Memorandum

To:	Manuherekia Technical Advisory Group
From:	Dean Olsen, Freshwater Scientist Freestone Freshwater Greg Ryder, Director/Environmental Scientist, Ryder Environmental
Cc:	
Date:	12 July 2021
Re:	Review of Cawthron reports presenting invertebrate drift relationships for the lower Manuherekia River

This memorandum presents the results of technical reviews of two reports prepared by Cawthron to inform the process to set the minimum flow for the Manuherekia River. The reports reviewed were:

1. Shearer K, Hayes J 2020. The relationship between invertebrate drift and flow in the Manuherikia River. Prepared for Otago Regional Council, Aukaha, and Otago Fish & Game. Cawthron Report No. 3574. 14 p. plus appendix
2. Hayes J, Shearer K, Casanovas P 2021. The relationship between invertebrate drift and flow in the Manuherikia River: revised analysis and implications for setting minimum flow and allocation limits. Prepared for Otago Regional Council, Aukaha, and Otago Fish & Game Council.. Cawthron Report No. 3574A. 19 p

Shearer K, Hayes J 2020. The relationship between invertebrate drift and flow in the Manuherikia River

This report presents the results of macroinvertebrate drift sampling undertaken in the Manuherekia River in late 2019 and early 2020.

1. The authors state at Page 1, paragraph 3 that *"Understanding whether drift concentration and rate declines with flow reduction is relevant to assessing the effects of flow abstraction on dispersal of invertebrates as well as food supply for drift-feeding fishes, such as introduced trout and some native galaxiids"*. It should be noted here that whilst some native galaxiids do drift feed, in the presence of trout, galaxias are more likely to be benthic feeding[1], rather than drift-feeding[2]. Secondly, I consider the risk associated with trout predation to be a far more important factor than any effect of water allocation on galaxiids.
2. Water velocities observed in the January sampling event were below the calibration range for the current meters in the drift nets, meaning that it was not possible to calculate drift concentrations on these occasions (Section 2.4.1, paragraph 1). Because of this, the authors report drift rates (individuals per hour) in the report.
3. A series of high flow events in early December 2019 (max. ~28 m^3/s) led to the sampling being abandoned and re-started in January 2020 (Figure 1). The authors state that *"The drift data from the two recessions are not directly comparable because drift rates are influenced by benthic density and which will have changed over the one and a half months between the two recessions."* The second report reviewed here (Hayes, Shearer & Casanovas 2021) reanalyses these data to standardise drift rates by benthic density.

[1] Feeding on invertebrates on and within the bed.

[2] McIntosh & Townsend (1995). Contrasting predation risk presented by introduced brown trout and native common river galaxias in New Zealand streams. *Canadian Journal of Fisheries and Aquatic Sciences* **52**. 1821-1833. 10.1139/f95-175.

Given the changes caused by the combination of these high flow events and the time elapsed between the first and second flow recession sampled and the physical changes between these occasions, I agree that the drift data from the two flow recessions are not directly comparable due to physical changes (such as proliferation of periphyton, change in the composition of the macroinvertebrate community) and have serious concerns regarding the analysis presented in Hayes et al. (2021) and, consequently, the conclusions the authors draw from these data. I discuss these concerns in my comments on the analysis presented in Hayes et al. (2021) below.

4. **Section 3.1 Benthic Invertebrate Densities and Size Structure** – The reasons given by the authors for the increase in macroinvertebrate density "*will in part be due to concentration of invertebrates, resulting from contraction of the available habitat area (i.e. reduction in river width as flows decreased), recruitment over the summer period, and periphyton proliferation favouring species that prefer high algal biomass (extensive filamentous algal biomass were noted over the January flow recession…)*" (Section 3.1, paragraph 1). Recruitment over the six-week period between the surveys is likely to have affected the composition of the macroinvertebrate community. This is evident in Figure 2 of Shearer & Hayes (2020), which shows a large increase in the abundance of orthoclad midge larvae and *Hydropsyche*[3]. Different macroinvertebrate taxa exhibit different drift behaviours, so any change to community composition may affect drift propensity.

   Thick growths of periphyton observed during the surveys in January 2020 would also affect near-bed shear stresses and turbulence and may account for the much lower rate of drift observed during the January 2020 surveys. For this reason alone, I do not think it is appropriate to analyse the November 2019 and January 2020 datasets together, as the effects of changing periphyton confound the comparison.

5. It is not clear why benthic data from 21 February 2020 was used, as there was not matching drift data collected at this time (it is a month after the last drift sampling) and there was a ~40 m^3/s fresh between the last drift sampling and the collection of benthic invertebrate samples. For comparison, the freshes that occurred between the November 2019 and January 2020 sampling events was 25 m^3/s.
6. The authors conclude (Section 3.2, paragraph 1) that *"The significant regression for the > 6 mm standardised drift rate versus flow relationship was driven by a difference in the mean standardised drift rate between the recessions (recession co-efficient P = 0.005) and not by flow (i.e. there were proportionately more large invertebrates (> 6 mm) drifting in the first recession than the second, but there was no significant relationship between standardised drift rate and flow within either recession).*". I agree with this conclusion given the limitations of the data.
7. "…Deleatidium *are often more exposed to water currents because they are more active in searching for food than the smaller chironomids that tend to create burrows"* (Page 11, paragraph 2). Some chironomid taxa do construct tubes that they dwell in, which would reduce their drift propensity.

[3] The authors use the outdated genus *Aoteapsyche* in the report, *Aoteapsyche* was synonymized with *Hydropsyche* by Geraci *et al.* 2010

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Hayes et al. 2021. The relationship between invertebrate drift and flow in the Manuherikia River: revised analysis and implications for setting minimum flow and allocation limits.

This report revisits the results of macroinvertebrate drift sampling presented in Shearer & Hayes (2020). The revised report has a substantially broadened scope. The main change in the analysis is that the Hayes et al. report standardises the macroinvertebrate drift rates for each sampling occasion by benthic densities based on samples collected on or close to the drift sampling occasions. This revised analysis approach reverses the conclusions based on the previous analysis. The very substantial change in the conclusions based on this analysis warrants particular scrutiny of the validity of the changes to analysis approach, because of the risk of confirmation bias[4].

1. **Section 2.1.1 (Data summary and standardisation)** – The authors state that *"due to time and cost constraints we did not test whether temporal differences in benthic density were statistically significant and if they were, then standardise drift rate by benthic density"* (Section 2.1.1, paragraph 1). This justification for standardising drift rates by benthic densities is valid but does not address other confounding differences between the two recessions, such as differences in the composition of macroinvertebrate community and the drift propensity of different macroinvertebrate taxa. Figure 2 of Shearer & Hayes (2020), which compares the composition of the macroinvertebrate community between sampling occasions. This figure is omitted from Hayes et al. (2021). This figure shows a large increase in the abundance of orthoclad midge larvae and larvae of the net-spinning caddis fly *Hydropsyche*. Different macroinvertebrate taxa exhibit different drift behaviours, so any change to community composition may affect drift propensity.

   These differences in community between the November 2019 and January 2020 recessions are not trivial and would be expected to affect drift densities. In addition, thick growths of periphyton observed during the surveys in January 2020 (shown in Appendix 1 of Shearer & Hayes 2020, which was omitted from this report) would also affect near-bed shear stresses and turbulence and may account for the much lower rate of drift observed during the January 2020 surveys. For this reason alone, I do not think it is appropriate to analyse the November 2019 and January 2020 datasets together, as the effects of changing periphyton confound the comparison.

2. **Section 2.2.2 (Drift rate versus flow relationship)** – Page 3 – *"Limitations with our results mean that we were unable to derive a predictive regression between drift rate and flow (and drift concentration and flow) based on several data points that would allow estimation of the percentage change in drift rate (or concentration) for a given percentage change in flow—to define the scale of effects of flow alteration on drift transport capacity. The limitations arose from the narrow range of flows sampled (missing mid-range flows between MALF and median flow) and very low water velocities over the low-flow range sampled. However, a sense of the magnitude of the reduction in drift rate over the MALF to low flow range can be obtained from a simple linear regression between mean standardised drift rate for the first and second flow recessions (i.e. a regression between two points representing the mean of sampled flows (m³/s) and corresponding mean standardised drift rates for each flow recession)."* (Page 3, paragraph 3).

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[4] Confirmation bias is the tendency to search for, interpret, favor, and recall information in a way that confirms or supports one's prior beliefs or values.

The limitations that prevent the derivation of a predictive regression between drift rate and flow also apply to the linear regression between the mean standardised drift rates between the two recessions. It is inappropriate to apply a linear regression to estimate the magnitude of change between the two recessions given that this relationship is expected to be non-linear. In my opinion, the differences between the macroinvertebrate community composition and periphyton cover between the two recessions confound any comparison between them to a degree that makes any such comparison invalid. The authors seem to recognise these limitations in the last paragraph on page 3 and onto page 4 but go on to present the results of this analysis and draw conclusions from it.

3. The final paragraph on page 4 states *"In summary, our revised analysis indicates that drift rate declined with flow reduction in the Manuherikia study reach from about the MALF (~ 4 m³/s) to about 2 m³/s. However, drift rate appeared to be insensitive to further flow reduction."* This statement is not consistent with the data collected. Flows in the first recession sampled were approximately 4 and 3 m^3/s, while flows during the second recession ranged from 2.3 m^3/s to approximately 1 m^3/s. Therefore, the conclusion that the drift *"declined with flow reduction…from about the MALF (~ 4 m³/s) to about 2 m³/s."* is unfounded given the limitations outlined above that prevent comparison between the two recessions.
4. **Section 3.2** – This section discusses the challenges of isolating passive drift that is related to flow from active drift. This raises the question, how does the magnitude of the effect of flow on drift compare with the magnitude of daily variation in (behavioural) drift? A 30% or 40% drop in the drift rate/concentration sounds substantial, but if the passive, flow-related drift rate is very low compared to other periods, is it actually significant for the bioenergetics of drift-feeding fish? It is not unusual for fish to exhibit significant variation in feeding activity throughout the day, with crepuscular (morning/evening) feeding peaks coinciding with significantly higher rates of drift (especially in the presence of trout [5]). Drift sampling to assess the effects on passive (flow-related) drift are (understandably) conducted outside of these periods of active drift to minimise variation between sampling occasions (i.e. flows). However, I think in doing so, they fail to put the scale of any such effect on overall food availability in the context of the potential daily variation in macroinvertebrate drift.
5. **Section 3.3, second paragraph** – The authors state *"Hence, we were unable to stitch the data sets from the two recessions together because the standardised drift rates were comparable only within, not between, recessions. Our subsequent revised analysis, done for the present report, standardised drift rate for temporal variation in benthic density thereby overcoming this limitation.".* I do not believe that this revised analysis overcomes the limitations that prevent comparison between the two flow recessions, for the reasons outlined above (in particular the changes in community composition and the effects of filamentous algae).
6. **Figure 6** – data points from the Lindis River are presented with a curve fitted (for the >3 mm size class) despite these samples all being collected across a relatively narrow flow range. The small sample size (n=3) and the narrow range of flows across which they were collected raise questions regarding the validity of the fitted curve. It is possible that the variation between these three points simply reflects inter-daily variability in invertebrate drift concentration. Collection across a wider range of flows would provide greater confidence that the fitted curve is valid.
7. **Section 3.5.2** – *"These examples highlight the importance of context and isolating confounding variables when interpreting drift concentration (and rate) versus flow responses."* (page 14, paragraph 1). The authors stress this point at multiple points in this report. However, information on macroinvertebrate community composition and periphyton presented in Shearer & Hayes (2020) provides important context for the interpretation of the data presented in this report and these changes potentially

[5] Williams J.K. (2000) Influence of Abiotic and Biotic Factors on Invertebrate Drift. Unpublished MSc Thesis, University of Otago, New Zealand

confound the comparison between Recession 1 (November 2019) and Recession 2 (January 2020), yet the authors have removed both from this revised report.

8. **Section 5** – Despite the authors highlighting the "*importance of context and isolating confounding variables when interpreting drift concentration (and rate) versus flow responses.*", they go on to state that *"the decline in drift rate with flow reduction from the MALF is relatively steep; the percentage reduction in drift rate being 32-38% for a 25% reduction in flow"*.

   Given the factors that confound the combination of the results between the two recessions, I believe that the dataset is not able to used to make such confident and specific conclusions.

   In my view, the limitations of the dataset mean that comparisons should be limited to within each of the recessions, that is:

   a. That there was no difference in drift rate between 3 m^3/s and 4.1 m^3/s, and
   b. That there was no difference in drift rate between 1 m^3/s and 2.3 m^3/s.

   In addition, I think that the following conclusion can be drawn from this dataset:

   c. That the drift rates observed in Recession 1 were higher than those observed in Recession 2.

9. *"The low drift transport capacity, and periphyton proliferation, at flows below 2.3 m³/s observed during our study (Shearer & Hayes 2020) are indicative of ecological stress."* Periphyton proliferation (and low drift transport capacity) may be indicative of ecological stress, but it can also reflect stability and the natural accrual period following disturbance. It is common to observe periphyton proliferation in natural waterways in the inland parts of the lower South Island during summer/autumn months due to long accrual periods, long daylight hours and warm water temperatures. Conversely, such periods could be seen as the most productive periods of the ecosystem. Therefore, I think that this statement is not justified by the results of this study and is speculative.
10. *"The further that minimum flow options depart downward from the MALF to about 2 m³/s, and the higher the primary allocation rate, the more drift transport capacity will be adversely affected in the lower Manuherikia River."* For the reasons stated above, I do not think that this conclusion can be made on the basis of this dataset, given its limitations.

Conclusion - Given the limitations of the dataset, I have serious concerns regarding the conclusions drawn by the authors. In my view, the limitations of the dataset (particularly the differences in the composition of the macroinvertebrate community and periphyton cover and biomass) mean that comparisons should be limited to within each of the recessions, that is:

a. That there was no difference in drift rate between 3 m^3/s and 4.1 m^3/s (Recession 1),
b. That there was no difference in drift rate between 1 m^3/s and 2.3 m^3/s (Recession 2), and
c. That the drift rates observed in Recession 1 were higher than those observed in Recession 2.

The much lower drift rates observed in Recession 2 are consistent with reduced drift at higher algal biomass (Shearer et al. 2003).

References

Geraci CJ, Zhou X, Morse JC & Kjer KM (2010). Defining the genus Hydropsyche (Trichoptera:Hydropsychidae) based on DNA and morphological evidence. *Journal of the North American Benthological Society* **29**: 918-933.

Hayes J, Shearer K, Casanovas P 2021. The relationship between invertebrate drift and flow in the Manuherikia River: revised analysis and implications for setting minimum flow and allocation limits.. Prepared for Otago Regional Council, Aukaha, and Otago Fish & Game Council.. Cawthron Report No. 3574A. 19 p

Shearer K, Hayes J 2020. The relationship between invertebrate drift and flow in the Manuherikia River. Prepared for Otago Regional Council, Aukaha, and Otago Fish & Game. Cawthron Report No. 3574. 14 p. plus appendix

Shearer KA, Stark JD, Hayes JW &. Young RG (2003) Relationships between drifting and benthic invertebrates in three New Zealand rivers: Implications for drift-feeding fish. *New Zealand Journal of Marine and Freshwater Research* **37**: 809-820.

Williams J.K. (2000) Influence of Abiotic and Biotic Factors on Invertebrate Drift. Unpublished MSc Thesis, University of Otago, New Zealand.