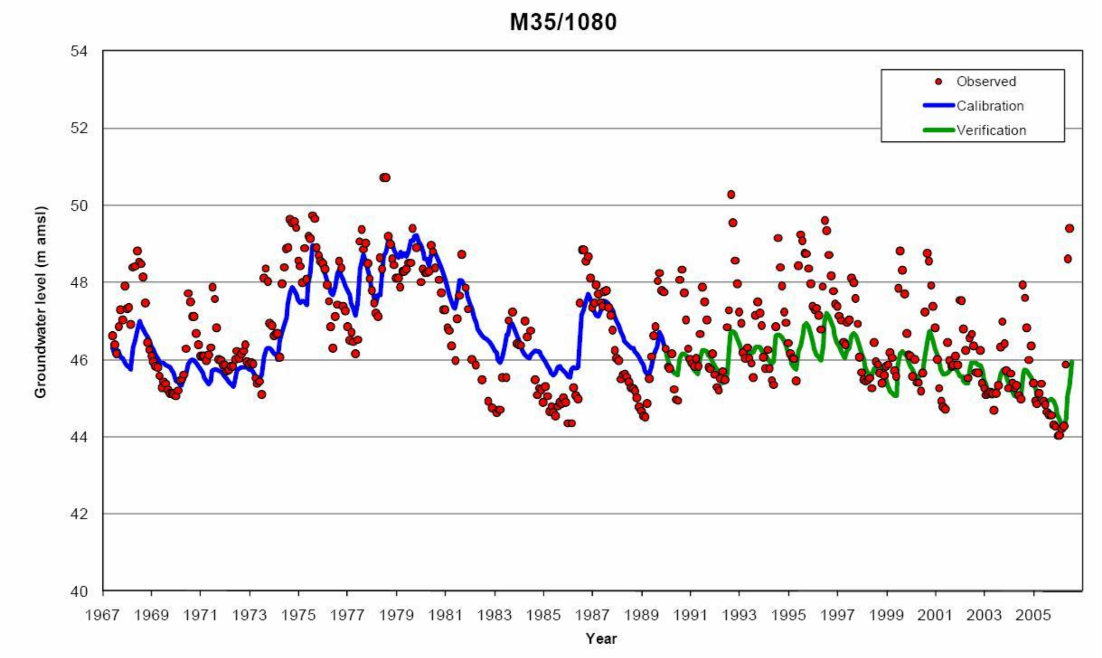



L36/0092
Observed
Calibration
Verification
Groundwater level (m amsl)
Year
95
90
85
80
75
70
65
60
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005


L36/0092
(Zone 18, Aquifer 2)
Water table elevation (m amsl)
95
90
85
80
75
70
65
60


L36/0142
Observed
Calibration
Verification
Groundwater level (m amsl)
55
50
45
40
35
30
1967 1969 1971 1973 1975 1977 1979 1981 1983 1985 1987 1989 1991 1993 1995 1997 1999 2001 2003 2005
Year


Water table elevation (m am
55
50
45
40
35
30


M35/1080
Observed
Calibration
Verification
Groundwater level (m amsl)
Year
54
52
50
48
46
44
42
40
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
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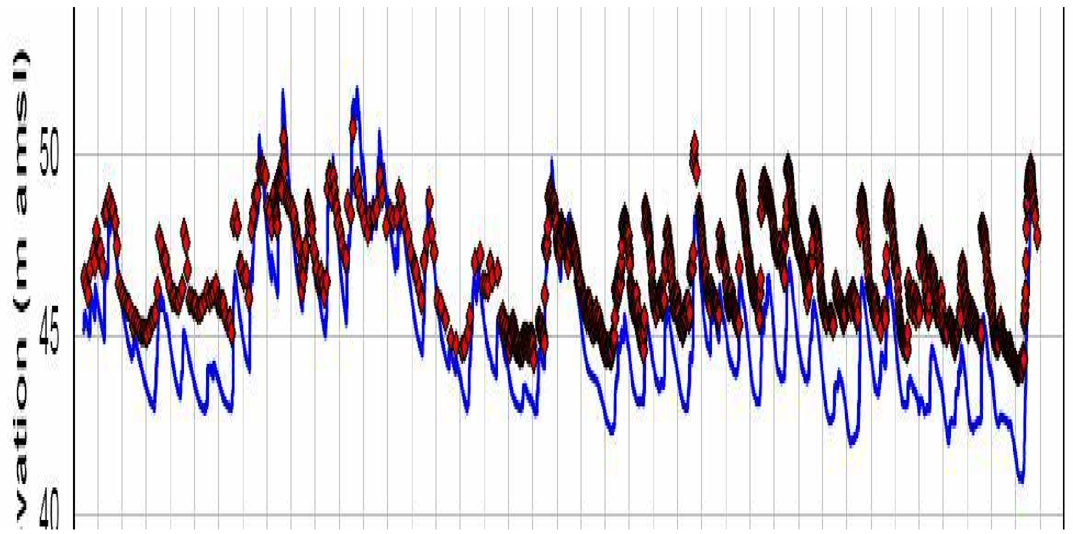
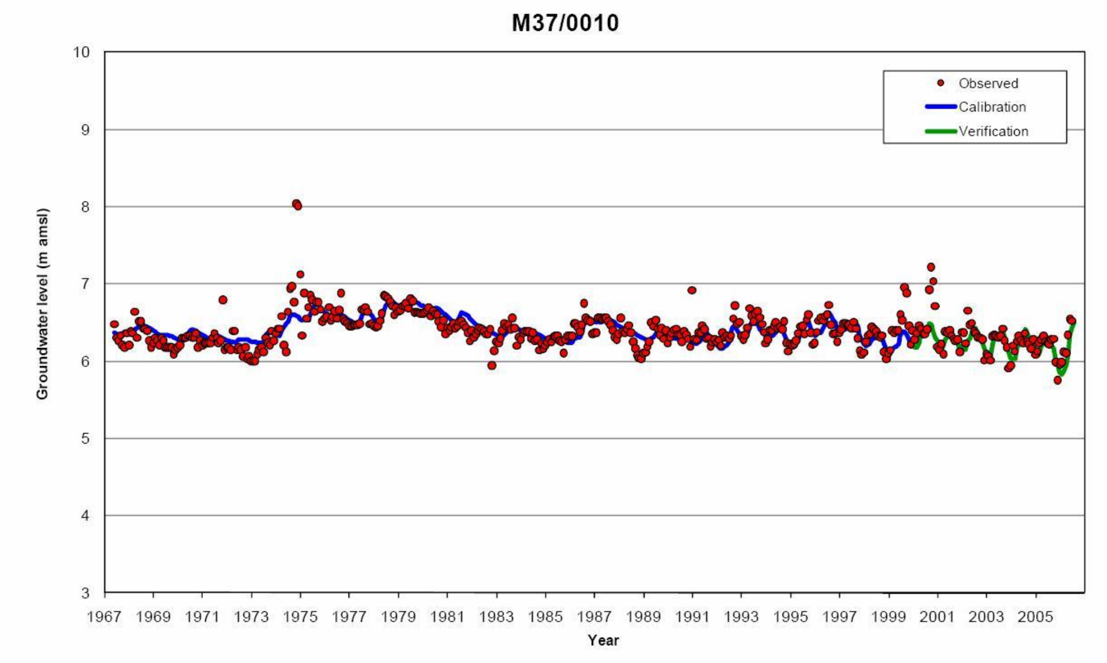
1993
1995
1997
1999
2001
2003
2005


50
45
40


M37/0010
Observed
Calibration
Verification
Groundwater level (m amsl)
10
9
8
7
6
5
4
3
1967
1969
1971
1973
1975
1977
1979
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
Year