12 March 2014

Mr Mark Trewartha
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Dear Mark

RE: RE-ASSESSMENT OF RETURN FLOW FROM THE PROPOSED RUATANIWHA PLAIN IRRIGATION SCHEME

Following an assessment of return flow for 11 soils at two sites with different climates reported in a letter dated 19 June 2013, NIWA was recently requested use the data to determine the total return flow volume from the proposed scheme. Out of that assessment came an estimate of the scheme water requirement. These estimates can be termed Phase 1. Following the Phase 1 assessments came a request to:

1. Repeat the exercise in Phase 1, but vary factors such as the irrigation efficiency, and atmospheric demand, in a defensible way, to attempt to get an average annual scheme demand of 72 million cubic meters. The result to be expressed as an annual return flow volume.
2. Use the result from 1 above to predict the effective scheme area and annual return flow if the average amount water available to the scheme was 88 million cubic meters per year.

The model used in the Phase 1 assessment used the assumptions detailed in a letter to Rob Christie dated 19 June 2013 and areas of representative soils supplied by Grant Pechey in an email, dated 4 March 2014, that gave an effective scheme area of 27,800 ha. The data from **one** climate site with 920 mm annual rainfall and two irrigation rates (6mm and 15 mm/application) were used to obtain the average return flow of 16- 18.5 million cubic meters per average year and an average water requirement of 67-71 million cubic meters per year. The numbers were derived from a 41 year data set (1972 2012).

Phase 2 (items 1 and 2 above) was calculated in similar way except that **two** climate sites (mean annual rainfall 920 mm/y and 948 mm/y) were used and the irrigation efficiency was marginally altered as detailed below.

Return flows from the 10 soils nominated by HBRC have been calculated using a daily water balance model and soil profile available water (PAW) supplied by HBRC. The following assumptions and conditions were used in the model:

1. The ground cover is pasture, rather than a mix of pasture and cropping. This assumption will most likely maximise water requirement and return flow.
2. This study uses the (PAW) over a depth of 0-600 mm.
3. The Penman potential evapotranspiration (PET) estimates supplied from NIWA's virtual climate network (VCN) have been reduced. Penman PET estimates have long been known to overestimate PET from well-watered pasture. The Penman estimates have been reduced by the mean monthly ratio of evapotranspiration as measured by NIWA's eddy covariance tower

at Methven to Penman PET calculated from meteorological parameters measured at the same site (details are given in the letter dated 19 June 2013). The Methven site has well-watered, high producing dairy pasture and an annual rainfall of ~900 mm, not unlike the annual rainfall on the Ruataniwha Plain. The effect of the PET reduction is to reduce irrigation demand and increase winter return flows regardless of whether the sites are irrigated or not.

4. Two irrigation rates were applied, one representing centre pivot irrigation (6 mm/application), and one representing linear-move/rotorainer/big gun irrigation (15 mm/application). There is also a dryland case.

5. Irrigation was assumed to be 85% efficient, with 2% being droplet loss, 10% (was 6%) lost to drainage and the balance redistributed within the root zone and being available for transpiration (see comment towards the end of this letter).

6. The irrigation was applied when soil water had reduced to 50% of profile available water (PAW) in the top 600 mm of soil.

7. No irrigation from May to August.

8. The rainfall and Penman PET were generated from NIWA's virtual climate network for nodes 27363 and 30496. One site is believed to be on the western side of the Ruataniwha Plain and the other on the eastern side. There is very little difference in the mean annual rainfalls of the sites. The Penman PET was reduced as indicated above.

9. Actual evapotranspiration (AET) was based on the modified Penman PET. In irrigated cases AET was assumed to be equal to PET.

10. In the dryland (non-irrigated) case AET was assumed to be equal to PET until soil water was reduced to 50% of PAW. At lower soil water levels AET was assumed to be proportional to PET times the ratio of remaining soil water to 50% of PAW.

11. Simulations were carried out for 41 years for 10 different soils, each with its own area, nominated by HBRC.

The differences in the modelling reported here compared to previous work, including the Phase 1 of the current work, is that the 85% application efficiency assumed that of the 15% "lost", the amount retained in the soil and available for evapotranspiration, was reduced from 7% to 3% of the total application and the contribution to drainage was increased from 6% to 10%, while the loss to the atmosphere (droplet evaporation) stayed the same at 2%. The other difference was that data from both climate sites were used.

In calculating the return flow and water requirement it was assumed that each climate site represented half the scheme area and that half of each climate area was irrigated with 6 mm/application and half with 15 mm/application. Higher application rates would increase return flow and scheme demand.

The average annual return flow was calculated to be 22.1 million cubic meters for an average annual application of 71.85 million cubic meters. Thus the average return flow is 30.8% of the application. The different climates and application rates give rise to a range of average annual application volumes and return flows that are 69.5- 74.1 million cubic meters and 20.1 -29.1 million cubic meters respectively and give a range of return flow percentage of application volumes of 28.5% to 32.5%.

If the scheme had 88 million cubic meters of water available for an average year, the scheme could command an effective (irrigated) 34,048 ha. The range of application volumes for that area is 85.1 to 90.7 million cubic meters depending on climate site and application rate. The annual average return flow is 24.6 to 29.5 million cubic meters with a range of return flow volume percentages from 28.5% to 32.5%. To obtain these estimates the areas of each soil were increased by the same proportion. Higher application rates than assumed would reduce the area able to be irrigated with 88 million cubic meters of water.

These results contain some uncertainty resulting from:

- The lack of spatial detail on the distribution of the soils in relation to the climate.
- Uncertainty in the climatic inputs from the VCN.
- The use of a simple model that does not take into account soil physical variables such as macropore channels that can enhance drainage.
- The use of a daily water balance model that may not replicate the movement of soil water across and through the soil, e.g., the model assumes there is no surface runoff.

More details of the calculations are available on request.

Yours sincerely

Maurice Duncan
Senior Surface Water Scientist.