

UNDER the Environment Canterbury (Temporary Commissioners and Improved Water Management Act) 2010 and the Resource Management Act 1991

AND

IN THE MATTER of an application to amend the National Water Conservation (Rakaia River) Order 1988

BY **TRUSTPOWER LIMITED**
Applicant

**STATEMENT OF EVIDENCE OF DARREN CLIFFORD LEFTLEY
ON BEHALF OF CANTERBURY REGIONAL COUNCIL**

2 FEBRUARY 2012

Evidence of Darren Leftley

Qualifications and experience: Darren Leftley

1. My full name is Darren Clifford Leftley. I am employed by Canterbury Regional Council (“Environment Canterbury”) as a Senior Hydrological Scientist.
2. I hold the qualifications of Bsc(Hons) in Geography/Geology from West London Institute of Higher Education and a Master of Science in Hydrology for Environmental Management from Imperial College, University of London.
3. I have 17 years’ experience as a hydrologist and have been employed by Environment Canterbury since March 2009. I am a Chartered Scientist, a member of the Chartered Institute of Water and Environmental Managers and a member of the New Zealand Hydrological Society.

Scope of evidence

4. I have prepared the evidence in compliance with the Code of Conduct for expert witnesses set out in the Environment Court’s consolidated practice note which took effect 1 November 2011. I confirm that the evidence is within my area of expertise and that I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express. I am authorised to give evidence on behalf of Environment Canterbury.
5. The purpose of this evidence is to provide expert opinion on the hydrological information prepared by the applicant. In particular I have reviewed the following reports:
 - Tonkin & Taylor, July 2011 “Lake Coleridge Project: Hydrology Assessment”
 - Beca Ltd, July 2011 “ Lake Coleridge Project – Rakaia River Hydrology and Geomorphology Overview”

I have also reviewed the evidence submitted by Mr Leong, Mr Levy, Mr Lilley & Mr Levy and Mr Single

The general hydrology of the Rakaia River catchment

6. The technical reports by Tonkin & Taylor and Beca provide the information on the hydrology of the Rakaia River including Lake Coleridge. These reports have been summarised into the evidence of Mr Leong and Mr Lilley & Mr Levy. The reports and evidence describe the key aspects of the Rakaia River hydrology including:
 - Gorge Flows;
 - The historical effect of the Lake Coleridge hydro-electric power station (HEPS) on river flows and lake levels;

- The historical effect of Highbank hydro electric power scheme (“HEPS”) on river flows;
- River flows below the gorge; and
- Consented out of stream takes and discharges.

Gorge flows

7. The gorge is downstream of Lake Coleridge and the recorded river flow measurements include the modified effects of the lake’s operation for hydroelectric power generation. The effect of the existing scheme operation on the gorge flows varies with time with all the diverted flow ultimately returning to the Rakaia River upstream of the gorge.
8. The Rakaia River flows in the gorge have been measured since December 1957 and provide a valuable long-term record across a number of Interdecadal Pacific Oscillation (“IPO”) cycles with several droughts and large-scale floods included. The record is therefore representative of not only average flow conditions but also extremes, which are important for in-stream and out of stream values. The flow statistics and analysis of the flows for the period 1958-2009 are included in the applicant’s reports and evidence.

Lake Coleridge HEPS discharge

9. The discharge and lake levels have been measured since 1928 and again provide a valuable long-term record of the existing scheme’s historical operation, which includes a number of phases of development and refinement. The flow statistics and analysis of the flows for the period 1980-2009 are included in the applicant’s reports and evidence. This period was chosen for a number of reasons especially to represent a period where the effects of the Wilberforce diversion into Lake Coleridge were included.

Highbank HEPS discharge

10. The discharge from Highbank HEPS is summarised in the reports and evidence for the period 2002-2009. This is a much shorter record than the Lake Coleridge HEPS discharge record. This means that the record is less likely to be representative of the variations in the long-term record. In addition the scenario modelling includes a longer historical data set for the full simulation period of 1980-2009.
11. The river flow below Highbank is modified by consented abstractions and discharges as well as being affected by natural losses and gains. There are no continuous measurements of flow from the gorge to SH1 due to the braided nature of the river and the instability of these braids and channels. The flow has been measured by taking spot measurements concurrently down the river during stable flow recessions and when the out of stream takes and discharges have also been measured. These spot measurements provide an insight into the natural flow regime of the river below Highbank.

12. The applicant has summarised the recorded loss information in the report by Beca and the evidence by Mr Levy. However, they have only shown the most recent spot measurements (2009-2011) and have not allowed for abstractions and discharges, which represent an estimate of natural loss. For the full historical measurements, which go back to 1971, an Environment Canterbury memorandum by Ritson, July 2011 shows all the historical gaugings and concludes that the general pattern of loss below the gorge has not changed from earlier records in the 1980's.
13. There are also some discrepancies between the data presented by the applicant and those reported by Ritson. However, there is no disagreement in the general pattern of loss between the gorge and the river mouth.
14. In conclusion, the applicant has adequately summarised and interpreted the available hydrology information and presented this clearly in the technical reports and evidence.

The effects of stage 3 of the project on the flow regime of the Rakaia River

15. Stage 3 of the applicant's Lake Coleridge project allows 'stored' and 'normal' water to be conveyed by a new canal with a capacity of between 20-25 m³/s for irrigation to the north and south of the Rakaia River and hydro-power generation.

The modelling approach

16. The report by Tonkin & Taylor and the evidence of Mr Leong and Mr Lilley & Mr Levy describe the effects of stage 3 of the project on the flows in the Rakaia River. The approach taken is to compare a 'future' stage 3 scenario with three baseline scenarios simulated over a period from 1980-2009. These baseline scenarios are:
 - Historical operation and infrastructure of Lake Coleridge without CPW and BCI – called 'Historical: no take' in technical reports and evidence;
 - Historical operation and infrastructure of lake Coleridge with CPW and BCI with run of river demand - called 'Consented run-of-river take' in technical reports and evidence;
 - Historical operation and infrastructure of lake Coleridge with CPW and BCI with storage demand - called 'Take to alternative storage' in technical reports and evidence.
17. Scenario modelling is a standard approach used in many water resource hearings and one which I support. In order to create these scenarios key assumptions have been made which form the basis of discussion and debate from submitters. The simulation period from 1980-2009 includes a number of significant dry periods as well as floods and provides in my opinion an adequate basis for the comparative scenario modelling undertaken by the applicant.

18. The stage 3 scenario relies on simulating the future operation of Lake Coleridge and predicting the flows in the canal; discharges to the Rakaia River from the existing HEPS at Lake Coleridge and Highbank; plus the pumped abstractions from the river at Highbank.
19. This modelling was undertaken by Trustpower and has not been reviewed in producing this evidence. The submission by Ngāi Tahu suggests that the future operational lake modelling could be flawed as the derivation of 'stored water' and 'gorge flow' maybe overestimated. The effect this might have on the hydrology and irrigation reliability is unclear but if correct should be investigated.
20. The stage 3 scenario simulations assume that there is no change to the inflows into Lake Coleridge. This assumption has attracted some comments from submitters suggesting that the changes in lake operational level could induce more flow into the lake and reduce the residual flow in the Wilberforce River.
21. Mr Leong in his evidence acknowledges that at certain times when the lake level is low and flow high then there could be marginally more inflow from the Wilberforce River. He also goes on to acknowledge that with lake levels predicted to be in the choking zone for longer this will offset the periods when inflows could be higher. I certainly agree that the effect on average will be negligible.
22. The greatest risk would appear to be the effect on summer fresh flows in the Wilberforce River when the lake level is predicted to be low and more of this flow could be captured. This may well be an academic point as the operation of the lake levels and the inflows will still be operating within their existing consent conditions.
23. In order to illustrate the changes in the flow regime of the river, several locations have been chosen. The first comparison point is at the gorge (Fighting Hill). The assumption here is that changes to the Lake Coleridge HEPS discharge under stage 3 will translate to a 1:1 change in the Fighting Hill recorded flow albeit with a 3 hour delay. This in my opinion seems a reasonable assumption.
24. The second comparison point is downstream of Highbank HEPS discharge. The actual flow is not measured at this location and the flow has been estimated for each scenario based on the assumption that there are no losses/gains or changes in storage between Fighting Hill and the location downstream of Highbank. In the historical scenario this will mean that the flow downstream of the Highbank HEPS discharge will just be the flow recorded at Fighting Hill plus the discharge.
25. For comparative analysis, such as this, then the assumption is a reasonable one. In terms of predicting absolute flows for each scenario this assumption has some limitations as there could well be gains and losses between the two locations and changes in storage could be a factor on a daily timestep.

26. The report by Tonkin & Taylor states that there is limited catchment between the two locations and therefore their assumption of no inflows is a conservative one. There is no comment in the report on the losses between the two locations. A quick analysis of the concurrent gauging data seems to suggest that there is more likely to be a gain rather than a loss between these locations. This supports the view that the modelled assumptions are conservative in terms of the predicted flows. In my opinion these assumptions are reasonable.
27. The discharged flows from the RDR through the Highbank HEPS are assumed to remain unchanged for the future scenario. This is convenient as it allows the comparative effects to be analysed on the changes from the stage 3 project alone. In reality, the discharges may well change due to irrigation demand and other factors affecting demand for water. However, I don't believe that this speculative future should be included in the modelling as this could happen regardless of the future of the Lake Coleridge project.
28. The two baseline scenarios, which include CPW and BCI consents, have assumed that the irrigation demand is the same as the future Stage 3 modelling, I believe undertaken by Trustpower. The derivation of this irrigation demand time series has not been reviewed or compared to the time series derived by CPW or BCI for their consent hearings. Therefore, I am unable to comment on the sensitivity of this assumption to the predicted flows in the river.
29. Overall, the model assumptions and scenarios seem reasonable.

Analysis of model results

30. The technical reports and evidence summarise the results of the modelling by using a number of standard metrics including:
 - MALF (7d), Summer average 7 day low flow, mean flow, median flow;
 - Monthly mean flows and monthly box and whisker plots;
 - Monthly average number of days below RWCO minimum flows;
 - Average number of days per annum below a flow threshold.
31. These metrics provide a useful feel for the scale and type of effect. For example the analysis shows that the greatest mean monthly flow reductions occur in December for the historical baseline scenario but May for the consented run of river take scenario. The flow reduction is much less for the run of river scenario than the historical scenario.
32. In my opinion the major limitation of the analysis is that it provides very limited information on changes to the duration of low flows and the variability between years. Duration of low flow is important ecologically as longer durations lead to stress on the system and the development of periphyton and nuisance algal growths. There are a number of metrics, which could be used to assess this effect including consecutive number of days below a threshold

and number of events of a given duration below a flow threshold. The inter-annual variability has also been excluded from the presented analysis and this could be important information for some of the in-stream and out of stream values.

The effects of stage 3 of the project on the water levels of the Rakaia River

33. The changes in the flow regime of the Rakaia River will also lead to changes in the water levels. A report by Beca and evidence prepared by Mr Levy describe the likely effects of changes to water levels. The changes in the flow regime and the direct effects on water levels can easily be determined at Fighting Hill where there is a direct relationship between flow and water level. This relationship, called a rating curve, is maintained by the National Institute for Water and Atmospheric Research (NIWA). However, for all other sections of the river this relationship is unknown and variable and will differ from reach to reach and braid to braid depending on the nature of the hydraulic control.
34. In order to estimate the relationship between flow and water level Beca installed, in March 2010, a number of water level monitoring sites down the river. The water level monitoring was installed in the main braid and for some sites in a secondary braid. The measured water level changes were then analysed against periods when changes in flow were controlled and predictable. The best periods for this analysis were when either Highbank HEPS discharges or Coleridge HEPS discharges are constant or zero and then changes in the flow at the other plant can be isolated. There was only two periods when this was possible: 14th-16th July 2010 and 3rd-5th September 2010.
35. The results of this analysis are included in the Beca report and evidence by Mr Levy and state the water level change in the river at six locations for different changes in release at Coleridge and Highbank. These results are presented without any acknowledgement of the uncertainty associated with the limited number of sites and samples analysed. Having said that the scale of the effects presented seems reasonable i.e. a 110mm maximum change in water level for a 33m³/s change in river flow during low flow periods.

The effects of stage 3 of the project on irrigation reliability

36. The stage 3 project will result in significant changes to the flow at Fighting Hill compared to what has happened historically. This would change the reliability for any irrigators who are restricted based on the flow at the gorge. However, proposed changes to the definition of the 'gorge flow' and the introduction of 'stored' water into the RWCO should retain the reliability of supply for any existing takes who do not transfer onto the register. However, a comparison between existing reliability and reliability under stage 3 has not been included in the applicant's evidence and therefore remains uncertain. This comparison should be done for those bands who are unlikely to go on the register i.e. the lower bands who have sufficient reliability not to require stored water.

The effects of stage 3 of the project on the Rakaia River mouth

37. The Rakaia river mouth is a very dynamic, complex environment with numerous factors affecting its morphology. One of the factors affecting the morphology is the fluvial flow entering the lagoon/river mouth (“hapua”). The evidence of Mr Levy and Mr Single deal in part with this issue. The evidence of Mr Single states that “prolonged periods of low flow raises the potential for flooding...”. He also states that the flows capable of breaching the hapua are “thought to be 200 m³/s”. Mr Levy states that “Factors that affect the chance of closure are very low flows..”
38. I have already stated that the information presented in the applicant’s reports and evidence does not include changes to the duration of low flows nor the inter-annual variability of such changes. According to the statements above this information is important in determining the potential effects on the river mouth environment. I would therefore like to see more analysis completed on the effect of changes to the duration of low flows on hapua levels and openings.

The effects of climate variability and climate change

39. The report by Beca and the evidence of Mr Levy includes some general comments on climate change and the effects on the Rakaia River. However, these general comments do not provide any quantitative assessment of the risks of climate change on the river or project. NIWA has undertaken two detailed pieces of science work on the effect of climate change on the flows of the Rangitata and Waimakariri¹ Rivers, both alpine rivers. There are limitations with the analysis and scope of these reports but they do provide some quantitative analysis on the effects of climate change, which in my opinion should be included in the evidence presented to the hearing.

Conclusions

40. In my opinion the hydrological information provided by the applicant in the form of technical reports and evidence is based on robust analysis, interpretation and modelling. There are some areas where I would like additional analysis and information and these are:
- Impact of scenarios on duration of low flows in the Rakaia River;
 - Impact of stage 3 on the reliability of supply for existing abstractors not on the register;
 - Climate change effects based on the quantitative analysis undertaken for the Rangitata and Waimakariri Rivers.

Darren Leftley

2 February 2012

¹ NIWA 2011, “Projected climate and river flow for the Waimakariri catchment for 2040s and 2090s”